



Building knowledge

Job Order Contract Technical Specifications

Book 1 of 1 CSI Divisions 01 - 43 October 2016

County of San Mateo
Mechanical Works



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SECTION 01 22 16 00 - NO SPECIFICATION REQUIRED

1.1 GENERAL

- A. A separate specification is not required for this item. The description given in the line item of the Construction Task Catalog completely defines the item.

1.2 PRODUCTS - (Not Used)

1.3 EXECUTION - (Not Used)

END OF SECTION 01 22 16 00



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Task	Specification	Specification Description
01 22 20 00	01 22 16 00	No Specification Required
01 22 23 00	01 22 16 00	No Specification Required



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SECTION 01 32 33 00 - SCHEDULE OF VALUES

1.1 GENERAL

A. Description Of Work

1. This specification covers the preparation, content and submittal of the schedule of values. The Schedule of Values is an itemized list that establishes the value or cost of each part of the Work. It shall be used as the basis for preparing progress payments.

B. Preparation

1. Schedule shall show breakdown of labor, materials equipment and other costs as directed by the Owner.
2. Costs shall be in sufficient detail to indicate separate amounts for each major subsection of the Work. The Contractor may include an item for bond, insurance, temporary facilities and job mobilization.
3. Schedule of Values shall be prepared on 8-1/2-inch by 11-inch white paper.
4. Use the major subsections of the Detailed Scope of Work as the basis for Schedule format. List sub-items of major products or systems as appropriate or when requested by the Owner.
5. When requested by the Owner, support values with data that will substantiate their correctness.
6. The sum of the individual values shown on the Schedule of Values must equal the total Job Order Price.
7. Schedule shall show the purchase and delivery costs for materials and equipment that the Contractor anticipates it shall request payment for prior to their installation.

- #### C. Submittal: Submit two copies of Schedule, or any other number of copies as directed by the Owner, to the Owner for approval at least 20 days prior to submitting first application for a progress payment. After review by the Owner, revise and resubmit Schedule as required until it is approved.

1.2 PRODUCTS (Not Used)

1.3 EXECUTION (Not Used)

END OF SECTION 01 32 33 00



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**SECTION 01 32 33 00a - SPECIAL PROCEDURES FOR HISTORIC TREATMENT**

1.1 GENERAL

A. Summary

1. This Section includes special procedures for historic treatment on Project including, but not limited to, the following:
 - a. Storage and protection of existing historic materials.
 - b. Temporary protection of historic materials during construction.
 - c. Protection during application of chemicals.
 - d. Protection during use of heat-generating equipment.
 - e. Historic treatment procedures.
 - f. Removal of bird excrement.
2. This specification applies to all tasks in the Construction Task Catalog® when they are used on Historic Buildings or Historic Sites.

B. Definitions

1. "Preservation": To apply measures necessary to sustain the existing form, integrity, and materials of a historic property. Work may include preliminary measures to protect and stabilize the property.
2. "Rehabilitation": To make possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features that convey its historical, cultural, or architectural values.
3. "Restoration": To accurately depict the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and the reconstruction of missing features from the restoration period.
4. "Reconstruction": To reproduce in the exact form and detail a building, structure, or artifact as it appeared at a specific period in time.
5. "Stabilize": To apply measures designed to reestablish a weather-resistant enclosure and the structural reinforcement of an item or portion of the building while maintaining the essential form as it exists at present.
6. "Protect and Maintain": To remove deteriorating corrosion, reapply protective coatings, and install protective measures such as temporary guards; to provide the least degree of intervention.
7. "Repair": To stabilize, consolidate, or conserve; to retain existing materials and features while employing as little new material as possible. Repair includes patching, piecing-in, splicing, consolidating, or otherwise reinforcing or upgrading materials. Within restoration, repair also includes limited replacement in kind, rehabilitation, and reconstruction, with compatible substitute materials for deteriorated or missing parts of features when there are surviving prototypes.
8. "Replace": To duplicate and replace entire features with new material in kind. Replacement includes the following conditions:
 - a. Duplication: Includes replacing elements damaged beyond repair or missing. Original material is indicated as the pattern for creating new duplicated elements.
 - b. Replacement with New Materials: Includes replacement with new material when original material is not available as patterns for creating new duplicated elements.
 - c. Replacement with Substitute Materials: Includes replacement with compatible substitute materials. Substitute materials are not allowed, unless otherwise indicated.
9. "Remove": To detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.
10. "Remove and Salvage": To detach items from existing construction and deliver them to the Owner ready for reuse.
11. "Remove and Reinstall": To detach items from existing construction, repair and clean them for reuse, and reinstall them where indicated.
12. "Existing to Remain" or "Retain": Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled.



13. "Material in Kind": Material that matches existing materials, as much as possible, in species, cut, color, grain, and finish.

C. Submittals

1. Historic Treatment Program: Submit a written plan for each phase or process including protection of surrounding materials during operations. Describe in detail materials, methods, and equipment to be used for each phase of work.
2. Alternative Methods and Materials: If alternative methods and materials to those indicated are proposed for any phase of work, provide a written description including evidence of successful use on other, comparable projects, and program of testing to demonstrate effectiveness for use on this Project.
3. Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by historic treatment operations. Submit before work begins.

D. Quality Assurance

1. Historic Treatment Specialist Qualifications: A firm that employs personnel, including supervisory personnel, experienced and skilled in the processes and operations indicated.
2. Historic Treatment Preconstruction Conference: Conduct conference at Project site.

E. Storage And Protection Of Historic Materials

1. Removed and Salvaged Historic Materials:
 - a. Clean salvaged historic items.
 - b. Pack or crate items after cleaning. Identify contents of containers.
 - c. Store items in a secure area until delivery to the Owner.
 - d. Transport items to the Owner's storage area on-site **OR** off-site **OR** designated by the Owner **OR** indicated on Drawings, **as directed**.
 - e. Protect items from damage during transport and storage.
 - f. Do not dispose of items removed from existing construction without prior written consent of the Owner.
2. Removed and Reinstalled Historic Materials:
 - a. Clean and repair historic items to functional condition adequate for intended reuse.
 - b. Pack or crate items after cleaning and repairing. Identify contents of containers.
 - c. Protect items from damage during transport and storage.
 - d. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.
3. Existing Historic Materials to Remain: Protect construction indicated to remain against damage and soiling during historic treatment. When permitted, items may be removed to a suitable, protected storage location during historic treatment and cleaned and reinstalled in their original locations after historic treatment operations are complete.
4. Storage and Protection: When removed from their existing location, store historic materials within a weathertight enclosure where they are protected from wetting by rain, snow, or ground water, and temperature variations. Secure stored materials to protect from theft.
 - a. Identify removed items with an inconspicuous mark indicating their original location.

F. Project-Site Conditions

1. Exterior Cleaning and Repairing:
 - a. Proceed with the work only when forecasted weather conditions are favorable.
 - 1) Wet Weather: Do not attempt repairs during rainy or foggy weather. Do not apply primer, paint, putty, or epoxy when the relative humidity is above 80 percent. Do not remove exterior elements of structures when rain is forecast or in progress.
 - 2) Do not perform exterior wet work when the air temperature is below 40 deg F (5 deg C).



- 3) Do not begin cleaning, patching, or repairing when there is any likelihood of frost or freezing.
- 4) Do not begin cleaning when either the air or the surface temperature is below 45 deg F (7 deg C) unless approved means are provided for maintaining a 45 deg F (7 deg C) temperature of the air and materials during, and for 48 hours subsequent to, cleaning.
 - b. Perform cleaning and rinsing of the exterior only during daylight hours.
2. the Owner will occupy portions of building immediately adjacent to historic treatment area. Conduct historic treatment so the Owner's operations will not be disrupted. Provide not less than 72 hours' notice to the Owner of activities that will affect the Owner's operations.

1.2 PRODUCTS (Not Used)

1.3 EXECUTION

A. Protection, General

1. Comply with manufacturer's written instructions for precautions and effects of products and procedures on adjacent building materials, components, and vegetation.
2. Ensure that supervisory personnel are present when work begins and during its progress.
3. Temporary Protection of Historic Materials during Construction:
 - a. Protect existing materials during installation of temporary protections and construction. Do not deface or remove existing materials.
 - b. Attachments of temporary protection to existing construction shall be approved prior to installation.
4. Protect landscape work adjacent to or within work areas as follows:
 - a. Provide barriers to protect tree trunks.
 - b. Bind spreading shrubs.
 - c. Use coverings that allow plants to breathe and remove coverings at the end of each day. Do not cover plant material with a waterproof membrane for more than 8 hours at a time.
 - d. Set scaffolding and ladder legs away from plants.
5. Existing Drains: Prior to the start of work or any cleaning operations, test drains and other water removal systems to ensure that drains and systems are functioning properly. Notify the Owner immediately of drains or systems that are stopped or blocked. Do not begin Work of this Section until the drains are in working order.
 - a. Provide a method to prevent solids including stone or mortar residue from entering the drains or drain lines. Clean out drains and drain lines that become blocked or filled by sand or any other solids because of work performed under this Contract.
 - b. Protect storm drains from pollutants. Block drains or filter out sediments, allowing only clean water to pass.

B. Protection During Application Of Chemicals

1. Protect persons, motor vehicles, surrounding surfaces of building being restored, building site, plants, and surrounding buildings from harm or damage resulting from applications of chemical cleaners and paint removers.
2. Comply with requirements in Division 01 Section "Temporary Facilities And Controls".
3. Cover adjacent surfaces with materials that are proven to resist chemical cleaners selected for Project unless chemicals being used will not damage adjacent surfaces. Use covering materials that contain only waterproof, UV-resistant adhesives. Apply masking agents to comply with manufacturer's written instructions. Do not apply liquid masking agent to painted or porous surfaces. When no longer needed, promptly remove masking to prevent adhesive staining.
4. Do not clean surfaces during winds of sufficient force to spread cleaning solutions to unprotected surfaces.
5. Neutralize and collect alkaline and acid wastes and dispose of off the Owner's property.



6. Dispose of runoff from chemical operations by legal means and in a manner that prevents soil erosion, undermining of paving and foundations, damage to landscaping, and water penetration into building interiors.

C. Protection During Use Of Heat-Generating Equipment

1. Comply with the following procedures while performing work with heat-generating equipment, including welding, cutting, soldering, brazing, paint removal with heat, and other operations where open flames or implements utilizing heat are used:
 - a. Obtain the Owner's approval for operations involving use of open-flame or welding equipment.
 - 1) Notification shall be given for each occurrence and location of work with heat-generating equipment.
 - b. As far as practical, use heat-generating equipment in shop areas or outside the building.
 - c. Before work with heat-generating equipment commences, furnish personnel to serve as a fire watch (or watches) for location(s) where work is to be performed.
 - d. Do not perform work with heat-generating equipment in or near rooms or in areas where flammable liquids or explosive vapors are present or thought to be present. Use a combustible gas indicator test to ensure that the area is safe.
 - e. Remove and keep the area free of combustibles, including, rubbish, paper, waste, etc., within area of operations.
 - 1) If combustible material cannot be removed, provide fireproof blankets to cover such materials.
 - f. Where possible, furnish and use baffles of metal or gypsum board to prevent the spraying of sparks or hot slag into surrounding combustible material.
 - g. Prevent the extension of sparks and particles of hot metal through open windows, doors, holes, and cracks in floors, walls, ceilings, roofs, and other openings.
 - h. Inspect each location of the day's work not sooner than 30 minutes after completion of operations to detect hidden or smoldering fires and to ensure that proper housekeeping is maintained.
2. Where sprinkler protection exists and is functional, maintain it without interruption while operations are being performed. If operations are performed close to automatic sprinkler heads, shield the individual heads temporarily with guards.

D. Historic Treatment Procedures

1. The principal aim of preservation work is to halt the process of deterioration and stabilize the item's condition, unless otherwise indicated. Repair is required where specifically indicated. The following procedures shall be followed:
 - a. Retain as much existing material as possible; repair and consolidate rather than replace.
 - b. Use additional material or structure to reinforce, strengthen, prop, tie, and support existing material or structure.
 - c. Use reversible processes wherever possible.
 - d. Use traditional replacement materials and techniques. New work shall be distinguishable to the trained eye, on close inspection, from old work.
 - e. Record the work before the procedure with preconstruction photos and during the work with periodic construction photos.
2. Prohibit smoking by personnel performing work on or near historic structures.
3. Obtain review and written approval in the form of a Constructive Change Directive or Supplemental Instruction before making changes or additions to construction or removing historic materials.
4. Notify the Owner of visible changes in the integrity of material or components whether due to environmental causes including biological attack, UV degradation, freezing, or thawing; or due to structural defects including cracks, movement, or distortion.
 - a. Do not proceed with the work in question until directed.



5. Where missing features are indicated to be repaired or replaced, provide features whose designs are based on accurate duplications rather than on conjectural designs, subject to the approval of the Owner and Historic Treatment Specialist.
 6. Where Work requires existing features to be removed, cleaned, and reused, perform these operations without damage to the material itself, to adjacent materials, or to the substrate.
 7. Identify new or replacement materials and features with inconspicuous, permanent marks to distinguish them from original materials. Record the legend of identification marks and the locations of these marks on Record Drawings.
 8. When cleaning, match samples of existing materials that have been cleaned and identified for acceptable cleaning levels. Avoid overcleaning to prevent damage to existing materials during cleaning.
- E. Removal Of Bird Excrement
1. General: Before disturbing accumulated bird excrement, consult with an occupational medicine physician, industrial hygienist, and authorities having jurisdiction to determine acceptable removal procedures and appropriate protective measures for personnel.
 2. Removing Bird Excrement: Treat bird excrement before its removal as required by authorities having jurisdiction.
 - a. Prior to removal, dampen excrement to prevent it from becoming airborne.
 - b. Use only nonmetallic tools (plastic spatulas and brushes with natural fiber or nylon bristles, or their equivalent) to remove excrement.
 - c. Collect removed excrement and legally disposed of off site.
 - d. Perform bird excrement removal work from the outside of the building with windows and other openings in the building closed.

END OF SECTION 01 32 33 00a



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SECTION 01 32 33 00b - LEED REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes general requirements and procedures for compliance with certain USGBC LEED prerequisites and credits needed for Project to obtain LEED-Certified **OR** Silver **OR** Gold **OR** Platinum, **as directed**, certification based on USGBC's "LEED 2009 for New Construction & Major Renovations," "LEED 2009 for Commercial Interiors," "LEED 2009 for Core and Shell Development," or "LEED 2009 for Schools New Construction and Major Renovations."
1. Other LEED prerequisites and credits needed to obtain LEED certification depend on product selections and may not be specifically identified as LEED requirements. Compliance with requirements needed to obtain LEED prerequisites and credits may be used as one criterion to evaluate substitution requests and comparable product requests.
 2. Additional LEED prerequisites and credits needed to obtain the indicated LEED certification depend on Architect's design and other aspects of Project that are not part of the Work of the Contract.
 3. A copy of the LEED Project checklist is attached at the end of this Section for information only.
 4. Specific requirements for LEED are included in greater detail in other Sections.

1.2 DEFINITIONS

- A. Chain-of-Custody Certificates: Certificates signed by manufacturers certifying that wood used to make products was obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship." Certificates shall include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.
- B. Regional Materials: Materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site. If only a fraction of a product or material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value. Manufacturing refers to the final assembly of components into the building product that is installed at Project site.
- C. Recycled Content: The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.
1. "Post-consumer" material is defined as waste material generated by households or by commercial, industrial, and institutional facilities in their role as end users of the product, which can no longer be used for its intended purpose.
 2. "Pre-consumer" material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind, or scrap generated in a process and capable of being reclaimed within the same process that generated it.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Respond to questions and requests from the Owner and the USGBC regarding LEED credits that are the responsibility of the Contractor, that depend on product selection or product qualities, or that depend



on Contractor's procedures until the USGBC has made its determination on the project's LEED certification application. Document responses as informational submittals.

1.4 ACTION SUBMITTALS

- A. General: Submit additional LEED submittals required by other Specification Sections.
- B. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
- C. LEED Documentation Submittals:
 - 1. FOR CONSTRUCTION AND MAJOR RENOVATIONS:
 - a. Credit EA 5: Product data and wiring diagrams for sensors and data collection system used to provide continuous metering of building energy-consumption performance over time **OR** a period of time of not less than one year of postconstruction occupancy, **as directed**.
 - b. Credit MR 2: Comply with Section 017419 "Construction Waste Management and Disposal."
 - c. Credit MR 3: Receipts for salvaged and refurbished materials used for Project, indicating sources and costs for salvaged and refurbished materials.
 - d. Credit MR 4: Product data and certification letter from product manufacturers indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating material cost for each product having recycled content.
 - e. Credit MR 5: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
 - f. Credit MR 7: Product data and chain-of-custody certificates for products containing certified wood. Include statement indicating cost for each certified wood product.
 - g. Credit IEQ 3.1:
 - 1) Construction indoor-air-quality management plan.
 - 2) Product data for temporary filtration media.
 - 3) Product data for filtration media used during occupancy.
 - 4) Construction Documentation: Six photographs at three different times during the construction period, along with a brief description of the SMACNA approach employed, documenting implementation of the indoor-air-quality management measures, such as protection of ducts and on-site stored or installed absorptive materials.
 - h. Credit IEQ 3.2:
 - 1) Signed statement describing the building air flush-out procedures including the dates when flush-out was begun and completed and statement that filtration media was replaced after flush-out.
 - 2) Product data for filtration media used during flush-out and during occupancy.
 - 3) Report from testing and inspecting agency indicating results of indoor-air-quality testing and documentation showing compliance with indoor-air-quality testing procedures and requirements.
 - i. Credit IEQ 4.1: Product data for adhesives and sealants used inside the weatherproofing system indicating VOC content of each product used.
 - j. Credit IEQ 4.2: Product data for paints and coatings used inside the weatherproofing system indicating VOC content of each product used.
 - k. Credit IEQ 4.4: Product data for products containing composite wood or agrifiber products or wood glues indicating that they do not contain urea-formaldehyde resin.
 - 2. FOR COMMERCIAL INTERIORS:



- a. Credit EA 3: Product data and wiring diagrams for sensors and data collection system used to provide continuous metering of building energy-consumption performance over time **OR** a period of time of not less than one year of postconstruction occupancy, **as directed**.
 - b. Credit MR 2: Comply with Section 017419 "Construction Waste Management and Disposal."
 - c. Credit MR 3.1 and Credit MR 3.2: Receipts for salvaged and refurbished materials used for Project, indicating sources and costs for salvaged and refurbished materials.
 - d. Credit MR 4: Product data and certification letter from product manufacturers indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating material costs for each product having recycled content.
 - e. Credit MR 5: Product data indicating location of material manufacturer for regionally manufactured materials. Include statement indicating cost for each regionally manufactured material and for each regionally extracted and manufactured material.
 - 1) Include statement indicating distance from manufacturer to Project for each regionally manufactured material.
 - 2) Include statement indicating location of and distance from Project to point of extraction, harvest, or recovery for each raw material used in regionally extracted and manufactured materials.
 - f. Credit MR 7: Product data and chain-of-custody certificates for products containing certified wood. Include statement indicating cost for each certified wood product.
 - g. Credit IEQ 3.1:
 - 1) Construction indoor-air-quality management plan.
 - 2) Product data for temporary filtration media.
 - 3) Product data for filtration media used during occupancy.
 - 4) Construction Documentation: Six photographs at three different times during the construction period, along with a brief description of the SMACNA approach employed, documenting implementation of the indoor-air-quality management measures, such as protection of ducts and on-site stored or installed absorptive materials.
 - h. Credit IEQ 3.2:
 - 1) Signed statement describing the building air flush-out procedures including the dates when flush-out was begun and completed and statement that filtration media was replaced after flush-out.
 - 2) Product data for filtration media used during flush-out and during occupancy.
 - 3) Report from testing and inspecting agency indicating results of indoor-air-quality testing and documentation showing compliance with indoor-air-quality testing procedures and requirements.
 - i. Credit IEQ 4.1: Product data for adhesives and sealants used inside the weatherproofing system indicating VOC content of each product used.
 - j. Credit IEQ 4.2: Product data for paints and coatings used inside the weatherproofing system indicating VOC content of each product used.
 - k. Credit IEQ 4.4: Product data for products containing composite wood or agrifiber products or wood glues indicating that they do not contain urea-formaldehyde resin.
3. FOR CORE AND SHELL DEVELOPMENT:
- a. Credit EA 5.1 and 5.2: Product data and wiring diagrams for sensors and data collection system used to provide continuous metering of building energy-consumption performance over time **OR** a period of time of not less than one year of postconstruction occupancy, **as directed**.
 - b. Credit MR 2: Comply with Section 017419 "Construction Waste Management and Disposal."
 - c. Credit MR 3: Receipts for salvaged and refurbished materials used for Project, indicating sources and costs for salvaged and refurbished materials.
 - d. Credit MR 4: Product data and certification letter from product manufacturers indicating percentages by weight of post-consumer and pre-consumer recycled content for products



- having recycled content. Include statement indicating material costs for each product having recycled content.
- e. Credit MR 5: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
 - f. Credit MR 6: Product data and chain-of-custody certificates for products containing certified wood. Include statement indicating cost for each certified wood product.
 - g. Credit IEQ 3:
 - 1) Construction indoor-air-quality management plan.
 - 2) Product data for temporary filtration media.
 - 3) Product data for filtration media used during occupancy.
 - 4) Construction Documentation: Six photographs at three different times during the construction period, along with a brief description of the SMACNA approach employed, documenting implementation of the indoor-air-quality management measures, such as protection of ducts and on-site stored or installed absorptive materials.
 - h. Credit IEQ 4.1: Product data for adhesives and sealants used inside the weatherproofing system indicating VOC content of each product used.
 - i. Credit IEQ 4.2: Product data for paints and coatings used inside the weatherproofing system indicating VOC content of each product used.
 - j. Credit IEQ 4.4: Product data for products containing composite wood or agrifiber products or wood glues indicating that they do not contain urea-formaldehyde resin.
4. FOR SCHOOLS:
- a. Credit EA 5: Product data and wiring diagrams for sensors and data collection system used to provide continuous metering of building energy-consumption performance over time **OR** a period of time of not less than one year of postconstruction occupancy, **as directed**.
 - b. Credit MR 2: Comply with Section 017419 "Construction Waste Management and Disposal."
 - c. Credit MR 3: Receipts for salvaged and refurbished materials used for Project, indicating sources and costs for salvaged and refurbished materials.
 - d. Credit MR 4: Product data and certification letter from product manufacturers indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating material costs for each product having recycled content.
 - e. Credit MR 5: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
 - f. Credit MR 7: Product data and chain-of-custody certificates for products containing certified wood. Include statement indicating cost for each certified wood product.
 - g. Credit IEQ 3.1:
 - 1) Construction indoor-air-quality management plan.
 - 2) Product data for temporary filtration media.
 - 3) Product data for filtration media used during occupancy.
 - 4) Construction Documentation: Six photographs at three different times during the construction period, along with a brief description of the SMACNA approach employed, documenting implementation of the indoor-air-quality management measures, such as protection of ducts and on-site stored or installed absorptive materials.
 - h. Credit IEQ 3.2:
 - 1) Signed statement describing the building air flush-out procedures including the dates when flush-out was begun and completed and statement that filtration media was replaced after flush-out.
 - 2) Product data for filtration media used during flush-out and during occupancy.



- 3) Report from testing and inspecting agency indicating results of indoor-air-quality testing and documentation showing compliance with indoor-air-quality testing procedures and requirements.
- i. Credit IEQ 4: Laboratory test reports for the following products and systems installed inside the weatherproofing system indicating that they meet the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
 - 1) Adhesives and sealants.
 - 2) Paints and coatings.
 - 3) Composite wood and agrifiber products.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For LEED coordinator.
- B. Project Materials Cost Data: Provide statement indicating total cost for materials used for Project. Costs exclude labor, overhead, and profit. Include breakout of costs for the following categories of items:
 1. Furniture.
 2. Plumbing.
 3. Mechanical.
 4. Electrical.
 5. Specialty items such as elevators and equipment.
 6. Wood-based construction materials.
- C. LEED Action Plans: Provide preliminary submittals within seven **OR 14 OR 30 OR 60, as directed**, days of date established for commencement of the Work **OR** the Notice to Proceed **OR** the Notice of Award, **as directed**, indicating how the following requirements will be met:
 1. FOR CONSTRUCTION AND MAJOR RENOVATIONS:
 - a. Credit MR 2: Waste management plan complying with Section 017419 "Construction Waste Management and Disposal."
 - b. Credit MR 3: List of proposed salvaged, refurbished, and reused materials. Identify each material that will be salvaged, refurbished, or reused, including its source, cost, and replacement cost if the item was to be purchased new.
 - c. Credit MR 4: List of proposed materials with recycled content. Indicate cost, post-consumer recycled content, and pre-consumer recycled content for each product having recycled content.
 - d. Credit MR 5: List of proposed regional materials. Identify each regional material, including its source, cost, and the fraction by weight that is considered regional.
 - e. Credit MR 7: List of proposed certified wood products. Indicate each product containing certified wood, including its source and cost of certified wood products.
 - f. Credit IEQ 3.1: Construction indoor-air-quality management plan.
 2. FOR COMMERCIAL INTERIORS:
 - a. Credit MR 2: Waste management plan complying with Section 017419 "Construction Waste Management and Disposal."
 - b. Credit MR 3.1 and Credit MR 3.2: List of proposed salvaged, refurbished, and reused materials. Identify each material that will be salvaged, refurbished, or reused, including its source, cost, and replacement cost if the item was to be purchased new.
 - c. Credit MR 4: List of proposed materials with recycled content. Indicate cost, post-consumer recycled content, and pre-consumer recycled content for each product having recycled content.
 - d. Credit MR 5: List of proposed regionally manufactured materials and regionally extracted and manufactured materials.
 - 1) Identify each regionally manufactured material, including its source and cost.



- 2) Identify each regionally extracted and manufactured material, including its source and cost.
 - e. Credit MR 7: List of proposed certified wood products. Indicate each product containing certified wood, including its source and cost of certified wood products.
 - f. Credit IEQ 3.1: Construction indoor-air-quality management plan.
 3. FOR CORE AND SHELL DEVELOPMENT:
 - a. Credit MR 2: Waste management plan complying with Section 017419 "Construction Waste Management and Disposal."
 - b. Credit MR 3: List of proposed salvaged, refurbished, and reused materials. Identify each material that will be salvaged, refurbished, or reused, including its source, cost, and replacement cost if the item was to be purchased new.
 - c. Credit MR 4: List of proposed materials with recycled content. Indicate cost, post-consumer recycled content, and pre-consumer recycled content for each product having recycled content.
 - d. Credit MR 5: List of proposed regional materials. Identify each regional material, including its source, cost, and the fraction by weight that is considered regional.
 - e. Credit MR 6: List of proposed certified wood products. Indicate each product containing certified wood, including its source and cost of certified wood products.
 - f. Credit IEQ 3: Construction indoor-air-quality management plan.
 4. FOR SCHOOLS:
 - a. Credit MR 2: Waste management plan complying with Section 017419 "Construction Waste Management and Disposal."
 - b. Credit MR 3: List of proposed salvaged, refurbished, and reused materials. Identify each material that will be salvaged, refurbished, or reused, including its source, cost, and replacement cost if the item was to be purchased new.
 - c. Credit MR 4: List of proposed materials with recycled content. Indicate cost, post-consumer recycled content, and pre-consumer recycled content for each product having recycled content.
 - d. Credit MR 5: List of proposed regional materials. Identify each regional material, including its source, cost, and the fraction by weight that is considered regional.
 - e. Credit MR 7: List of proposed certified wood products. Indicate each product containing certified wood, including its source and cost of certified wood products.
 - f. Credit IEQ 3.1: Construction indoor-air-quality management plan.
- D. LEED Progress Reports: Concurrent with each Application for Payment, submit reports comparing actual construction and purchasing activities with LEED action plans for the following:
1. FOR CONSTRUCTION AND MAJOR RENOVATIONS:
 - a. Credit MR 2: Waste reduction progress reports complying with Section 017419 "Construction Waste Management and Disposal."
 - b. Credit MR 3: Salvaged, refurbished, and reused materials.
 - c. Credit MR 4: Recycled content.
 - d. Credit MR 5: Regional materials.
 - e. Credit MR 7: Certified wood products.
 2. FOR COMMERCIAL INTERIORS:
 - a. Credit MR 2: Waste reduction progress reports complying with Section 017419 "Construction Waste Management and Disposal."
 - b. Credit MR 3.1 and Credit MR 3.2: Salvaged, refurbished, and reused materials.
 - c. Credit MR 4: Recycled content.
 - d. Credit MR 5: Regionally manufactured materials and regionally extracted and manufactured materials.
 - e. Credit MR 7: Certified wood products.
 3. FOR CORE AND SHELL DEVELOPMENT:
 - a. Credit MR 2: Waste reduction progress reports complying with Section 017419 "Construction Waste Management and Disposal."
 - b. Credit MR 3: Salvaged, refurbished, and reused materials.



- c. Credit MR 4: Recycled content.
 - d. Credit MR 5: Regional materials.
 - e. Credit MR 6: Certified wood products.
4. FOR SCHOOLS:
- a. Credit MR 2: Waste reduction progress reports complying with Section 017419 "Construction Waste Management and Disposal."
 - b. Credit MR 3: Salvaged, refurbished, and reused materials.
 - c. Credit MR 4: Recycled content.
 - d. Credit MR 5: Regional materials.
 - e. Credit MR 7: Certified wood products.

1.6 QUALITY ASSURANCE

- A. LEED Coordinator: Engage an experienced LEED-Accredited Professional to coordinate LEED requirements. LEED coordinator may also serve as waste management coordinator.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

- A. Provide products and procedures necessary to obtain LEED credits required in this Section. Although other Sections may specify some requirements that contribute to LEED credits, the Contractor shall determine additional materials and procedures necessary to obtain LEED credits indicated.

2.2 SALVAGED, REFURBISHED, OR REUSED MATERIALS

- A. FOR CONSTRUCTION AND MAJOR RENOVATIONS
 - 1. Credit MR 3: Not less than 5 **OR** 10 percent, **as directed**, of building materials (by cost) shall be salvaged, refurbished, or reused materials. Certain materials may be salvaged, refurbished, or reused materials **as directed**.
- B. FOR COMMERCIAL INTERIORS
 - 1. Credit MR 3.1 and Credit MR 3.2: Not less than 5 **OR** 10 percent, **as directed**, of building materials (by cost) shall be salvaged, refurbished, or reused materials.
- C. FOR CORE AND SHELL DEVELOPMENT
 - 1. Credit MR 3: Not less than 5 percent of building materials (by cost) shall be salvaged, refurbished, or reused materials.
- D. FOR SCHOOLS
 - 1. Credit MR 3: Not less than 1 percent of building materials (by cost) shall be salvaged, refurbished, or reused materials.

2.3 RECYCLED CONTENT OF MATERIALS

- A. Credit MR 4: Building materials shall have recycled content such that post-consumer recycled content plus one-half of pre-consumer recycled content for Project constitutes a minimum of 10 **OR** 20, **as directed**, percent of cost of materials used for Project.



1. Cost of post-consumer recycled content plus one-half of pre-consumer recycled content of an item shall be determined by dividing weight of post-consumer recycled content plus one-half of pre-consumer recycled content in the item by total weight of the item and multiplying by cost of the item.
2. Do not include furniture, plumbing, mechanical and electrical components, and specialty items such as elevators and equipment in the calculation.

2.4 REGIONAL MATERIALS

- A. FOR CONSTRUCTION AND MAJOR RENOVATIONS, CORE AND SHELL DEVELOPMENT, and SCHOOLS
 1. Credit MR 5: Not less than 10 **OR** 20 percent, **as directed**, of building materials (by cost) shall be regional materials.
- B. FOR COMMERCIAL INTERIORS
 1. Credit MR 5, Option 1: Not less than 20 percent of materials (by cost) shall be regionally manufactured materials.
 2. Credit MR 5, Option 2: Not less than 10 percent of materials (by cost) shall be regionally extracted and manufactured materials.

2.5 CERTIFIED WOOD

- A. Wood-based materials include, but are not limited to, the following materials when made from wood, engineered wood products, or wood-based panel products:
 1. Rough carpentry.
 2. Miscellaneous carpentry.
 3. Heavy timber construction.
 4. Wood decking.
 5. Metal-plate-connected wood trusses.
 6. Structural glued-laminated timber.
 7. Finish carpentry.
 8. Architectural woodwork.
 9. Wood paneling.
 10. Wood veneer wall covering.
 11. Wood flooring.
 12. Wood lockers.
 13. Wood cabinets.
 14. Furniture
- B. FOR CONSTRUCTION AND MAJOR RENOVATIONS, COMMERCIAL INTERIORS , and SCHOOLS
 1. Credit MR 7: Not less than 50 percent (by cost) of wood-based materials shall be produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
- C. FOR CORE AND SHELL DEVELOPMENT
 1. Credit MR 6: Not less than 50 percent (by cost) of wood-based materials shall be produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."



2.6 LOW-EMITTING MATERIALS

- A. FOR CONSTRUCTION AND MAJOR RENOVATIONS, COMMERCIAL INTERIORS, and CORE AND SHELL DEVELOPMENT
1. Credit IEQ 4.1: For field applications that are inside the weatherproofing system, adhesives and sealants shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - a. Wood Glues: 30 g/L.
 - b. Metal-to-Metal Adhesives: 30 g/L.
 - c. Adhesives for Porous Materials (Except Wood): 50 g/L.
 - d. Subfloor Adhesives: 50 g/L.
 - e. Plastic Foam Adhesives: 50 g/L.
 - f. Carpet Adhesives: 50 g/L.
 - g. Carpet Pad Adhesives: 50 g/L.
 - h. VCT and Asphalt Tile Adhesives: 50 g/L.
 - i. Cove Base Adhesives: 50 g/L.
 - j. Gypsum Board and Panel Adhesives: 50 g/L.
 - k. Rubber Floor Adhesives: 60 g/L.
 - l. Ceramic Tile Adhesives: 65 g/L.
 - m. Multipurpose Construction Adhesives: 70 g/L.
 - n. Fiberglass Adhesives: 80 g/L.
 - o. Contact Adhesive: 80 g/L.
 - p. Structural Glazing Adhesives: 100 g/L.
 - q. Wood Flooring Adhesive: 100 g/L.
 - r. Structural Wood Member Adhesive: 140 g/L.
 - s. Single-Ply Roof Membrane Adhesive: 250 g/L.
 - t. Special-Purpose Contact Adhesive (contact adhesive that is used to bond melamine-covered board, metal, unsupported vinyl, rubber, or wood veneer 1/16 inch or less in thickness to any surface): 250 g/L.
 - u. Top and Trim Adhesive: 250 g/L.
 - v. Plastic Cement Welding Compounds: 250 g/L.
 - w. ABS Welding Compounds: 325 g/L.
 - x. CPVC Welding Compounds: 490 g/L.
 - y. PVC Welding Compounds: 510 g/L.
 - z. Adhesive Primer for Plastic: 550 g/L.
 - aa. Sheet-Applied Rubber Lining Adhesive: 850 g/L.
 - bb. Aerosol Adhesive, General-Purpose Mist Spray: 65 percent by weight.
 - cc. Aerosol Adhesive, General-Purpose Web Spray: 55 percent by weight.
 - dd. Special-Purpose Aerosol Adhesive (All Types): 70 percent by weight.
 - ee. Other Adhesives: 250 g/L.
 - ff. Architectural Sealants: 250 g/L.
 - gg. Nonmembrane Roof Sealants: 300 g/L.
 - hh. Single-Ply Roof Membrane Sealants: 450 g/L.
 - ii. Other Sealants: 420 g/L.
 - jj. Sealant Primers for Nonporous Substrates: 250 g/L.
 - kk. Sealant Primers for Porous Substrates: 775 g/L.
 - ll. Modified Bituminous Sealant Primers: 500 g/L.
 - mm. Other Sealant Primers: 750 g/L.
 2. Credit IEQ 4.2: For field applications that are inside the weatherproofing system, paints and coatings shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - a. Flat Paints and Coatings: VOC not more than 50 g/L.
 - b. Nonflat Paints and Coatings: VOC not more than 150 g/L.
 - c. Dry-Fog Coatings: VOC not more than 400 g/L.
 - d. Primers, Sealers, and Undercoaters: VOC not more than 200 g/L.
 - e. Anticorrosive and Antirust Paints Applied to Ferrous Metals: VOC not more than 250 g/L.



- f. Zinc-Rich Industrial Maintenance Primers: VOC not more than 340 g/L.
 - g. Pretreatment Wash Primers: VOC not more than 420 g/L.
 - h. Clear Wood Finishes, Varnishes: VOC not more than 350 g/L.
 - i. Clear Wood Finishes, Lacquers: VOC not more than 550 g/L.
 - j. Floor Coatings: VOC not more than 100 g/L.
 - k. Shellacs, Clear: VOC not more than 730 g/L.
 - l. Shellacs, Pigmented: VOC not more than 550 g/L.
 - m. Stains: VOC not more than 250 g/L.
3. Credit IEQ 4.4: Composite wood, agrifiber products, and adhesives shall not contain urea-formaldehyde resin.

B. FOR SCHOOLS

- 1. Credit IEQ 4: The following products and systems, where installed inside the weatherproofing system, shall meet the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
 - a. Adhesives and sealants.
 - b. Paints and coatings.
 - c. Flooring systems.
 - d. Composite wood and agrifiber products.
 - e. Ceilings and wall systems.

PART 3 - EXECUTION

3.1 REFRIGERANT AND CLEAN-AGENT FIRE-EXTINGUISHING-AGENT REMOVAL

- A. Prerequisite EA 3: Remove CFC-based refrigerants from existing HVAC&R equipment indicated to remain and replace with refrigerants that are not CFC based. Replace or adjust existing equipment to accommodate new refrigerant as described in HVAC Sections.
- B. Credit EA 4: Remove clean-agent fire-extinguishing agents that contain HCFCs or halons and replace with agent that does not contain HCFCs or halons. See Section 212200 "Clean-Agent Fire-Extinguishing Systems" for additional requirements.

3.2 MEASUREMENT AND VERIFICATION

A. FOR CONSTRUCTION AND MAJOR RENOVATIONS and SCHOOLS

- 1. Credit EA 5: Implement measurement and verification plan consistent with Option B: Energy Conservation Measure Isolation **OR** Option D: Calibrated Simulation, Savings Estimation Method 2, **as directed**, in the EVO's "International Performance Measurement and Verification Protocol (IPMVP), Volume III: Concepts and Options for Determining Energy Savings in New Construction," and **as directed**.

B. FOR COMMERCIAL INTERIORS

- 1. Credit EA 3: Implement measurement and verification plan consistent with Option B: Energy Conservation Measure Isolation **OR** Option D: Calibrated Simulation, Savings Estimation Method 2, **as directed**, in the EVO's "International Performance Measurement and Verification Protocol (IPMVP), Volume III: Concepts and Options for Determining Energy Savings in New Construction," and **as directed**.

C. FOR CORE AND SHELL DEVELOPMENT



1. Credit EA 5.1 and 5.2: Implement measurement and verification plan consistent with Option B: Energy Conservation Measure Isolation **OR** Option D: Calibrated Simulation, Savings Estimation Method 2, **as directed**, in the EVO's "International Performance Measurement and Verification Protocol (IPMVP), Volume III: Concepts and Options for Determining Energy Savings in New Construction," and **as directed**.
 - D. If not already in place, install metering equipment to measure energy usage. Monitor, record, and trend log measurements.
 - E. Evaluate energy performance and efficiency by comparing actual to predicted performance.
 - F. Measurement and verification period shall cover at least one year of postconstruction occupancy.
- 3.3 CONSTRUCTION WASTE MANAGEMENT
- A. Credit MR 2: Comply with Section 017419 "Construction Waste Management and Disposal."
- 3.4 CONSTRUCTION INDOOR-AIR-QUALITY MANAGEMENT
- A. Credit IEQ 3.1: Comply with SMACNA's "SMACNA IAQ Guideline for Occupied Buildings under Construction."
 1. If Owner authorizes use of permanent heating, cooling, and ventilating systems during construction period as specified in Section 015000 "Temporary Facilities and Controls," install filter media having a MERV 8 according to ASHRAE 52.2 at each return-air inlet for the air-handling system used during construction.
 2. Replace all air filters immediately prior to occupancy.
 - B. Credit IEQ 3.2: Comply with one of the following requirements, **as directed**:
 1. After construction ends, prior to occupancy and with all interior finishes installed, perform a building flush-out by supplying a total volume of 14000 cu. ft. (4 300 000 L) of outdoor air per sq. ft. (sq. m) of floor area while maintaining an internal temperature of at least 60 deg F (16 deg C) and a relative humidity no higher than 60 percent.
 2. If occupancy is desired prior to flush-out completion, the space may be occupied following delivery of a minimum of 3500 cu. ft. (1 070 000 L) of outdoor air per sq. ft. (sq. m) of floor area to the space. Once a space is occupied, it shall be ventilated at a minimum rate of 0.30 cfm per sq. ft. (1.52 L/s per sq. m) of outside air or the design minimum outside air rate determined in Prerequisite IEQ 1, whichever is greater. During each day of the flush-out period, ventilation shall begin a minimum of three hours prior to occupancy and continue during occupancy. These conditions shall be maintained until a total of 14000 cu. ft./sq. ft. (4 300 000 L/sq. m) of outside air has been delivered to the space.
 3. Air-Quality Testing:
 - a. Conduct baseline indoor-air-quality testing, after construction ends and prior to occupancy, using testing protocols consistent with the EPA's "Compendium of Methods for the Determination of Air Pollutants in Indoor Air," and as additionally detailed in the USGBC's "Green Building Design and Construction Reference Guide."
 - b. Demonstrate that the contaminant maximum concentrations listed below are not exceeded:
 - 1) Formaldehyde: 27 ppb.
 - 2) Particulates (PM10): 50 micrograms/cu. m.



- 3) Total Volatile Organic Compounds (TVOC): 500 micrograms/cu. m.
 - 4) 4-Phenylcyclohexene (4-PH): 6.5 micrograms/cu. m.
 - 5) Carbon Monoxide: 9 ppm and no greater than 2 ppm above outdoor levels.
- c. For each sampling point where the maximum concentration limits are exceeded, conduct additional flush-out with outside air and retest the specific parameter(s) exceeded to indicate the requirements are achieved. Repeat procedure until all requirements have been met. When retesting noncomplying building areas, take samples from same locations as in the first test.
- d. Air-sample testing shall be conducted as follows:
- 1) All measurements shall be conducted prior to occupancy but during normal occupied hours, and with building ventilation system starting at the normal daily start time and operated at the minimum outside air flow rate for the occupied mode throughout the duration of the air testing.
 - 2) Building shall have all interior finishes installed including, but not limited to, millwork, doors, paint, carpet, and acoustic tiles. Nonfixed furnishings such as workstations and partitions are encouraged, but not required, to be in place for the testing.
 - 3) Number of sampling locations varies depending on the size of building and number of ventilation systems. For each portion of building served by a separate ventilation system, the number of sampling points shall not be less than one per 25,000 sq. ft. (2300 sq. m) or for each contiguous floor area, whichever is larger, and shall include areas with the least ventilation and greatest presumed source strength.
 - 4) Air samples shall be collected between 3 and 6 feet (0.9 and 1.8 m) from the floor to represent the breathing zone of occupants, and over a minimum four-hour period.

END OF SECTION01 32 33 00b.13



SECTION 01 32 33 00c - REFERENCES

1.1 GENERAL

A. Definitions

1. General: Basic Contract definitions are included in the Conditions of the Contract.
2. "Approved": When used to convey Architect's action on Contractor's submittals, applications, and requests, "approved" is limited to Architect's duties and responsibilities as stated in the Conditions of the Contract.
3. "Directed": A command or instruction by Architect. Other terms including "requested," "authorized," "selected," "required," and "permitted" have the same meaning as "directed."
4. "Indicated": Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown," "noted," "scheduled," and "specified" have the same meaning as "indicated."
5. "Regulations": Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work.
6. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
7. "Install": Operations at Project site including unloading, temporarily storing, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.
8. "Provide": Furnish and install, complete and ready for the intended use.
9. "Project Site": Space available for performing construction activities. The extent of Project site is shown on Drawings and may or may not be identical with the description of the land on which Project is to be built.

B. Industry Standards

1. Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.
2. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
3. Copies of Standards: Each entity engaged in construction on Project should be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents.
 - a. Where copies of standards are needed to perform a required construction activity, obtain copies directly from publication source.

C. Abbreviations And Acronyms

1. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.

AA	Aluminum Association, Inc. (The) www.aluminum.org	(703) 358-2960
AAADM	American Association of Automatic Door Manufacturers www.aaadm.com	(216) 241-7333
AABC	Associated Air Balance Council www.aabchq.com	(202) 737-0202



AAMA	American Architectural Manufacturers Association www.aamanet.org	(847) 303-5664
AASHTO	American Association of State Highway and Transportation Officials www.transportation.org	(202) 624-5800
AATCC	American Association of Textile Chemists and Colorists (The) www.aatcc.org	(919) 549-8141
ABAA	Air Barrier Association of America www.airbarrier.org	(866) 956-5888
ABMA	American Bearing Manufacturers Association www.abma-dc.org	(202) 367-1155
ACI	ACI International (American Concrete Institute) www.aci-int.org	(248) 848-3700
ACPA	American Concrete Pipe Association www.concrete-pipe.org	(972) 506-7216
AEIC	Association of Edison Illuminating Companies, Inc. (The) www.aeic.org	(205) 257-2530
AF&PA	American Forest & Paper Association www.afandpa.org	(800) 878-8878 (202) 463-2700
AGA	American Gas Association www.aga.org	(202) 824-7000
AGC	Associated General Contractors of America (The) www.agc.org	(703) 548-3118
AHA	American Hardboard Association (Now part of CPA)	
AHAM	Association of Home Appliance Manufacturers www.aham.org	(202) 872-5955
AI	Asphalt Institute www.asphaltinstitute.org	(859) 288-4960
AIA	American Institute of Architects (The) www.aia.org	(800) 242-3837 (202) 626-7300
AISC	American Institute of Steel Construction www.aisc.org	(800) 644-2400 (312) 670-2400
AISI	American Iron and Steel Institute www.steel.org	(202) 452-7100
AITC	American Institute of Timber Construction	(303) 792-9559



	www.aitc-glulam.org	
ALCA	Associated Landscape Contractors of America (Now PLANET - Professional Landcare Network)	
ALSC	American Lumber Standard Committee, Incorporated www.alsc.org	(301) 972-1700
AMCA	Air Movement and Control Association International, Inc. www.amca.org	(847) 394-0150
ANSI	American National Standards Institute www.ansi.org	(202) 293-8020
AOSA	Association of Official Seed Analysts, Inc. www.aosaseed.com	(405) 780-7372
APA	Architectural Precast Association www.archprecast.org	(239) 454-6989
APA	APA - The Engineered Wood Association www.apawood.org	(253) 565-6600
APA EWS	APA - The Engineered Wood Association; Engineered Wood Systems (See APA - The Engineered Wood Association)	
API	American Petroleum Institute www.api.org	(202) 682-8000
ARI	Air-Conditioning & Refrigeration Institute www.ari.org	(703) 524-8800
ARMA	Asphalt Roofing Manufacturers Association www.asphaltroofing.org	(202) 207-0917
ASCE	American Society of Civil Engineers www.asce.org	(800) 548-2723 (703) 295-6300
ASCE/SEI	American Society of Civil Engineers/Structural Engineering Institute (See ASCE)	
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers www.ashrae.org	(800) 527-4723 (404) 636-8400
ASME	ASME International (The American Society of Mechanical Engineers International) www.asme.org	(800) 843-2763 (973) 882-1170
ASSE	American Society of Sanitary Engineering www.asse-plumbing.org	(440) 835-3040
ASTM	ASTM International (American Society for Testing and Materials International)	(610) 832-9585



	www.astm.org	
AWCI	AWCI International (Association of the Wall and Ceiling Industry International) www.awci.org	(703) 534-8300
AWCMA	American Window Covering Manufacturers Association (Now WCSC)	
AWI	Architectural Woodwork Institute www.awinet.org	(571) 323-3636
AWPA	American Wood-Preservers' Association www.awpa.com	(205) 733-4077
AWS	American Welding Society www.aws.org	(800) 443-9353 (305) 443-9353
AWWA	American Water Works Association www.awwa.org	(800) 926-7337 (303) 794-7711
BHMA	Builders Hardware Manufacturers Association www.buildershardware.com	(212) 297-2122
BIA	Brick Industry Association (The) www.bia.org	(703) 620-0010
BICSI	Building Industry Consulting Service International www.bicsi.org	(800) 242-7405 (813) 979-1991
BIFMA	BIFMA International (Business and Institutional Furniture Manufacturer's Association International) www.bifma.com	(616) 285-3963
BISSC	Baking Industry Sanitation Standards Committee www.bissc.org	(866) 342-4772
CCC	Carpet Cushion Council www.carpetcushion.org	(610) 527-3880
CDA	Copper Development Association www.copper.org	(800) 232-3282 (212) 251-7200
CEA	Canadian Electricity Association www.canelect.ca	(613) 230-9263
CFFA	Chemical Fabrics & Film Association, Inc. www.chemicalfabricsandfilm.com	(216) 241-7333
CGA	Compressed Gas Association www.cganet.com	(703) 788-2700
CIMA	Cellulose Insulation Manufacturers Association www.cellulose.org	(888) 881-2462 (937) 222-2462



CISCA	Ceilings & Interior Systems Construction Association www.cisca.org	(630) 584-1919
CISPI	Cast Iron Soil Pipe Institute www.cispi.org	(423) 892-0137
CLFMI	Chain Link Fence Manufacturers Institute www.chainlinkinfo.org	(301) 596-2583
CRRC	Cool Roof Rating Council www.coolroofs.org	(866) 465-2523 (510) 485-7175
CPA	Composite Panel Association www.pbmdf.com	(301) 670-0604
CPPA	Corrugated Polyethylene Pipe Association www.cppa-info.org	(800) 510-2772 (202) 462-9607
CRI	Carpet & Rug Institute (The) www.carpet-rug.com	(800) 882-8846 (706) 278-3176
CRSI	Concrete Reinforcing Steel Institute www.crsi.org	(847) 517-1200
CSA	Canadian Standards Association	(800) 463-6727 (416) 747-4000
CSA	CSA International (Formerly: IAS - International Approval Services) www.csa-international.org	(866) 797-4272 (416) 747-4000
CSI	Cast Stone Institute www.caststone.org	(717) 272-3744
CSI	Construction Specifications Institute (The) www.csinet.org	(800) 689-2900 (703) 684-0300
CSSB	Cedar Shake & Shingle Bureau www.cedarbureau.org	(604) 820-7700
CTI	Cooling Technology Institute (Formerly: Cooling Tower Institute) www.cti.org	(281) 583-4087
DHI	Door and Hardware Institute www.dhi.org	(703) 222-2010
EIA	Electronic Industries Alliance www.eia.org	(703) 907-7500
EIMA	EIFS Industry Members Association www.eima.com	(800) 294-3462 (770) 968-7945
EJCDC	Engineers Joint Contract Documents Committee www.ejdc.org	(703) 295-5000



EJMA	Expansion Joint Manufacturers Association, Inc. www.ejma.org	(914) 332-0040
ESD	ESD Association www.esda.org	(315) 339-6937
FIBA	Federation Internationale de Basketball (The International Basketball Federation) www.fiba.com	41 22 545 00 00
FIVB	Federation Internationale de Volleyball (The International Volleyball Federation) www.fivb.ch	41 21 345 35 35
FM Approvals	FM Approvals www.fmglobal.com	(781) 762-4300
FM Global	FM Global (Formerly: FMG - FM Global) www.fmglobal.com	(401) 275-3000
FMRC	Factory Mutual Research (Now FM Global)	
FRSA	Florida Roofing, Sheet Metal & Air Conditioning Contractors Association, Inc. www.floridarroof.com	(407) 671-3772
FSA	Fluid Sealing Association www.fluidsealing.com	(610) 971-4850
FSC	Forest Stewardship Council www.fsc.org	49 228 367 66 0
GA	Gypsum Association www.gypsum.org	(202) 289-5440
GANA	Glass Association of North America www.glasswebsite.com	(785) 271-0208
GRI	(Now GSI)	
GS	Green Seal www.greenseal.org	(202) 872-6400
GSI	Geosynthetic Institute www.geosynthetic-institute.org	(610) 522-8440
HI	Hydraulic Institute www.pumps.org	(888) 786-7744 (973) 267-9700
HI	Hydronics Institute www.gamanet.org	(908) 464-8200



HMMA	Hollow Metal Manufacturers Association (Part of NAAMM)	
HPVA	Hardwood Plywood & Veneer Association www.hpva.org	(703) 435-2900
HPW	H. P. White Laboratory, Inc. www.hpwhite.com	(410) 838-6550
IAS	International Approval Services (Now CSA International)	
IBF	International Badminton Federation www.internationalbadminton.org	(6-03) 9283-7155
ICEA	Insulated Cable Engineers Association, Inc. www.icea.net	(770) 830-0369
ICRI	International Concrete Repair Institute, Inc. www.icri.org	(847) 827-0830
IEC	International Electrotechnical Commission www.iec.ch	41 22 919 02 11
IEEE	Institute of Electrical and Electronics Engineers, Inc. (The) www.ieee.org	(212) 419-7900
IESNA	Illuminating Engineering Society of North America www.iesna.org	(212) 248-5000
IEST	Institute of Environmental Sciences and Technology www.iest.org	(847) 255-1561
IGCC	Insulating Glass Certification Council www.igcc.org	(315) 646-2234
IGMA	Insulating Glass Manufacturers Alliance www.igmaonline.org	(613) 233-1510
ILI	Indiana Limestone Institute of America, Inc. www.iliai.com	(812) 275-4426
ISO	International Organization for Standardization www.iso.ch	41 22 749 01 11
	Available from ANSI www.ansi.org	(202) 293-8020
ISSFA	International Solid Surface Fabricators Association www.issfa.net	(877) 464-7732 (702) 567-8150
ITS	Intertek Testing Service NA www.intertek.com	(972) 238-5591
ITU	International Telecommunication Union www.itu.int/home	41 22 730 51 11



KCMA	Kitchen Cabinet Manufacturers Association www.kcma.org	(703) 264-1690
LMA	Laminating Materials Association (Now part of CPA)	
LPI	Lightning Protection Institute www.lightning.org	(800) 488-6864
MBMA	Metal Building Manufacturers Association www.mbma.com	(216) 241-7333
MFMA	Maple Flooring Manufacturers Association, Inc. www.maplefloor.org	(847) 480-9138
MFMA	Metal Framing Manufacturers Association, Inc. www.metalframingmfg.org	(312) 644-6610
MH	Material Handling (Now MHIA)	
MHIA	Material Handling Industry of America www.mhia.org	(800) 345-1815 (704) 676-1190
MIA	Marble Institute of America www.marble-institute.com	(440) 250-9222
MPI	Master Painters Institute www.paintinfo.com	(888) 674-8937
MSS	Manufacturers Standardization Society of The Valve and Fittings Industry Inc. www.mss-hq.com	(703) 281-6613
NAAMM	National Association of Architectural Metal Manufacturers www.naamm.org	(312) 332-0405
NACE	NACE International (National Association of Corrosion Engineers International) www.nace.org	(800) 797-6623 (281) 228-6200
NADCA	National Air Duct Cleaners Association www.nadca.com	(202) 737-2926
NAGWS	National Association for Girls and Women in Sport www.aahperd.org/nagws/	(800) 213-7193, ext. 453
NAIMA	North American Insulation Manufacturers Association www.naima.org	(703) 684-0084
NBGQA	National Building Granite Quarries Association, Inc. www.nbgqa.com	(800) 557-2848



NCAA	National Collegiate Athletic Association (The) www.ncaa.org	(317) 917-6222
NCMA	National Concrete Masonry Association www.ncma.org	(703) 713-1900
NCPI	National Clay Pipe Institute www.ncpi.org	(262) 248-9094
NCTA	National Cable & Telecommunications Association www.ncta.com	(202) 775-3550
NEBB	National Environmental Balancing Bureau www.nebb.org	(301) 977-3698
NECA	National Electrical Contractors Association www.necanet.org	(301) 657-3110
NeLMA	Northeastern Lumber Manufacturers' Association www.nelma.org	(207) 829-6901
NEMA	National Electrical Manufacturers Association www.nema.org	(703) 841-3200
NETA	InterNational Electrical Testing Association www.netaworld.org	(888) 300-6382 (303) 697-8441
NFHS	National Federation of State High School Associations www.nfhs.org	(317) 972-6900
NFPA	NFPA (National Fire Protection Association) www.nfpa.org	(800) 344-3555 (617) 770-3000
NFRC	National Fenestration Rating Council www.nfrc.org	(301) 589-1776
NGA	National Glass Association www.glass.org	(866) 342-5642 (703) 442-4890
NHLA	National Hardwood Lumber Association www.natlhardwood.org	(800) 933-0318 (901) 377-1818
NLGA	National Lumber Grades Authority www.nlga.org	(604) 524-2393
NOFMA	NOFMA: The Wood Flooring Manufacturers Association (Formerly: National Oak Flooring Manufacturers Association) www.nofma.com	(901) 526-5016
NRCA	National Roofing Contractors Association www.nrca.net	(800) 323-9545 (847) 299-9070
NRMCA	National Ready Mixed Concrete Association www.nrmca.org	(888) 846-7622 (301) 587-1400



NSF	NSF International (National Sanitation Foundation International) www.nsf.org	(800) 673-6275 (734) 769-8010
NSSGA	National Stone, Sand & Gravel Association www.nssga.org	(800) 342-1415 (703) 525-8788
NTMA	National Terrazzo & Mosaic Association, Inc. (The) www.ntma.com	(800) 323-9736 (540) 751-0930
NTRMA	National Tile Roofing Manufacturers Association (Now TRI)	
NWWDA	National Wood Window and Door Association (Now WDMA)	
OPL	Omega Point Laboratories, Inc. (Now ITS)	
PCI	Precast/Prestressed Concrete Institute www.pci.org	(312) 786-0300
PDCA	Painting & Decorating Contractors of America www.pdca.com	(800) 332-7322 (314) 514-7322
PDI	Plumbing & Drainage Institute www.pdionline.org	(800) 589-8956 (978) 557-0720
PGI	PVC Geomembrane Institute http://pgi-tp.ce.uiuc.edu	(217) 333-3929
PLANET	Professional Landcare Network (Formerly: ACLA - Associated Landscape Contractors of America) www.landcarenetwork.org	(800) 395-2522 (703) 736-9666
PTI	Post-Tensioning Institute www.post-tensioning.org	(602) 870-7540
RCSC	Research Council on Structural Connections www.boltcouncil.org	
RFCI	Resilient Floor Covering Institute www.rfci.com	(301) 340-8580
RIS	Redwood Inspection Service www.calredwood.org	(888) 225-7339 (415) 382-0662
SAE	SAE International www.sae.org	(877) 606-7323 (724) 776-4841
SDI	Steel Deck Institute www.sdi.org	(847) 458-4647
SDI	Steel Door Institute	(440) 899-0010



	www.steeldoor.org	
SEFA	Scientific Equipment and Furniture Association www.sefalabs.com	(516) 294-5424
SEI/ASCE	Structural Engineering Institute/American Society of Civil Engineers (See ASCE)	
SGCC	Safety Glazing Certification Council www.sgcc.org	(315) 646-2234
SIA	Security Industry Association www.siaonline.org	(703) 683-2075
SIGMA	Sealed Insulating Glass Manufacturers Association (Now IGMA)	
SJI	Steel Joist Institute www.steeljoist.org	(843) 626-1995
SMA	Screen Manufacturers Association www.smacentral.org	(561) 533-0991
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association www.smacna.org	(703) 803-2980
SMPTE	Society of Motion Picture and Television Engineers www.smpte.org	(914) 761-1100
SPFA	Spray Polyurethane Foam Alliance (Formerly: SPI/SPFD - The Society of the Plastics Industry, Inc.; Spray Polyurethane Foam Division) www.sprayfoam.org	(800) 523-6154
SPIB	Southern Pine Inspection Bureau (The) www.spib.org	(850) 434-2611
SPRI	Single Ply Roofing Industry www.spri.org	(781) 647-7026
SSINA	Specialty Steel Industry of North America www.ssina.com	(800) 982-0355 (202) 342-8630
SSPC	SSPC: The Society for Protective Coatings www.sspc.org	(877) 281-7772 (412) 281-2331
STI	Steel Tank Institute www.steeltank.com	(847) 438-8265
SWI	Steel Window Institute www.steelwindows.com	(216) 241-7333
SWRI	Sealant, Waterproofing, & Restoration Institute www.swrionline.org	(816) 472-7974



TCA	Tile Council of America, Inc. www.tileusa.com	(864) 646-8453
TIA/EIA	Telecommunications Industry Association/Electronic Industries Alliance www.tiaonline.org	(703) 907-7700
TMS	The Masonry Society www.masonrysociety.org	(303) 939-9700
TPI	Truss Plate Institute, Inc. www.tpinst.org	(703) 683-1010
TPI	Turfgrass Producers International www.turfgrassod.org	(800) 405-8873 (847) 649-5555
TRI	Tile Roofing Institute www.tilerroofing.org	(312) 670-4177
UL	Underwriters Laboratories Inc. www.ul.com	(877) 854-3577 (847) 272-8800
UNI	Uni-Bell PVC Pipe Association www.uni-bell.org	(972) 243-3902
USAV	USA Volleyball www.usavolleyball.org	(888) 786-5539 (719) 228-6800
USGBC	U.S. Green Building Council www.usgbc.org	(202) 828-7422
USITT	United States Institute for Theatre Technology, Inc. www.usitt.org	(800) 938-7488 (315) 463-6463
WASTEC	Waste Equipment Technology Association www.wastec.org	(800) 424-2869 (202) 244-4700
WCLIB	West Coast Lumber Inspection Bureau www.wclib.org	(800) 283-1486 (503) 639-0651
WCMA	Window Covering Manufacturers Association (Now WCSC)	
WCSC	Window Covering Safety Council (Formerly: WCMA - Window Covering Manufacturers Association) www.windowcoverings.org	(800) 506-4636 (212) 297-2109
WDMA	Window & Door Manufacturers Association (Formerly: NWWDA - National Wood Window and Door Association) www.wdma.com	(800) 223-2301 (847) 299-5200
WI	Woodwork Institute (Formerly: WIC - Woodwork Institute of	(916) 372-9943



	California) www.wicnet.org	
WIC	Woodwork Institute of California (Now WI)	
WMMPA	Wood Moulding & Millwork Producers Association www.wmmpa.com	(800) 550-7889 (530) 661-9591
WSRCA	Western States Roofing Contractors Association www.wsrca.com	(800) 725-0333 (650) 570-5441
WWPA	Western Wood Products Association www.wwpa.org	(503) 224-3930
2.	Code Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.	
IAPMO	International Association of Plumbing and Mechanical Officials www.iapmo.org	(909) 472-4100
IBC	International Building Code (See ICC)	
ICBO	International Conference of Building Officials (See ICC)	
ICBO ES	ICBO Evaluation Service, Inc. (See ICC-ES)	
ICC	International Code Council www.iccsafe.org	(888) 422-7233 (703) 931-4533
ICC-ES	ICC Evaluation Service, Inc. www.icc-es.org	(800) 423-6587 (562) 699-0543
SBCCI	Southern Building Code Congress International, Inc. (See ICC)	
3.	Federal Government Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.	
CE	Army Corps of Engineers www.usace.army.mil	
CPSC	Consumer Product Safety Commission www.cpsc.gov	(800) 638-2772 (301) 504-7923
DOC	Department of Commerce www.commerce.gov	(202) 482-2000



DOD	Department of Defense http://.dodssp.daps.dla.mil	(215) 697-6257
DOE	Department of Energy www.energy.gov	(202) 586-9220
EPA	Environmental Protection Agency www.epa.gov	(202) 272-0167
FAA	Federal Aviation Administration www.faa.gov	(866) 835-5322
FCC	Federal Communications Commission www.fcc.gov	(888) 225-5322
FDA	Food and Drug Administration www.fda.gov	(888) 463-6332
GSA	General Services Administration www.gsa.gov	(800) 488-3111
HUD	Department of Housing and Urban Development www.hud.gov	(202) 708-1112
LBL	Lawrence Berkeley National Laboratory www.lbl.gov	(510) 486-4000
NCHRP	National Cooperative Highway Research Program (See TRB)	
NIST	National Institute of Standards and Technology www.nist.gov	(301) 975-6478
OSHA	Occupational Safety & Health Administration www.osha.gov	(800) 321-6742 (202) 693-1999
PBS	Public Building Service (See GSA)	
PHS	Office of Public Health and Science www.osophs.dhhs.gov/ophs	(202) 690-7694
RUS	Rural Utilities Service (See USDA)	(202) 720-9540
SD	State Department www.state.gov	(202) 647-4000
TRB	Transportation Research Board http://gulliver.trb.org	(202) 334-2934
USDA	Department of Agriculture www.usda.gov	(202) 720-2791



USPS	Postal Service www.usps.com	(202) 268-2000
4.	Standards and Regulations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the standards and regulations in the following list. Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.	
ADAAG	Americans with Disabilities Act (ADA) Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities Available from Access Board www.access-board.gov	(800) 872-2253 (202) 272-0080
CFR	Code of Federal Regulations Available from Government Printing Office www.gpoaccess.gov/cfr/index.html	(866) 512-1800 (202) 512-1800
DOD	Department of Defense Military Specifications and Standards Available from Department of Defense Single Stock Point http://dodssp.daps.dla.mil	(215) 697-2664
DSCC	Defense Supply Center Columbus (See FS)	
FED-STD	Federal Standard (See FS)	
FS	Federal Specification Available from Department of Defense Single Stock Point http://dodssp.daps.dla.mil Available from Defense Standardization Program www.dps.dla.mil Available from General Services Administration www.gsa.gov Available from National Institute of Building Sciences www.wbdg.org/ccb	(215) 697-2664 (202) 619-8925 (202) 289-7800
FTMS	Federal Test Method Standard (See FS)	
MIL	(See MILSPEC)	
MIL-STD	(See MILSPEC)	
MILSPEC	Military Specification and Standards Available from Department of Defense Single Stock Point http://dodssp.daps.dla.mil	(215) 697-2664
UFAS	Uniform Federal Accessibility Standards Available from Access Board www.access-board.gov	(800) 872-2253 (202) 272-0080
5.	State Government Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following	



list. Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.

CBHF	State of California, Department of Consumer Affairs Bureau of Home Furnishings and Thermal Insulation www.dca.ca.gov/bhfti	(800) 952-5210 (916) 574-2041
CCR	California Code of Regulations www.calregs.com	(916) 323-6815
CPUC	California Public Utilities Commission www.cpuc.ca.gov	(415) 703-2782
TFS	Texas Forest Service Forest Resource Development http://txforestservation.tamu.edu	(979) 458-6650

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 32 33 00c

**SECTION 01 32 33 00d - ABBREVIATIONS, ACRONYMS, DEFINITIONS, AND SYMBOLS**

1.1 GENERAL

A. Description Of Work

1. This specification covers abbreviations, acronyms, definitions, and symbols used in the Contract Documents.

B. Unit of Measure Definitions

1. Following is a list of Industry Standard abbreviations.

A	Area Square Feet; Ampere	B&W	Black and White
AB	Anchor Bolt	BC	Between Centers
ABC	Aggregate Base Course	BCY	Bank Cubic Yard
ABS	Acrylonitrile Butadiene Styrene	BDL	Bundle
AC	Alternating Current; Air-Conditioning; Asphaltic Concrete; Plywood Grade A & C	BD FT	Board Feet
ACFM	Actual Cubic Feet Per Minute	BEV	Bevel/Beveled
ACM	Asbestos Containing Material	BF	Board Feet
ACP	Asphaltic Concrete Paving	BFP	Boiler Feed Pump
ACR	Acre	BHN	Brinell Hardness Number
ACZA	Ammoniacal Copper Zinc Arsenate	BHP	Boiler Horsepower; Brake Horsepower
AD	Plywood, Grade A & D	BI	Black Iron
ADDL	Additional	Bit.	Bituminous
ADJ	Adjustable	Bitum.	Bituminous
ADMIN	Administer; Administration	Bk.	Backed
AGG	Aggregate	Brkrs.	Breakers
AH	Ampere Hours	Bldg.	Building
AHM	Ampere-Hour Meter	BLK	Black; Block
AHU	Air Handling Unit	BM	Bank Measure; Beam
AIC	Amperes Interrupting Capacity	BOD	Biochemical Oxygen Demand
AL	Aluminum	BOX	Box (each)
ALT	Alternate	BR	Bedroom
AMP	Ampere	Brg.	Bearing
AMT	Amount	BRK	Brick
AOT	Adjusted Oxygen Transfer	BTFLY VLV	Butterfly Valve
APP	Attactic Polypropylene	BTR	Better (Lumber)
APPROX	Approximate	BTU	British Thermal Units
Apt.	Apartment	BTU/HR	British Thermal Units per Hour
ART	Articulated	BUR	Built Up Roof
ASB	Asbestos	BW	Butt Weld
ASJ	All Surface Jacketing	BWG	Birmingham Wire Gauge
Avg.	Average	BX	Interlocked Armored Cable
AWG	American Wire Gauge	C	Centigrade; Conductance; Conductivity, Hundred
BAG	Bag	CA	Corrosion Allowance
BBL	Barrel	Cab.	Cabinet
B&B	Grade B and Better; Balled & Burlapped	CAP	Capacity
B&S	Bell and Spigot	CB	Circuit Breaker
		CC	Center to Center
		CCA	Chromate Copper Arsenate
		CCF	Hundred Cubic Feet



CCY	Compacted Cubic Yard	Dis.	Discharge
cd	Candela	Disch.	Discharge
cd/sf	Candela per Square Foot	DB	Dry Bulb; Decibel
CF	Cubic Foot (Feet)	DBL	Double
CFM	Cubic Feet per Minute	DC	Direct Current
CHG	Charge	DCS	Distributed Control System
CHW	Chilled Water; Commercial Hot Water	DDC	Direct Digital Control
CI	Cast Iron	Demob	Demobilization
CIP	Cast in Place; Cast Iron Pipe	DF	Douglas Fir
CIRC	Circulating; Circuit	DFT	Dry Film Thickness
CLF	Hundred Linear Feet; Current Limiting Fuse	DH	Double Hung
CLP	Cross Linked Polyethylene	DHW	Domestic Hot Water
cm	Centimeter	DI	Ductile Iron
CMP	Corrugated Metal Pipe	D/P	Differential Pressure
CMPA	Corrugated Metal Pipe - Arched	DIA	Diameter
CMU	Concrete Masonry Unit	Diam	Diameter
CO	Carbon Monoxide	Diag.	Diagonal
CO2	Carbon Dioxide	Distrib.	Distribution
COL	Column	DL	Dead Load; Diesel
Comb	Combination	DLH	Deep Long Span Bar Joist
Compr	Compressor	DPST	Double Pole, Single Throw
CONC	Concrete	DS	Double Strength
CONSTR	Construction	DSA	Double Strength A Quality Glass
Cont	Continuous; Continued	DSB	Double Strength B Quality Glass
Corr	Corrugated	DWV	Drain, Waste, Vent Piping
CP	Chrome Plated	DX	Deluxe White, Direct Expansion
CPE	Chlorinated Polyethylene	dyn	Dyne
Cplg.	Coupling	e	Eccentricity
CPM	Cycles per Minute	E	Electrical Grade (Fiberglass Construction)
CPM	Critical Path Method	EA	Each
CPS	Centipoise	Econ.	Economy
CPRSR	Compressor	ECR	Electrical Grade, Corrosion Resistant (Fiberglass Construction)
CPVC	Chlorinated Polyvinyl Chloride	EDP	Electronic Data Processing
CS	Carbon Steel	EDR	Equiv. Direct Radiation
CSF	Hundred Square Feet	EG	Electro Galvanized
CSPE	ChloroSulphinated Polyethylene	EIFS	Exterior Insulation Finish System
CSS	Cast Semi Steel	ELEC	Electric; Electrical
CT	Current Transformer	Elev.	Elevator; Elevating
CTB	Cement Treated Base	EM	Electron Microscopy
CTR	Center	EMT	Electric Metallic Tubing; Thin Wall Conduit
CU FT	Cubic Foot	Eng.	Engine, Engineered
CU IN	Cubic Inch	EPDM	Ethylene Propylene Diene Monomer
CU YD	Cubic Yard	EPS	Expanded Polystyrene
CW	Chilled Water; Cold Water	EQL	Equally
CWR	Chilled Water Return	Equip.	Equipment
CWS	Chilled Water Supply	ERW	Electrical Resistance Welded
CWT	Hundred Weight	EROPS	Enclosed Roll Over Protection System
CY	Cubic Yard (27 cu. ft.); Cycle	ES	Energy Saver
CYH	Cubic Yards Per Hour	Est.	Estimated
Cyl	Cylinder	EW	Each Way
d	Penny (nail size)	EWT	Entering Water Temperature
D	Deep; Depth; Discharge		



Excav.	Excavation	Gen.	General
EXH	Exhaust	GFCI	Ground Fault Circuit Interrupter
Exp.	Expansion; Exposure	GFR	Ground Fault Relay
EXP JT	Expansion Joint	GPD	Gallons per Day
Ext.	Exterior	GPH	Gallon per Hour
		GPM	Gallon per Minute
F	Fahrenheit; Female; Fill	GR	Grade
f	Fiber stress	Grnd.	Ground
f _c	Compressive Stress in Concrete	GSF	Ground Square Foot
f _y	Minimum Yield Stress of Steel	GVW	Gross Vehicle Weight
f _m	Compressive Strength of Masonry		
F&D	Flanged-and-Dished	H	High, Height; High Strength Bar Joist
F&I	Furnished and Installed	HC	Handicapped; High Capacity
Fab.	Fabricated	HD	High Density; Heavy Duty
FAD	Free Air Delivery	HDO	High Density Overlay
FBGS	Fiberglass	HDPE	High Density Polyethylene
FC	Footcandles	Hdr.	Header
FCXP	Fan Cooled Explosion Proof	Hdw.	Hardware
FDA	Food and Drug Administration	HEPA	High Efficiency Particulate Air
FEP	Fluorinated Ethylene Propylene (Teflon)	Hg	Mercury
FF	Flat Face	HIC	High Interrupting Capacity
Fig.	Figure	HM	Hollow Metal
Fin.	Finished	HNDL	Handle
FL	Full Load	HO	High Output; Heel Outlet
FLDG	Folding	Horiz.	Horizontal
Fl. Oz.	Fluid Ounces	HP	High Pressure; Horse Power
Flr.	Floor	HPF	High Pressure Factor
FM	Frequency Modulation; Factory Mutual	HPL	High Pressure Laminate
Frmg.	Framing	HR	Hour
Fndtn.	Foundation	HRS	Hot-Rolled Steel
FT	Foot, Feet	HS	High Speed; High Strength
FTNG(S)	Fitting(s)	HSC	High Short Circuit
FLG	Flange	HSLA	High Strength Low Alloy
FOB	Freight on Board	HT	Hospital Tips; Height
Fount.	Fountain	Htg.	Heating
FPM	Feet Per Minute	Htrs.	Heaters
FPS	Feet Per Second	HVAC	Heating, Ventilating & Air Conditioning
FPT	Female Pipe Thread	Hvy.	Heavy
FRP	Fiberglass Reinforced Plastic	HW	Hot Water
FS	Forged Steel	HWR	Hot Water Return
FSC	Cast Body, Cast Switch Box	HWS	Hot Water Supply
Ftg.	Footing	HWT	Hundred Carton Weight
Ft. Lb.	Foot Pound	Hyd.	Hydraulic
Furn.	Furniture	Hydr.	Hydraulic
FVNR	Full Voltage Non-Reversing	HZ	Hertz (cycles)
FXM	Female by Male		
		I	Moment of Inertia
G	Gravity	IC	Interrupt Capacity
g	Gram	ICFM	Inlet Cubic Feet per Minute
GA	Gauge or Gage	ID	Inside Diameter
G & A	General and Administrative	I.D.	Identification; Inside Dimension
GAL	Gallon	IF	Inside Frosted
Gal./Min.	Gallon per Minute	IMC	Intermediate Metal Conduit
GALV	Galvanized	IN	Inch
GBSD	Gear Box Sheave Diameter	IN LB	Inch Pound
		IN WC	Inches Water Column



Incan.	Incandescent	LE	Leading Edge; Lead Equivalent
Incl.	Include, Including	LED	Light Emitting Diode
Inst.	Install, Installation	LEL	Lower Explosive Limit
Insul.	Insulation, Insulated	LF	Linear Foot
Int.	Interior	LFD	Linear Feet Per Day
INTSCT	Intersect	LFTL	Lineal Feet Tube Length
IP	Iron Pipe	Lge.	Large; Long
IPS	International Pipe Standard	LH	Labor Hours; Long Span Bar Joist
	Iron Pipe Size	LIN	Linear
	Inches per Second	LL	Live Load
IPT	Iron Pipe Threaded	LLD	Lamp Lumen Depreciation
ISP	Inlet Steam Pressure	LNG	Liquid Natural Gas
IW	Indirect Waste	LOA	Length Over All
		L-O-L	Lateraloleet
J	Joule	LP(G)	Liquid Propane (Gas)
JOB	Job	LS	Low Speed; Lump Sum
JOC	Job Order Contracting	Lt	Light
JT	Joint	Lt Ga	Light Gauge
		LTL	Less than Truck Load
K	Thousand; Thousand Pounds; Heavy Wall Copper Tubing; Kelvin	Lt Wt	Light Weight
KAH	Thousand Amp Hours	LV	Low Voltage
KD	Kiln Dried; Knocked Down	lm	Lumen
KDAT	Kiln Dried After Treatment	lm/sf	Lumen per square foot
Kip	1000 Pounds	lm/W	Lumen per Watt
KO	Knockout	m	Meter
Km	Kilometer	m ³ /H	Cubic Meters per Hour
KLF	Kips per Linear Foot	mA	Milliampere
KSF	Kips per Square Foot	m/S	Meters per Second
KSI	Kips per Square Inch	M	Thousand; Male; Light Wall Copper Tubing
kA	KiloAmp	MATL	Material
kg	Kilogram	MAX	Maximum
kHz	Kilohertz	Mach	Machine
kJ	Kilojoule	Mag. Str.	Magnetic Starter
kV	Kilovolt	Maint.	Maintenance
kVA	Kilovolt Ampere (1,000 volt amps)	Mat	Material
KVAR	Kilovar (Reactance)	Mat'l;	Material
kW	Kilowatt	Max.	Maximum
kWh	Kilowatt Hour	Mb	Million Bytes (characters)
		MBF	Thousand Board Feet
L	Length; Long; Medium Wall Copper Tubing	MBH	Thousand BTU per Hour
L&E	Labor and Equipment	MBtu	Thousand British Thermal Units
LAB	Labor	MC	Metal Clad Cable
LAN	Lane	MCF	Thousand Cubic Feet
LAT	Latitude	MCM	Thousand Circular Mills
LAV	Lavatory	MCP	Motor Circuit Protector
L.B.	Load Bearing; L Conduit Body	MD	Medium Duty
LB	Pound (Force or Mass)	MDO	Medium Density Overlaid
LB/HR	Pounds per Hour	Med.	Medium
LBS	Pounds	MF	Thousand Feet
LBSF	Pounds per Square Foot	MF3	Thousand Cubic Feet
LCD	Liquid Crystal Display	Mfg.	Manufacturing
LCL	Less Than Carload Lot	Mfrs.	Manufacturers
LCY	Loose Cubic Yard	Mg	Milligram



MG	Market Grade	nW	Nanowatt
MGD	Million Gallons per Day	OAL	Overall Length
MGPH	Thousand Gallons per Hour	OB	Opposing Blade
MH	Manhole; Manhour; Metal Halide	OC	On Center
MHz	MegaHertz	OD	Outside Diameter
Mi	Mile	O.D.	Outside Dimension
MI	Malleable Iron; Mineral Insulated	ODP	Open Drip Roof
MIN	Minimum; Minute	ODS	Overhead Distribution System
MISC	Miscellaneous	OEM	Original Equipment Manufacturer
ml	Milliliter; Mainline	OG	Ogee
MLF	Thousand Linear Feet	OH	Overhead
mm	Millimeter	OH&P	Overhead and Profit
MO	Month	OHL	Over Hung Load
Mobil.	Mobilization	Oper.	Operator
Mog.	Mogul Base	Opng.	Opening
MPH	Miles Per Hour	OPR	Operating
MPT	Male Pipe Thread	Orna.	Ornamental
MRT	Mile Round Trip	OSA	Outside Air
ms	Millisecond	OSB	Oriented Strand Board
MSD	Motor Sheave Diameter	OS & Y	Outside Screw and Yoke
MSF	Thousand Square Feet	OUT	Outlet or Output (each)
MSY	Thousand Square Yards	Ovhd.	Overhead
MT	Mount	OWG	Oil, Water or Gas
MTD	Mounted	OWSJ	Open Web Steel Joist
MTG	Mounting	OZ	Ounce
MTR	Mill Test Report	P	Pole; Applied Load; Projection
MVA	Million Volt Ampere	p	Page
MVAR	Million Volt Amperes Reactance	pp	Pages
MV	Megavolt	PAPR	Powered Air Purifying Respirator
MW	Megawatt	PAR	Weatherproof Reflector
MXM	Male by Male	PB	Push Button
MYD	Thousand Yards	PC	Personal Computer; Piece;
N	Natural; North	PCs	Pieces
nA	Nanoampere	P.C.	Portland Cement; Power Connector
NA	Not Applicable	PCF	Pounds per Cubic Foot
NC	Normally Closed	PCM	Phase Contrast Microscopy
NEHB	Bolted Circuit Breaker to 600V	PE	Professional Engineer; Plain End Porcelain Enamel; Polyethylene;
NDT	Non Destructive Testing	PERF	Perforated
NIOSH	National Alloy	PH	Phase
NLB	Non-Load Bearing	PI	Pressure Injected
NM	Non-Metallic Cable	PID	Programmable Integral Derivative Con- troller
nm	Nanometer	PKG	Package
NO	Normally Open	PL	Plate
No.	Number	PLC	Programmable Loop Controller
NOM	Nominal	PLM	Polarized Light Microscopy
NQOD	Combination Plug-on/Bolt-on Circuit Breaker to 240V	PLTC	Power Limited Tray Cable
NRC	Noise Reduction Coefficient	PLY	Plywood
NPT	National Pipe Thread	PNEU	Pneumatic
NPS	Nominal Pipe Size	PNTD	Painted
NRP	Non-Removable Pins	POA	Priced On Application/Priced On Approv- al
NRS	Non-Rising Stem	PESB	Pre-engineered Steel Building
ns	Nanosecond		
NTE	Note		
NTP	National Taper Pipe (Thread)		



PPD	Pounds Per Day	ROM	Room
PP; PPL	Polypropylene	ROPS	Roll Over Protection System
PPM	Parts Per Million	ROW	Row
PPS	Polyphenylene Sulfide	R.O.W.	Right of Way
PR	Pair	RPM	Revolutions Per Minute
Prefab.	Prefabricated	RR	Direct Burial Feeder Conduit
Prefin.	Prefinished	RS	Rapid Start
PROGEN®	Proposal Generator Software for Job Order Contracting	RSC	Rigid Steel Conduit
PROP	Propelled; Propeller	RSR	Riser (Per Rise)
PSF	Pounds Per Square Foot	RT	Round Trip
PSI	Pounds Per Square Inch	RTD	Resistance Temperature Detector
PSIA	Pounds Per Square Inch Atmosphere	RTJ	Ring Type Joint
PSIG	Pounds Per Square Inch Gauge	RTRP	Reinforced Thermoset Resin Piping
PSP	Plastic Sewer Pipe	RVT	Reinforced Vinyl Tile
PT	Power or Potential Transformer	S	Suction; Single Entrance; South
Pt.	Pint	S1S2E	Surfaced 1 side, 2 Edges
Ptns.	Partitions	S2S	Surfaced 2 Sides
P&T	Pressure & Temperature	S4S	Surfaced 4 Sides
PTFE	Polytetrafluoroethylene	Sa	Sack
Pu	Ultimate Load	SA	Supply Air
PV	Photovoltaic	SBS	Styrene Butyl Styrene
PVA	Polyvinyl Acrylate	Scaf.	Scaffolding
PVC	Polyvinyl Chloride	SCFH	Standard Cubic Foot Per Hour
PVDC	Polyvinylidene Chloride	SCFM	Standard Cubic Foot per Minute
PVDF	Polyvinylidene Fluoride	SCH	Schedule
PVF	Polyvinyl Fluoride	SCR	Modular Brick
Pvmt.	Pavement	SCRD	Screwed
PVQ	Pressure Vessel Quality	SD	Sound Deadening
Pwr.	Power	SDR	Standard Dimension Brick; Size To Diameter Ratio
Q	Quantity Heat Flow	SE	Surfaced Edge; Semi-Elliptical
QA	Quality Assurance	SEA	Seat
QC	Quality Control; Quick Coupling	SER	Service Entrance Cable
QT	Quart	SEU	Service Entrance Cable
Quan.	Quantity	SET	Set
Qty.	Quantity	SF	Square Foot/Feet
R	Thermal Resistance	SFCA	Square Feet of Form in Contact with Concrete
R/L	Random Lengths	SHTS	Sheets
R/W/L	Random Widths and Lengths	SI	Square Inch
RA	Return Air; Registered Architect	SIS	Synthetic Heat-Resistant
RCP	Reinforced Concrete Pipe	SLDR	Solder
Rect.	Rectangle	SLH	Super Long Span Bar Joist
REINF	Reinforced/Reinforcing	SN	Solid Neutral
Req'd	Required	S-O-L	Socketolet
RF	Raised Face	SP	Self-Propelled; Single Pole; Space; Standpipe Static Pressure (measured in inches of water);
RGH	Rough	SPDT	Single Pole, Double Throw
RGS	Rigid Galvanized Steel	SPGR	Specific Gravity
RH	Relative Humidity	SPWG	Static Pressure Water Gauge
RHW	Rubber, Heat & Water Resistant; Residential Hot Water	SQ	Square; Hundred Square Feet (10' x 10' area)
rms	Root Mean Square		
RND	Round		
ROL	Roll (each)		



SQ FT	Square Foot/Square Feet	UA	Unequal Angle
SQ IN	Square Inch	UCI	Uniform Construction Index
SQ YD	Square Yard	UF	Underground Feeder
SS	Stainless Steel; Single Strength	UHF	Ultra High Frequency
SSB	Single Strength B Quality Glass	UI	United Inch
SSL	Self Sealing Lap	UNC	Unified Coarse (Threads)
STC	Sound Transmission Class	USP	United States Primed
STD	Standard	UTP	Unshielded Twisted Pair
STK	Select Tight Knot	UV	Under Voltage
STP	Stop (each); Standard Temperature & Pressure	V	Volt
SURF	Surface	VA	Volt Amperes
STL	Steel	VAV	Variable Air Volume
SURF	Surface	VCT	Vinyl Composition Tile
SW	Seam Weld	Vert.	Vertical
SW	Switch	VF	Vinyl Faced
SWBD	Switchboard	VHF	Very High Frequency
SWS	Segmentally Welded Steel	VLF	Vertical Linear Foot
SWSI	Single Width, Single Inlet	VLV	Valve
SY	Square Yard	Vol.	Volume
SYN	Synthetic	VRP	Vinyl Reinforced Polyester
SYP	Southern Yellow Pine	w/	With
SYS	System	W	Watt; Width; Wire; West
T	Thick; Temperature; Ton	WB	Wet Bulb
T&C	Threaded and Coupled	WC	Water Column; Water Closet
T&G	Tongue and Groove	WF	Wide Flange
TBC	Tensile Bolt Cloth	WG	Water Gauge
TBE	Threaded Both Ends	WHM	Watthour Meter
TC	Terra Cotta	WK	Week
TCLP	Toxicity Characteristic Leaching Procedure	Wldg.	Welding
TDS	Total Dissolved Solids	WOG	Water, Oil, Gas
TEAO	Totally Enclosed Air Over	W-O-L	Weldolet
TEFC	Totally Enclosed Fan Cooled	WP	Weather Protected
TETC	Totally Enclosed Tube Cooled	WR	Water Resistant
TFE	Tetrafluoroethylene (Teflon)	WSP	Water, Steam, Petroleum
THHN	Nylon Jacketed Wire	WT	Weight
THK	Thick	WWF	Welded Wire Fabric
THKNS	Thickness	X or x	By or Times
THW	Insulated Strand Wire	XFER	Transfer
THWN	Nylon Jacketed Wire	XFMR	Transformer
TI	Titanium	XHD	Extra Heavy Duty
TL	Truckload	XHHW; XLPE	Cross-Linked Polyethylene Wire Insulation
TM	Track Mounted	XLP	Cross-Linked Polyethylene
T-O-L	Threadolet	XP	Explosion Proof
TON	Ton	XRF	X-Ray Fluorescence
Tot.	Total	Y	Wye
TPH	Tons Per Hour	YD	Yard
Transf.	Transformer	YR	Year
TSHP	Total Shaft Horse Power		
T'STAT	Thermostat		
TV	Television		
TW	Thermoplastic Water Resistant Wire		

2. Symbols



Δ	Delta	∅	Diameter or Phase
/	per	'	feet
-	through or to	"	inches
@	at	#	pound or number
%	per 100 or percent	°	degree
\$	U.S. dollars	<	Less Than
~	Approximate	>	Greater Than

3. Explanation Of Terms

BTU: Stands for British Thermal Unit. The BTU number indicates the amount of heat required to raise one pound of water by one degree Fahrenheit. What this means is the higher the BTU rating, the higher the heating capacity of a product.

MBH: Equal to 1000 BTUs.

Tons (In Reference To Cooling): Unit of measurement for determining cooling capacity. One ton equals 12,000 BTUH.

SEER: Stands for Seasonal Energy Efficiency Ratio. This measures the cooling efficiency in air conditioners or heat pumps. The higher the SEER rating, the more energy-efficient the unit. The government's minimum SEER rating is 10.

4. Calculation Of Board Feet

a. All Lumber Grades Are Presumed To Be 75 Percent Construction And 25 Percent Standard Or Equivalent Grade Unless Otherwise Listed. Dimensions Are Nominal. Board Foot Is Defined As 1" x 12" x 1' Long; To Calculate BF/LF, Multiply The Size Of The Board Height x Width/12.

- 1) 1"x2" = 0.167 BF/LF
- 2) 1"x3" = 0.25 BF/LF
- 3) 2"x3" = 0.5 BF/LF
- 4) 2"x4" = 0.667 BF/LF
- 5) 2"x6" = 1.0 BF/LF
- 6) 2"x8" = 1.333 BF/LF
- 7) 2"x10" = 1.667 BF/LF
- 8) 2"x12" = 2.0 BF/LF
- 9) 4"x4" = 1.333 BF/LF
- 10) 6"x4" = 2.0 BF/LF
- 11) 6"x6" = 3.0 BF/LF
- 12) 8"x8" = 5.333 BF/LF
- 13) etc.

b. To Calculate Board Feet;

- 1) For most lumber: Thickness (inches) x width (inches) x length (feet) divided by 12 = board feet.
- 2) For small pieces: Thickness (inches) x width (inches) x length (inches) divided by 144 = board feet.

5. Conversion Tables

ENGLISH TO METRIC CONVERSION TABLE					
MULTIPLY	BY	TO GET	MULTIPLY	BY	TO GET
acres	0.404 687 3	Hectares	ounce(force)	0.278 013 9	newtons=N
board foot	0.002 359 74	cubic meter	pint(liq.)	0.473 176	liters=l



ENGLISH TO METRIC CONVERSION TABLE					
cubic ft.	0.028 316 85	cubic meter	pint(dry)	0.550 61	liters=l
cubic yd.	0.764 554 9	cubic meter	pound(wt.)	0.453 592 37	kilogram
feet	0.304 8	Meters	pound(force)	4.448 222	newtons=N
footcandles	10.763 91	lux=lumens/m ²	pound/sq.ft	47.880 26	pascal=N/m ²
ft.-lb _f	1.355 818	N□m=joule	pound/sq.in	6.894 757	kilopascals
gallon (US)	3.785 412	Liters	quart(liq.)	0.946 352 9	liters
horsepower [*]	745.699 9	watt=J/sec	sq. feet	0.092 903 04	sq. meter
* horsepower=550 ft-lb _f /sec			sq. in.	645.16	sq. mm
inch	25.4	Millimeters	sq. mile	258.998 8	hectares
inch-pound _f	0.112 984 8	N□m=joule	sq. mile	2.589 988	sq. km
kips	4.448 222	Kilonewton	sq. yard	0.836 127 4	sq. meter
kips/in ²	6.894 757	megapascal	ton(short)	0.907 184 7	metric ton
miles (US)	1.609 347	Kilometer	ton(short)	907.184 7	kilogram=kg
ounce (wt.)	28.349 52	Grams	ton(short)	8896.444	newtons=N
ounce(liq.)	29.573 53	MI	yards	0.914 4	meters=m

FOR TEMPERATURE CONVERSION USE °C= 5/9(°F - 32)



METRIC TO ENGLISH CONVERSION TABLE					
MULTIPLY	BY	TO GET	MULTIPLY	BY	TO GET
cubic meter	1.308 0	cubic yard	liter	0.264 17	gallon
	35.314 7	cubic foot		1.056 7	quart
	61,024	cubic inch		2.113 4	pint
	264.172	Gallon		33.814	fl.ounce
gram	0.035 274	ounce(wt)	milliliter	0.033 814	fl.ounce
	0.002 204 6	pound(wt)	liter/m	0.080 52	gal/ft
kilogram	35.274	ounce(wt)	liter/m ²	0.220 88	gal/sq.yd
	2.204 623	pound(wt)	lux	0.092 902	ft-candle
	0.002 204 6	Kip	meter	1.093 6	yard
	0.001 102 3	Ton		3.280 84	foot
megagram (metric ton)	1.102 3	ton	millimeter	0.039 370	inch
			kilometer	0.621 37	mile
hectare	2.471 04	Acre	micrometer	0.039 370 1	mil
	107,639	square feet	Newton	0.224 81	pound(f)
	11,959.9	square yard	kilonewton	0.224 81	kip(f)
	0.003 861 02	square mile	Pascal	0.020 885	lb/sq. feet
microare	0.155 00	square inch	kilopascal	0.145 04	lb/sq. inch
joule	0.737 56	foot pound	megapascal	0.145 04	kips/sq. inch
	8.849 5	inch pound	square meter	1.195 99	square yard
kg/m³	1.685 55	lbs./cubic yards		10.763 9	square feet
	0.062 428	lbs./cubic feet	square millimeter	0.001 55	square inch
km/hr	0.621 37	miles per hour	square kilometer	0.386 102	square mile
			watt (J/second)	0.001 341	horsepower
				0.737 56	ft-lb/second

FOR TEMPERATURE CONVERSION USE °F = 9/5 °C + 32



C. Material Weights/Engineering Values

1. The following engineering values are guidelines for establishing shrink/swell factors and shall be used unless otherwise directed by the Owner. The Owner has final authority in establishing unit weights that are appropriate for all material and may change the stated values.

a. Material weights (Lbs Per CY) for In-place (Bank) [BCY], Loose (Excavated Materials) [LCY], and Compacted [CCY]

<u>MATERIALS</u>	<u>BCY</u>	<u>LCY</u>	<u>CCY</u>
Earth, Common (Average)	3170	2536	3520
Sand (Dry)	2880	2590	3240
Sand (Wet)	3090	2940	3460
Earth, Dry	3030	2070	3520
Earth, Damp	3370	2360	3520
Earth, Wet	2940	2940	3520
Earth, Rock Mixture (75% E/ 25% R)	3380	2370	3720
Earth, Rock Mixture (50% E/ 50% R)	3750	2710	4000
Earth, Rock Mixture (25% E/ 75% R)	4120	3140	3680
Gravel (Average)	3280	2730	3570
Limestone	4380	2690	3220
Riprap Rock (Average)	4500	2610	3150
Granite	4540	2640	3170
Basalt	4950	3020	3640
Clay	3220	2150	3570
Gneiss	4550	2720	3180

D. Reclaimed Asphalt Pavement (RAP)

1. Origin

a. Reclaimed asphalt pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high-quality, well-graded aggregates coated by asphalt cement.

b. Asphalt pavement is generally removed either by milling or full-depth removal. Milling entails removal of the pavement surface using a milling machine, which can remove up to 50 mm (2 in) thickness in a single pass. Full-depth removal involves ripping and breaking the pavement using a rhino horn on a bulldozer and/or pneumatic pavement breakers. In most instances, the broken material is picked up and loaded into haul trucks by a front-end loader and transported to a central facility for processing. At this facility, the RAP is processed using a series of operations, including crushing, screening, conveying, and stacking.

c. Although the majority of old asphalt pavements are recycled at central processing plants, asphalt pavements may be pulverized in place and incorporated into granular or stabilized base courses using a self-propelled pulverizing machine. Hot in-place and cold in-place recycling processes have evolved into continuous train operations that include partial depth removal of the pavement surface, mixing the reclaimed material with beneficiating additives (such as virgin aggregate, binder, and/or softening or rejuvenating agents to improve binder properties), and placing and compacting the resultant mix in a single pass.

2. Physical Properties

a. The properties of RAP are largely dependent on the properties of the constituent materials and the type of asphalt concrete mix (wearing surface, binder course, etc.). There can be substantial differences between asphalt concrete mixes in aggregate quality, size, and consistency. Since the aggregates in surface course (wearing course) asphalt concrete must have high resistance to wear/abrasion (polishing) to contribute to acceptable friction



- resistance properties, these aggregates may be of higher quality than the aggregates in binder course applications, where polishing resistance is not of concern.
- b. Both milling and crushing can cause some aggregate degradation. The gradation of milled RAP is generally finer and more dense than that of the virgin aggregates. Crushing does not cause as much degradation as milling; consequently, the gradation of crushed RAP is generally not as fine as milled RAP, but finer than virgin aggregates crushed with the same type of equipment.
 - c. The particle size distribution of milled or crushed RAP may vary to some extent, depending on the type of equipment used to produce the RAP, the type of aggregate in the pavement, and whether any underlying base or subbase aggregate has been mixed in with the reclaimed asphalt pavement material during the pavement removal.
 - d. During processing, virtually all RAP produced is milled or crushed down to 38 mm (1.5 in) or less, with a maximum allowable top size of either 51 mm (2 in) or 63 mm (2.5 in). Table 13-1 lists the typical range of particle size distribution that normally results from the milling or crushing of RAP. Milled RAP is generally finer than crushed RAP. The pavement fraction passing a 2.36 mm (No. 8) sieve can be expected to increase from a premilled range of 41 to 69 percent to a postmilled range of 52 to 72 percent. The fraction passing a 0.075 mm (No. 200) sieve can be expected to increase from approximately 6 to 10 percent to a range of 8 to 12 percent. Most sources of RAP will be a well-graded coarse aggregate, comparable to, or perhaps slightly finer and more variable than, crushed natural aggregates.
 - e. The unit weight of milled or processed RAP depends on the type of aggregate in the reclaimed pavement and the moisture content of the stockpiled material. The unit weight of milled or processed RAP has been found to range from 1940 to 2300 kg/m³ (120 to 140 lb/ft³), which is slightly lower than that of natural aggregates.
 - f. Moisture content of the RAP will increase while in storage. Crushed or milled RAP can pick up a considerable amount of water if exposed to rain. Moisture contents up to 5 percent or higher have been measured for stored crushed RAP. As noted earlier, during periods of extensive precipitation, the moisture content of some RAP stockpiles may be as high as 7 to 8 percent. Lengthy stockpiling of crushed or milled RAP should, therefore, be kept to a minimum.
 - g. The asphalt cement content of RAP typically ranges between 3 and 7 percent by weight. The asphalt cement adhering to the aggregate is somewhat harder than new asphalt cement. This is due primarily to exposure of the pavement to atmospheric oxygen (oxidation) during use and weathering. The degree of hardening depends on several factors, including the intrinsic properties of the asphalt cement, the mixing temperature/time (increases with increasing high temperature exposure), the degree of asphalt concrete compaction (increases if not well compacted), asphalt cement/air voids content (increases with lower asphalt/higher air voids content), and age in service (increases with age).



Table 1. Typical range of particle size distribution for reclaimed asphalt pavement (RAP) (percent by weight passing).

Screen Size (mesh)	Percent Finer After Processing or Milling
37.5 mm (1.5 in)	100
25 mm (1.0 in)	95 - 100
19 mm (3/4 in)	84 - 100
12.5 mm (1/2 in)	70 - 100
9.5 mm (3/8 in)	58 - 95
75 mm (No. 4)	38 - 75
2.36 mm (No. 8)	25 - 60
1.18 mm (No. 16)	17 - 40
0.60 mm (No. 30)	10 - 35 ^a
0.30 mm (No. 50)	5 - 25 ^b
0.15 mm (No. 100)	3 - 20 ^c
0.075 mm (No. 200)	2 - 15 ^d
a. Usually less than 30 percent b. Usually less than 20 percent c. Usually less than 15 percent d. Usually less than 10 percent	

- h. The RAP obtained from most wearing surface mixes will usually have an asphalt content in the 4.5 to 6 percent range. The recovered asphalt from RAP usually exhibits low penetration and relatively high viscosity values, depending on the amount of time the original pavement has been in service. Penetration values at 25°C (77°F) are likely to range from 10 to 80 while the absolute viscosity values at 60°C (140°F) may range from as low as 2,000 poises (equivalent to AC-20) up to as high as 50,000 poises or greater, depending on the extent of aging. Viscosity ranges from 4,000 to 25,000 poises can normally be expected from the asphalt cement that is recovered from RAP material. Table 2 provides a summary of the typical ranges of physical properties of RAP, other than gradation.

**Table 2. Physical and mechanical properties of reclaimed asphalt pavement (RAP).**

Type of Property	RAP Property	Typical Range of Values
Physical Properties	Unit Weight	1940 - 2300 kg/m ³ (120-140 lb/ft ³)
	Moisture Content	Normal: up to 5% Maximum: 7-8%
	Asphalt Content	Normal: 4.5-6% Maximum Range: 3-7%
	Asphalt Penetration	Normal: 10-80 at 25°C (77°F)
	Absolute Viscosity or Recovered Asphalt Cement	Normal: 4,000 - 25,000 poises at 60°C (140°F)
Mechanical Properties	Compacted Unit Weight	1600 - 2000 kg/m ³ (100-125 lb/ft ³)
	California Bearing Ratio (CBR)	100% RAP: 20-25% 40% RAP and 60% Natural Aggregate: 150% or higher

3. Chemical Properties

- a. Mineral aggregates constitute the overwhelming majority (93 to 97 percent by weight) of RAP. Only a minor percentage (3 to 7 percent) of RAP consists of hardened asphalt cement. Consequently, the overall chemical composition of RAP is essentially similar to that of the naturally occurring aggregate that is its principal constituent.
- b. Asphalt cement is made up of mainly high molecular weight aliphatic hydrocarbon compounds, but also small concentrations of other materials such as sulfur, nitrogen, and polycyclic hydrocarbons (aromatic and/or naphthenic) of very low chemical reactivity. Asphalt cement is a combination of asphaltenes and maltenes (resins and oils). Asphaltenes are more viscous than either resins or oils and play a major role in determining asphalt viscosity. Oxidation of aged asphalt causes the oils to convert to resins and the resins to convert to asphaltenes, resulting in age hardening and a higher viscosity binder.

4. Mechanical Properties

- a. The mechanical properties of RAP depend on the original asphalt pavement type, the method(s) utilized to recover the material, and the degree of processing necessary to prepare the RAP for a particular application. Since most RAP is recycled back into pavements, there is a general lack of data pertaining to the mechanical properties for RAP in other possible applications.
- b. The compacted unit weight of RAP will decrease with increasing unit weight, with maximum dry density values reported to range from 1600 kg/m³ (100 lb/ft³) to 2000 kg/m³ (125 lb/ft³). California Bearing Ratio (CBR) values for RAP material containing trap rock aggregate have been reported in the 20 to 25 percent range. However, when RAP is blended with natural aggregates for use in granular base, the asphalt cement in the RAP has a significant strengthening effect over time, such that specimens containing 40 percent RAP have produced CBR values exceeding 150 after 1 week.
- c. Table 2 provides a summary of the mechanical properties of RAP discussed in the preceding paragraphs.

1.2 PRODUCTS (Not Used)



1.3 EXECUTION (Not Used)

END OF SECTION 01 32 33 00d



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**SECTION 01 51 13 00 - PANELBOARDS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for panelboards. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Distribution panelboards.
 - b. Lighting and appliance branch-circuit panelboards.
 - c. Load centers.
 - d. Electronic-grade panelboards.

C. Definitions

1. SVR: Suppressed voltage rating.
2. TVSS: Transient voltage surge suppressor.

D. Performance Requirements

1. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For each panelboard and related equipment.
 - a. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - b. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - c. Detail bus configuration, current, and voltage ratings.
 - d. Short-circuit current rating of panelboards and overcurrent protective devices.
 - e. Include evidence of NRTL listing for series rating of installed devices.
 - f. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - g. Include wiring diagrams for power, signal, and control wiring.
 - h. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
3. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Panelboard Schedules: For installation in panelboards.
5. Operation and maintenance data

F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA PB 1.
3. Comply with NFPA 70.



- G. Delivery, Storage, And Handling
 - 1. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
 - 2. Handle and prepare panelboards for installation according to NECA 407 **OR** NEMA PB 1.
- H. Project Conditions
 - 1. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of electric service.
 - b. Do not proceed with interruption of electric service without the Owner's written permission.
 - c. Comply with NFPA 70E.
- I. Warranty
 - 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within five years from date of Final Completion.

1.2 PRODUCTS

- A. General Requirements For Panelboards
 - 1. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
 - 2. Enclosures: Flush **OR** Surface **OR** Flush- and surface, **as directed**, -mounted cabinets.
 - a. Rated for environmental conditions at installed location.
 - 1) Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - 2) Outdoor Locations: NEMA 250, Type 3R.
 - 3) Kitchen or Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
 - 4) Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 5) Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5 **OR** Type 12, **as directed**.
 - b. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - c. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - d. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 - e. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - f. Finishes:
 - 1) Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - 2) Back Boxes: Galvanized steel **OR** Same finish as panels and trim, **as directed**.
 - 3) Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
 - g. Directory Card: Inside panelboard door, mounted in transparent card holder **OR** metal frame with transparent protective cover, **as directed**.
 - 3. Incoming Mains Location: Top **OR** Bottom **OR** Top and bottom, **as directed**.
 - 4. Phase, Neutral, and Ground Buses:
 - a. Material: Tin-plated aluminum **OR** Hard-drawn copper, 98 percent conductivity, **as directed**.



- b. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - c. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 - d. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
 - e. Split Bus: Vertical buses divided into individual vertical sections.
 5. Conductor Connectors: Suitable for use with conductor material and sizes.
 - a. Material: Tin-plated aluminum **OR** Hard-drawn copper, 98 percent conductivity, **as directed**.
 - b. Main and Neutral Lugs: Compression **OR** Mechanical, **as directed**, type.
 - c. Ground Lugs and Bus-Configured Terminators: Compression **OR** Mechanical, **as directed**, type.
 - d. Feed-Through Lugs: Compression **OR** Mechanical, **as directed**, type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - e. Subfeed (Double) Lugs: Compression **OR** Mechanical, **as directed**, type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - f. Gutter-Tap Lugs: Compression **OR** Mechanical, **as directed**, type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - g. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
 6. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
 7. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
 8. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.
 9. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.
- B. Distribution Panelboards
1. Panelboards: NEMA PB 1, power and feeder distribution type.
 2. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - a. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
 3. Mains: Circuit breaker **OR** Fused switch **OR** Lugs only, **as directed**.
 4. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in **OR** Bolt-on, **as directed**, circuit breakers.
 5. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
 6. Branch Overcurrent Protective Devices: Fused switches.
 7. Contactors in Main Bus: NEMA ICS 2, Class A, electrically **OR** mechanically, **as directed**, held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 - a. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 - b. External Control-Power Source: 120-V branch circuit **OR** 24-V control circuit, **as directed**.
- C. Lighting And Appliance Branch-Circuit Panelboards
1. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
 2. Mains: Circuit breaker **OR** Lugs only, **as directed**.
 3. Branch Overcurrent Protective Devices: Plug-in **OR** Bolt-on, **as directed**, circuit breakers, replaceable without disturbing adjacent units.
 4. Contactors in Main Bus: NEMA ICS 2, Class A, electrically **OR** mechanically, **as directed**, held, general-purpose controller, with same short-circuit interrupting rating as panelboard.



- a. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
- b. External Control-Power Source: 120-V branch circuit **OR** 24-V control circuit, **as directed**.
5. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
6. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

D. Load Centers

1. Load Centers: Comply with UL 67.
2. Mains: Circuit breaker **OR** Lugs only, **as directed**.
3. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
4. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

E. Electronic-Grade Panelboards

1. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.
2. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
3. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
4. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
5. Buses:
 - a. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
 - b. Copper equipment and isolated ground buses.
6. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, plug-in **OR** wired-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, short-circuit current rating complying with UL 1449, second edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.
 - a. Accessories:
 - 1) Fuses rated at 200-kA interrupting capacity.
 - 2) Fabrication using bolted compression lugs for internal wiring.
 - 3) Integral disconnect switch.
 - 4) Redundant suppression circuits.
 - 5) Redundant replaceable modules.
 - 6) Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 7) LED indicator lights for power and protection status.
 - 8) Audible alarm, with silencing switch, to indicate when protection has failed.
 - 9) Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - 10) Four **OR** Six, **as directed**,-digit, transient-event counter set to totalize transient surges.
 - b. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
 - c. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
 - 1) Line to Neutral: 70,000 A.
 - 2) Line to Ground: 70,000 A.
 - 3) Neutral to Ground: 50,000 A.
 - d. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
 - e. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**,-V, three-phase, four-wire circuits shall be as follows:



- 1) Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - 2) Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - 3) Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
- f. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:
- 1) Line to Neutral: 400 V.
 - 2) Line to Ground: 400 V.
 - 3) Neutral to Ground: 400 V.
- g. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
- 1) Line to Neutral: 400 V, 800 V from high leg.
 - 2) Line to Ground: 400 V.
 - 3) Neutral to Ground: 400 V.
- h. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
- 1) Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
 - 2) Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- F. Disconnecting And Overcurrent Protective Devices
1. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
 - a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long- and short-time time adjustments.
 - 4) Ground-fault pickup level, time delay, and I^2t response.
 - d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - e. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - f. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - g. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 - h. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - 1) Standard frame sizes, trip ratings, and number of poles.
 - 2) Lugs: Compression **OR** Mechanical, **as directed**, style, suitable for number, size, trip ratings, and conductor materials.
 - 3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - 4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.



- 5) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring And Control".
 - 6) Shunt Trip: 120 **OR** 24, **as directed**, -V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
 - 7) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional **OR** with field-adjustable 0.1- to 0.6-second, **as directed**, time delay.
 - 8) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - 9) Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - 10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - 11) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
 - 12) Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
 - 13) Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on **OR** off, **as directed**, position.
 - 14) Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
2. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- a. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses".
 - b. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
 - c. Auxiliary Contacts: One **OR** Two, **as directed**, normally open and normally closed contact(s) that operate with switch handle operation.

G. Panelboard Suppressors

1. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
 - a. Accessories:
 - 1) LED indicator lights for power and protection status.
 - 2) Audible alarm, with silencing switch, to indicate when protection has failed.
 - 3) One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
2. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, plug-in **OR** wired-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
 - a. Accessories:
 - 1) Fuses rated at 200-kA interrupting capacity.
 - 2) Fabrication using bolted compression lugs for internal wiring.
 - 3) Integral disconnect switch.
 - 4) Redundant suppression circuits.
 - 5) Redundant replaceable modules.
 - 6) Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 7) LED indicator lights for power and protection status.
 - 8) Audible alarm, with silencing switch, to indicate when protection has failed.
 - 9) Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position



- on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
- 10) Four **OR** Six, **as directed**, -digit, transient-event counter set to totalize transient surges.
 - b. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
 - c. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
 - 1) Line to Neutral: 70,000 A.
 - 2) Line to Ground: 70,000 A.
 - 3) Neutral to Ground: 50,000 A.
 - d. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
 - e. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**, -V, three-phase, four-wire circuits shall be as follows:
 - 1) Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - 2) Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - 3) Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - f. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:
 - 1) Line to Neutral: 400 V.
 - 2) Line to Ground: 400 V.
 - 3) Neutral to Ground: 400 V.
 - g. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
 - 1) Line to Neutral: 400 V, 800 V from high leg.
 - 2) Line to Ground: 400 V.
 - 3) Neutral to Ground: 400 V.
 - h. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
 - 1) Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
 - 2) Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- H. Accessory Components And Features
1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
 2. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

1.3 EXECUTION

A. Installation

1. Install panelboards and accessories according to NECA 407 **OR** NEMA PB 1.1, **as directed**.
2. Equipment Mounting: Install panelboards on concrete bases, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.



- b. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
- c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- d. Install anchor bolts to elevations required for proper attachment to panelboards.
- e. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
4. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers And Supports For Electrical Systems".
5. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
6. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
7. Install overcurrent protective devices and controllers not already factory installed.
 - a. Set field-adjustable, circuit-breaker trip ranges.
8. Install filler plates in unused spaces.
9. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
10. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing, **as directed**.
11. Comply with NECA 1.

B. Identification

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification For Electrical Systems".
2. Create a directory to indicate installed circuit loads after balancing panelboard loads, **as directed**; incorporate the Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
3. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
4. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".

C. Field Quality Control

1. Perform tests and inspections.
2. Acceptance Testing Preparation:
 - a. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - b. Test continuity of each circuit.
3. Tests and Inspections:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - c. Perform the following infrared scan tests and inspections and prepare reports:
 - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Final Completion.
 - 3) Instruments and Equipment:



- a) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 4. Panelboards will be considered defective if they do not pass tests and inspections.
 5. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Adjusting
1. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
 2. Set field-adjustable circuit-breaker trip ranges as indicated **OR** as specified in Division 26 Section "Overcurrent Protective Device Coordination Study", **as directed**.
 3. Load Balancing: After Final Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - a. Measure as directed during period of normal system loading.
 - b. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - c. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - d. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
- E. Protection
1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 01 51 13 00



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SECTION 01 52 13 00 - TEMPORARY FACILITIES AND CONTROLS

1.1 GENERAL

A. Summary

1. This Section includes requirements for temporary utilities, support facilities, and security and protection facilities.

B. Definitions

1. Permanent Enclosure: As determined by the Owner, permanent or temporary roofing is complete, insulated, and weathertight; exterior walls are insulated and weathertight; and all openings are closed with permanent construction or substantial temporary closures.

C. Use Charges

1. General: Cost or use charges for temporary facilities shall be included in the Contract Sum. Allow other entities to use temporary services and facilities without cost, including, but not limited to, the Owner's construction forces, the Owner, occupants of Project, testing agencies, and authorities having jurisdiction.
2. Water Service: Water from the Owner's existing water system is available for use without metering and without payment of use charges. Provide connections and extensions of services as required for construction operations.
3. Electric Power Service: Electric power from the Owner's existing system is available for use without metering and without payment of use charges. Provide connections and extensions of services as required for construction operations.

D. Submittals

1. Site Plan: Show temporary facilities, utility hookups, staging areas, and parking areas for construction personnel.

E. Quality Assurance

1. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.
2. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.

F. Project Conditions

1. Temporary Use of Permanent Facilities: Installer of each permanent service shall assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before the Owner's acceptance, regardless of previously assigned responsibilities.

1.2 PRODUCTS

A. Materials

1. Pavement: Comply with Division 32 Section(s) "Asphalt Paving" OR "Concrete Paving", **as directed**.
2. Chain-Link Fencing: Minimum 2-inch (50-mm), 0.148-inch- (3.76-mm-) thick, galvanized steel, chain-link fabric fencing; minimum 6 feet (1.8 m) high with galvanized steel pipe posts; minimum 2-3/8-inch- (60-mm-) OD line posts and 2-7/8-inch- (73-mm-) OD corner and pull posts, with 1-5/8-inch- (42-mm-) OD top rails **OR** with galvanized barbed-wire top strand, **as directed**.
3. Portable Chain-Link Fencing: Minimum 2-inch (50-mm), 9-gage, galvanized steel, chain-link fabric fencing; minimum 6 feet (1.8 m) high with galvanized steel pipe posts; minimum 2-3/8-inch- (60-mm-) OD line posts and 2-7/8-inch- (73-mm-) OD corner and pull posts, with 1-5/8-inch- (42-



mm-) OD top and bottom rails. Provide concrete **OR** galvanized steel, **as directed**, bases for supporting posts.

4. Wood Enclosure Fence: Plywood, 6 feet (1.8 m) **OR** 8 feet (2.4 m), **as directed**, high, framed with four 2-by-4-inch (50-by-100-mm) rails, with preservative-treated wood posts spaced not more than 8 feet (2.4 m) apart.
5. Lumber and Plywood: Comply with requirements in Division 06 Section(s) "Rough Carpentry" **OR** "Miscellaneous Rough Carpentry", **as directed**.
6. Gypsum Board: Minimum 1/2 inch (12.7 mm) thick by 48 inches (1219 mm) wide by maximum available lengths; regular-type panels with tapered edges. Comply with ASTM C 36/C 36M.
7. Insulation: Unfaced mineral-fiber blanket, manufactured from glass, slag wool, or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.
8. Paint: Comply with requirements in Division 09.

B. Temporary Facilities

1. Field Offices, General: Prefabricated or mobile units with serviceable finishes, temperature controls, and foundations adequate for normal loading.
2. Common-Use Field Office: Of sufficient size to accommodate needs of construction personnel. Keep office clean and orderly. Furnish and equip offices as follows:
 - a. Furniture required for Project-site documents including file cabinets, plan tables, plan racks, and bookcases.
 - b. Conference room of sufficient size to accommodate meetings of 10 individuals. Provide electrical power service and 120-V ac duplex receptacles, with not less than 1 receptacle on each wall. Furnish room with conference table, chairs, and 4-foot- (1.2-m-) square tack board.
 - c. Drinking water and private toilet.
 - d. Coffee machine and supplies.
 - e. Heating and cooling equipment necessary to maintain a uniform indoor temperature of 68 to 72 deg F (20 to 22 deg C).
 - f. Lighting fixtures capable of maintaining average illumination of 20 fc (215 lx) at desk height.
3. Storage and Fabrication Sheds: Provide sheds sized, furnished, and equipped to accommodate materials and equipment for construction operations.
 - a. Store combustible materials apart from building.

C. Equipment

1. Fire Extinguishers: Portable, UL rated; with class and extinguishing agent as required by locations and classes of fire exposures.
2. HVAC Equipment: Unless the Owner authorizes use of permanent HVAC system, provide vented, self-contained, liquid-propane-gas or fuel-oil heaters with individual space thermostatic control.
 - a. Use of gasoline-burning space heaters, open-flame heaters, or salamander-type heating units is prohibited.
 - b. Heating Units: Listed and labeled for type of fuel being consumed, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 - c. Permanent HVAC System: If the Owner authorizes use of permanent HVAC system for temporary use during construction, provide filter with MERV of 8 at each return air grille in system and remove at end of construction.

1.3 EXECUTION

A. Installation, General

1. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required by progress of the Work.



- a. For greenfield sites if reduced site disturbance is required for LEED-NC Credit SS 5.1: Locate facilities to limit site disturbance as specified in General Requirements.
 2. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.
- B. Temporary Utility Installation
1. General: Install temporary service or connect to existing service.
 - a. Arrange with utility company, the Owner, and existing users for time when service can be interrupted, if necessary, to make connections for temporary services.
 2. Sewers and Drainage: Provide temporary utilities to remove effluent lawfully.
 - a. Connect temporary sewers to municipal system **OR** private system indicated, **as directed**, as directed by authorities having jurisdiction.
 3. Water Service: Install water service and distribution piping in sizes and pressures adequate for construction.
OR
Water Service: Use of the Owner's existing water service facilities will be permitted, as long as facilities are cleaned and maintained in a condition acceptable to the Owner. At Final Completion, restore these facilities to condition existing before initial use.
 - a. Where installations below an outlet might be damaged by spillage or leakage, provide a drip pan of suitable size to minimize water damage. Drain accumulated water promptly from pans.
 4. Sanitary Facilities: Provide temporary toilets, wash facilities, and drinking water for use of construction personnel. Comply with authorities having jurisdiction for type, number, location, operation, and maintenance of fixtures and facilities.
 - a. Toilets: Use of the Owner's existing toilet facilities will be permitted, as long as facilities are cleaned and maintained in a condition acceptable to the Owner. At Final Completion, restore these facilities to condition existing before initial use.
 5. Heating **OR** Heating and Cooling, **as directed**: Provide temporary heating **OR** heating and cooling, **as directed**, required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed.
 6. Ventilation and Humidity Control: Provide temporary ventilation required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed. Coordinate ventilation requirements to produce ambient condition required and minimize energy consumption.
 7. Electric Power Service: Use of the Owner's existing electric power service will be permitted, as long as equipment is maintained in a condition acceptable to the Owner.
OR
Electric Power Service: Provide electric power service and distribution system of sufficient size, capacity, and power characteristics required for construction operations.
 - a. Install electric power service overhead **OR** underground, **as directed**, unless otherwise indicated.
 - b. Connect temporary service to the Owner's existing power source, as directed by the Owner.
 8. Lighting: Provide temporary lighting with local switching that provides adequate illumination for construction operations, observations, inspections, and traffic conditions.
 - a. Install and operate temporary lighting that fulfills security and protection requirements without operating entire system.
 - b. Install lighting for Project identification sign.
 9. Telephone Service: Provide temporary telephone service in common-use facilities for use by all construction personnel. Install one telephone line for each field office.
 - a. Provide additional telephone lines for the following:
 - 1) Provide a dedicated telephone line for each facsimile machine and computer in each field office.



- b. At each telephone, post a list of important telephone numbers.
 - 1) Police and fire departments.
 - 2) Ambulance service.
 - 3) Contractor's home office.
 - 4) the Owner's office.
 - 5) the Owner's office.
 - 6) Principal subcontractors' field and home offices.
 - c. Provide superintendent with cellular telephone or portable two-way radio for use when away from field office.
 10. Electronic Communication Service: Provide temporary electronic communication service, including electronic mail, in common-use facilities.
 - a. Provide DSL **OR** T-1 line, **as directed**, in primary field office.
- C. Support Facilities Installation
 1. General: Comply with the following:
 - a. Provide incombustible construction for offices, shops, and sheds located within construction area or within 30 feet (9 m) of building lines. Comply with NFPA 241.
 - b. Maintain support facilities until near Final Completion. Remove before Final Completion. Personnel remaining after Final Completion will be permitted to use permanent facilities, under conditions acceptable to the Owner.
 2. Temporary Roads and Paved Areas: Construct and maintain temporary roads and paved areas adequate for construction operations. Locate temporary roads and paved areas as indicated **OR** within construction limits indicated, **as directed**, on Drawings.
 - a. Provide dust-control treatment that is nonpolluting and nontracking. Reapply treatment as required to minimize dust.

OR
 3. Temporary Roads and Paved Areas: Construct and maintain temporary roads and paved areas adequate for construction operations. Locate temporary roads and paved areas in same location as permanent roads and paved areas. Extend temporary roads and paved areas, within construction limits indicated, as necessary for construction operations.
 - a. Coordinate elevations of temporary roads and paved areas with permanent roads and paved areas.
 - b. Prepare subgrade and install subbase and base for temporary roads and paved areas according to Division 31 Section "Earth Moving".
 - c. Recondition base after temporary use, including removing contaminated material, regrading, proofrolling, compacting, and testing.
 - d. Delay installation of final course of permanent hot-mix asphalt pavement until immediately before Final Completion. Repair hot-mix asphalt base-course pavement before installation of final course according to Division 32 Section "Asphalt Paving".
 4. Traffic Controls: Comply with requirements of authorities having jurisdiction.
 - a. Protect existing site improvements to remain including curbs, pavement, and utilities.
 - b. Maintain access for fire-fighting equipment and access to fire hydrants.
 5. Parking: Provide temporary **OR** Use designated areas of the Owner's existing, **as directed**, parking areas for construction personnel.
 6. Dewatering Facilities and Drains: Comply with requirements of authorities having jurisdiction. Maintain Project site, excavations, and construction free of water.
 - a. Dispose of rainwater in a lawful manner that will not result in flooding Project or adjoining properties nor endanger permanent Work or temporary facilities.
 - b. Remove snow and ice as required to minimize accumulations.
 7. Project Identification and Temporary Signs: Provide Project identification and other signs as indicated on Drawings, **OR as directed**. Install signs where indicated to inform public and individuals seeking entrance to Project. Unauthorized signs are not permitted.
 - a. Provide temporary, directional signs for construction personnel and visitors.
 - b. Maintain and touchup signs so they are legible at all times.



8. Waste Disposal Facilities: Provide waste-collection containers in sizes adequate to handle waste from construction operations. Comply with requirements of authorities having jurisdiction. Comply with General Requirements for progress cleaning requirements.
9. Lifts and Hoists: Provide facilities necessary for hoisting materials and personnel.
 - a. Truck cranes and similar devices used for hoisting materials are considered "tools and equipment" and not temporary facilities.
10. Temporary Elevator Use: Refer to Division 14 for temporary use of new elevators.
11. Existing Elevator Use: Use of the Owner's existing elevators will be permitted, as long as elevators are cleaned and maintained in a condition acceptable to the Owner. At Final Completion, restore elevators to condition existing before initial use, including replacing worn cables, guide shoes, and similar items of limited life.
 - a. Do not load elevators beyond their rated weight capacity.
 - b. Provide protective coverings, barriers, devices, signs, or other procedures to protect elevator car and entrance doors and frame. If, despite such protection, elevators become damaged, engage elevator Installer to restore damaged work so no evidence remains of correction work. Return items that cannot be refinished in field to the shop, make required repairs and refinish entire unit, or provide new units as required.
12. Temporary Stairs: Until permanent stairs are available, provide temporary stairs where ladders are not adequate.
13. Existing Stair Usage: Use of the Owner's existing stairs will be permitted, as long as stairs are cleaned and maintained in a condition acceptable to the Owner. At Final Completion, restore stairs to condition existing before initial use.
 - a. Provide protective coverings, barriers, devices, signs, or other procedures to protect stairs and to maintain means of egress. If, despite such protection, stairs become damaged, restore damaged areas so no evidence remains of correction work.
14. Temporary Use of Permanent Stairs: Cover finished, permanent stairs with protective covering of plywood or similar material so finishes will be undamaged at time of acceptance.

D. Security And Protection Facilities Installation

1. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction in ways and by methods that comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.
2. Temporary Erosion and Sedimentation Control: Provide measures to prevent soil erosion and discharge of soil-bearing water runoff and airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction.
 - a. Inspect, repair, and maintain erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
3. Stormwater Control: Comply with authorities having jurisdiction. Provide barriers in and around excavations and subgrade construction to prevent flooding by runoff of stormwater from heavy rains.
4. Tree and Plant Protection: Install temporary fencing located as indicated or outside the drip line of trees to protect vegetation from damage from construction operations. Protect tree root systems from damage, flooding, and erosion.
5. Pest Control: Engage pest-control service to recommend practices to minimize attraction and harboring of rodents, roaches, and other pests and to perform extermination and control procedures at regular intervals so Project will be free of pests and their residues at Final Completion. Obtain extended warranty for the Owner. Perform control operations lawfully, using environmentally safe materials.
6. Site Enclosure Fence: Before construction operations begin **OR** When excavation begins, **as directed**, furnish and install site enclosure fence in a manner that will prevent people and animals from easily entering site except by entrance gates.
 - a. Extent of Fence: As required to enclose entire Project site or portion determined sufficient to accommodate construction operations **OR** As indicated on Drawings, **as directed**.
 - b. Maintain security by limiting number of keys and restricting distribution to authorized personnel. Provide the Owner with one set of keys, **as directed**.



7. Security Enclosure and Lockup: Install substantial temporary enclosure around partially completed areas of construction. Provide lockable entrances to prevent unauthorized entrance, vandalism, theft, and similar violations of security.
8. Barricades, Warning Signs, and Lights: Comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting.
9. Covered Walkway: Erect structurally adequate, protective, covered walkway for passage of individuals along adjacent public street(s). Coordinate with entrance gates, other facilities, and obstructions. Comply with regulations of authorities having jurisdiction and requirements indicated on Drawings, **OR as directed**.
 - a. Construct covered walkways using scaffold or shoring framing.
 - b. Provide wood-plank overhead decking, protective plywood enclosure walls, handrails, barricades, warning signs, lights, safe and well-drained walkways, and similar provisions for protection and safe passage.
 - c. Extend back wall beyond the structure to complete enclosure fence.
 - d. Paint and maintain in a manner approved by the Owner.
10. Temporary Enclosures: Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities. Provide temporary weathertight enclosure for building exterior.
 - a. Where heating or cooling is needed and permanent enclosure is not complete, insulate temporary enclosures.
11. Temporary Partitions: Provide floor-to-ceiling dustproof partitions to limit dust and dirt migration and to separate areas occupied by the Owner and tenants from fumes and noise.
 - a. Construct dustproof partitions with gypsum wallboard with joints taped on occupied side, and fire-retardant plywood on construction operations side.
 - b. If containment of airborne particles and dust generated by construction activities is critical to occupants of other spaces in building, e.g., occupied healthcare facilities: Construct dustproof partitions with 2 layers of 3-mil (0.07-mm) polyethylene sheet on each side. Cover floor with 2 layers of 3-mil (0.07-mm) polyethylene sheet, extending sheets 18 inches (460 mm) up the sidewalls. Overlap and tape full length of joints. Cover floor with fire-retardant plywood.
 - 1) Construct vestibule and airlock at each entrance through temporary partition with not less than 48 inches (1219 mm) between doors. Maintain water-dampened foot mats in vestibule.
 - c. Insulate partitions to provide noise protection to occupied areas.
 - d. Seal joints and perimeter. Equip partitions with dustproof doors and security locks.
 - e. Protect air-handling equipment.
 - f. Weather strip openings.
 - g. Provide walk-off mats at each entrance through temporary partition.
12. Temporary Fire Protection: Install and maintain temporary fire-protection facilities of types needed to protect against reasonably predictable and controllable fire losses. Comply with NFPA 241.
 - a. Prohibit smoking in hazardous fire-exposure **OR** construction, **as directed**, areas.
 - b. Supervise welding operations, combustion-type temporary heating units, and similar sources of fire ignition according to requirements of authorities having jurisdiction.
 - c. Develop and supervise an overall fire-prevention and -protection program for personnel at Project site. Review needs with local fire department and establish procedures to be followed. Instruct personnel in methods and procedures. Post warnings and information.
 - d. Provide temporary standpipes and hoses for fire protection. Hang hoses with a warning sign stating that hoses are for fire-protection purposes only and are not to be removed. Match hose size with outlet size and equip with suitable nozzles.

E. Operation, Termination, And Removal

1. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.
2. Maintenance: Maintain facilities in good operating condition until removal.



- a. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and similar facilities on a 24-hour basis where required to achieve indicated results and to avoid possibility of damage.
3. Operate Project-identification-sign lighting daily from dusk until 12:00 midnight.
4. Temporary Facility Changeover: Do not change over from using temporary security and protection facilities to permanent facilities until Final Completion.
5. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Final Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.
 - a. Materials and facilities that constitute temporary facilities are property of Contractor. the Owner reserves right to take possession of Project identification signs.
 - b. Remove temporary paving not intended for or acceptable for integration into permanent paving. Where area is intended for landscape development, remove soil and aggregate fill that do not comply with requirements for fill or subsoil. Remove materials contaminated with road oil, asphalt and other petrochemical compounds, and other substances that might impair growth of plant materials or lawns. Repair or replace street paving, curbs, and sidewalks at temporary entrances, as required by authorities having jurisdiction.
 - c. At Final Completion, clean and renovate permanent facilities used during construction period. Comply with final cleaning requirements specified in General Requirements

END OF SECTION 01 52 13 00



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Task	Specification	Specification Description
01 52 13 00	01 22 16 00	No Specification Required
01 52 19 00	01 22 16 00	No Specification Required
01 52 19 00	01 52 13 00	Temporary Facilities and Controls
01 54 23 00	01 22 16 00	No Specification Required
01 54 26 00	01 22 16 00	No Specification Required
01 54 29 00	01 22 16 00	No Specification Required
01 55 23 00	01 22 16 00	No Specification Required
01 55 26 00	01 22 16 00	No Specification Required
01 56 16 00	01 22 16 00	No Specification Required



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SECTION 01 56 26 00 - SEDIMENT REMOVAL

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing of labor and equipment for sediment removal.

1.2 PRODUCTS - (Not Used)

1.3 EXECUTION

- A. The Contractor shall remove all material from areas as required to meet project requirements. Water and sediment removed from these areas shall be discharged to a sedimentation basin constructed and maintained by the Contractor. All work shall be in strict compliance with Pollution Control requirements and Dewatering requirements. All material removed shall be disposed of in an approved landfill in accordance with all State and Federal Regulations.

END OF SECTION 01 56 26 00



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SECTION 01 56 26 00a - EROSION CONTROL

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of mesh or netting for erosion control. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 PRODUCTS

A. Materials

1. Jute Mesh: Fed. Spec. CCC-C-467.
2. Plastic Mesh: Manufacturer's recommendation.
3. Plastic Netting: Manufacturer's recommendation.
4. Polypropylene Mesh: Manufacturer's recommendation.
5. Woven Fabric Fence: EPA specifications.
6. Hay-Bales: EPA specifications.

1.3 EXECUTION:

- A. Preparation: Grade, compact, fertilize, and seed the area to be protected.
- B. Installation: Apply blankets either horizontally or vertically to the slope. In ditches, apply blanket in direction of water flow. Lap and anchor blankets according to the manufacturer's instructions. Install woven fabric fence and hay bales adjacent to all excavated areas.

END OF SECTION 01 56 26 00a



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Task	Specification	Specification Description
01 56 26 00	01 22 16 00	No Specification Required
01 56 29 00	01 22 16 00	No Specification Required
01 56 33 00	01 22 16 00	No Specification Required
01 56 39 00	01 22 16 00	No Specification Required
01 58 13 00	01 22 16 00	No Specification Required
01 66 19 00	01 22 16 00	No Specification Required
01 71 13 00	01 22 16 00	No Specification Required



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SECTION 01 71 23 16 - CUTTING AND PATCHING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for cutting and patching. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes procedural requirements for cutting and patching.

C. Definitions

1. Cutting: Removal of in-place construction necessary to permit installation or performance of other Work.
2. Patching: Fitting and repair work required to restore surfaces to original conditions after installation of other Work.

D. Submittals

1. Cutting and Patching Proposal: Submit a proposal describing procedures at least 10 days before the time cutting and patching will be performed, requesting approval to proceed. Include the following information:
 - a. Extent: Describe cutting and patching, show how they will be performed, and indicate why they cannot be avoided.
 - b. Changes to In-Place Construction: Describe anticipated results. Include changes to structural elements and operating components as well as changes in building's appearance and other significant visual elements.
 - c. Products: List products to be used and firms or entities that will perform the Work.
 - d. Dates: Indicate when cutting and patching will be performed.
 - e. Utility Services and Mechanical/Electrical Systems: List services/systems that cutting and patching procedures will disturb or affect. List services/systems that will be relocated and those that will be temporarily out of service. Indicate how long services/systems will be disrupted.
 - f. Structural Elements: Where cutting and patching involve adding reinforcement to structural elements, submit details and engineering calculations showing integration of reinforcement with original structure.
 - g. the Owner's Approval: Obtain approval of cutting and patching proposal before cutting and patching. Approval does not waive right to later require removal and replacement of unsatisfactory work.

E. Quality Assurance

1. LEED Requirements for Building Reuse:
 - a. Credit MR 1.1 and 1.2, **as directed**: Maintain existing building structure (including structural floor and roof decking) and envelope (exterior skin and framing, excluding window assemblies and nonstructural roofing material) not indicated to be removed; do not cut such existing construction beyond indicated limits.
 - b. Credit MR 1.3: Maintain existing interior nonstructural elements (interior walls, doors, floor coverings, and ceiling systems) not indicated to be removed; do not cut such existing construction beyond indicated limits.
 - c. Credit MR 1.2 and 1.3, **as directed**: Maintain existing nonshell, nonstructural components (walls, flooring, and ceilings) not indicated to be removed; do not cut such existing construction beyond indicated limits.



2. Structural Elements: Do not cut and patch structural elements in a manner that could change their load-carrying capacity or load-deflection ratio.
 - a. **Refer to the Owner for list of elements that might otherwise be overlooked as structural elements and that require Architect's or Construction Manager's approval of a cutting and patching proposal.**
3. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety. Operating elements include the following:
 - a. Primary operational systems and equipment.
 - b. Air or smoke barriers.
 - c. Fire-suppression systems.
 - d. Mechanical systems piping and ducts.
 - e. Control systems.
 - f. Communication systems.
 - g. Conveying systems.
 - h. Electrical wiring systems.
 - i. Operating systems of special construction in Division 13.
4. Miscellaneous Elements: Do not cut and patch miscellaneous elements or related components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety. Miscellaneous elements include the following:
 - a. Water, moisture, or vapor barriers.
 - b. Membranes and flashings.
 - c. Exterior curtain-wall construction.
 - d. Equipment supports.
 - e. Piping, ductwork, vessels, and equipment.
 - f. Noise- and vibration-control elements and systems.
5. Visual Requirements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch construction exposed on the exterior or in occupied spaces in a manner that would, in Architect's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.
6. Cutting and Patching Conference: Before proceeding, meet at Project site with parties involved in cutting and patching, including mechanical and electrical trades. Review areas of potential interference and conflict. Coordinate procedures and resolve potential conflicts before proceeding.

F. Warranty

1. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during cutting and patching operations, by methods and with materials so as not to void existing warranties.

1.2 PRODUCTS

A. Materials

1. General: Comply with requirements specified in other Sections.
2. In-Place Materials: Use materials identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.
 - a. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of in-place materials.



1.3 EXECUTION

A. Preparation

1. Temporary Support: Provide temporary support of Work to be cut.
2. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.
3. Adjoining Areas: Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.
4. Existing Utility Services and Mechanical/Electrical Systems: Where existing services/systems are required to be removed, relocated, or abandoned, bypass such services/systems before cutting to minimize **OR** prevent, **as directed**, interruption to occupied areas.

B. Performance

1. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
 - a. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.
2. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.
 - a. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
 - b. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
 - c. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
 - d. Excavating and Backfilling: Comply with requirements in applicable Division 31 where required by cutting and patching operations.
 - e. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
 - f. Proceed with patching after construction operations requiring cutting are complete.
3. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other Work. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified in other Sections.
 - a. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate integrity of installation.
 - b. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
 - 1) Clean piping, conduit, and similar features before applying paint or other finishing materials.
 - 2) Restore damaged pipe covering to its original condition.
 - c. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove in-place floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.
 - 1) Where patching occurs in a painted surface, apply primer and intermediate paint coats over the patch and apply final paint coat over entire unbroken surface containing the patch. Provide additional coats until patch blends with adjacent surfaces.



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- d. Ceilings: Patch, repair, or rehang in-place ceilings as necessary to provide an even-plane surface of uniform appearance.
 - e. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition.
4. Cleaning: Clean areas and spaces where cutting and patching are performed. Completely remove paint, mortar, oils, putty, and similar materials.

END OF SECTION 01 71 23 16



Task	Specification	Specification Description
01 74 16 00	01 22 16 00	No Specification Required



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**SECTION 01 74 19 00 - CONSTRUCTION WASTE MANAGEMENT**

1.1 GENERAL

A. Summary

1. This Section includes administrative and procedural requirements for the following:
 - a. Salvaging nonhazardous demolition and construction waste.
Note: All salvageable materials remain the property of the Owner and shall be turned over as directed when specified in the Job Order.
 - b. Recycling nonhazardous demolition and construction waste.
 - c. Disposing of nonhazardous demolition and construction waste.

B. Definitions

1. Construction Waste: Building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.
2. Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.
3. Disposal: Removal off-site of demolition and construction waste and subsequent sale, recycling, reuse, or deposit in landfill or incinerator acceptable to authorities having jurisdiction.
4. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.
5. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.
6. Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.

C. Performance Goals **OR** Requirements, **as directed**

1. General: Develop waste management plan that results in end-of-Project rates for salvage/recycling of 50 **OR** 75, **as directed**, percent by weight of total waste generated by the Work.
2. Salvage/Recycle Goals **OR** Requirements, **as directed**: Owner's goal is to salvage and recycle as much nonhazardous demolition and construction waste as possible including the following materials:
OR
Salvage/Recycle Goals **OR** Requirements, **as directed**: Owner's goal is to salvage and recycle as much nonhazardous demolition and construction waste as possible. Owner has established minimum goals for the following materials:
 - a. Demolition Waste:
 - 1) Asphaltic concrete paving.
 - 2) Concrete.
 - 3) Concrete reinforcing steel.
 - 4) Brick.
 - 5) Concrete masonry units.
 - 6) Wood studs.
 - 7) Wood joists.
 - 8) Plywood and oriented strand board.
 - 9) Wood paneling.
 - 10) Wood trim.
 - 11) Structural and miscellaneous steel.
 - 12) Rough hardware.
 - 13) Roofing.
 - 14) Insulation.
 - 15) Doors and frames.



- 16) Door hardware.
- 17) Windows.
- 18) Glazing.
- 19) Metal studs.
- 20) Gypsum board.
- 21) Acoustical tile and panels.
- 22) Carpet.
- 23) Carpet pad.
- 24) Demountable partitions.
- 25) Equipment.
- 26) Cabinets.
- 27) Plumbing fixtures.
- 28) Piping.
- 29) Supports and hangers.
- 30) Valves.
- 31) Sprinklers.
- 32) Mechanical equipment.
- 33) Refrigerants.
- 34) Electrical conduit.
- 35) Copper wiring.
- 36) Lighting fixtures.
- 37) Lamps.
- 38) Ballasts.
- 39) Electrical devices.
- 40) Switchgear and panelboards.
- 41) Transformers.
- b. Construction Waste:
 - 1) Site-clearing waste.
 - 2) Masonry and CMU.
 - 3) Lumber.
 - 4) Wood sheet materials.
 - 5) Wood trim.
 - 6) Metals.
 - 7) Roofing.
 - 8) Insulation.
 - 9) Carpet and pad.
 - 10) Gypsum board.
 - 11) Piping.
 - 12) Electrical conduit.
 - 13) Packaging: Regardless of salvage/recycle goal indicated above, salvage or recycle 100 percent of the following uncontaminated packaging materials:
 - a) Paper.
 - b) Cardboard.
 - c) Boxes.
 - d) Plastic sheet and film.
 - e) Polystyrene packaging.
 - f) Wood crates.
 - g) Plastic pails.

D. Submittals

1. Waste Management Plan: Submit 3 copies of plan within 7 **OR** 30, **as directed**, days of date established for commencement of the Work **OR** the Notice to Proceed **OR** the Notice of Award, **as directed**.



2. Waste Reduction Progress Reports: Concurrent with each Application for Payment, submit three copies of report. Include separate reports for demolition and construction waste, **as directed**. Include the following information:
 - a. Material category.
 - b. Generation point of waste.
 - c. Total quantity of waste in tons (tonnes).
 - d. Quantity of waste salvaged, both estimated and actual in tons (tonnes).
 - e. Quantity of waste recycled, both estimated and actual in tons (tonnes).
 - f. Total quantity of waste recovered (salvaged plus recycled) in tons (tonnes).
 - g. Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.
 3. Waste Reduction Calculations: Before request for Final Completion, submit three copies of calculated end-of-Project rates for salvage, recycling, and disposal as a percentage of total waste generated by the Work.
 4. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
 5. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
 6. LEED Submittal: LEED letter template for Credit MR 2.1 and 2.2, **as directed**, signed by Contractor, tabulating total waste material, quantities diverted and means by which it is diverted, and statement that requirements for the credit have been met.
 7. Qualification Data: For Waste Management Coordinator and refrigerant recovery technician.
 8. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.
- E. Quality Assurance
1. Waste Management Coordinator Qualifications: LEED Accredited Professional by U.S. Green Building Council. Waste management coordinator may also serve as LEED coordinator.
 2. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.
 3. Regulatory Requirements: Comply with hauling and disposal regulations of authorities having jurisdiction.
 4. Waste Management Conference: Conduct conference at Project site. Review methods and procedures related to waste management including, but not limited to, the following:
 - a. Review and discuss waste management plan including responsibilities of Waste Management Coordinator.
 - b. Review requirements for documenting quantities of each type of waste and its disposition.
 - c. Review and finalize procedures for materials separation and verify availability of containers and bins needed to avoid delays.
 - d. Review procedures for periodic waste collection and transportation to recycling and disposal facilities.
 - e. Review waste management requirements for each trade.
- F. Waste Management Plan
1. General: Develop plan consisting of waste identification, waste reduction work plan, and cost/revenue analysis. Include separate sections in plan for demolition and construction waste if Project requires selective demolition or building demolition. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan.
 2. Waste Identification: Indicate anticipated types and quantities of demolition, site-clearing, and construction waste generated by the Work. Include estimated quantities and assumptions for estimates.
 3. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.



- a. Salvaged Materials for Reuse: For materials that will be salvaged and reused in this Project, describe methods for preparing salvaged materials before incorporation into the Work.
 - b. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
 - c. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
 - d. Handling and Transportation Procedures: Include method that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location on Project site where materials separation will be located.
4. Cost/Revenue Analysis: Indicate total cost of waste disposal as if there was no waste management plan and net additional cost or net savings resulting from implementing waste management plan. Include the following:
- a. Total quantity of waste.
 - b. Estimated cost of disposal (cost per unit). Include hauling and tipping fees and cost of collection containers for each type of waste.
 - c. Total cost of disposal (with no waste management).
 - d. Revenue from salvaged materials.
 - e. Revenue from recycled materials.
 - f. Savings in hauling and tipping fees by donating materials.
 - g. Savings in hauling and tipping fees that are avoided.
 - h. Handling and transportation costs. Include cost of collection containers for each type of waste.
 - i. Net additional cost or net savings from waste management plan.

1.2 PRODUCTS (Not Used)

1.3 EXECUTION

A. Plan Implementation

1. General: Implement waste management plan as approved by the Owner. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.
 - a. Comply with Division 01 Section "Temporary Facilities And Controls" for operation, termination, and removal requirements.
2. Waste Management Coordinator: Engage a waste management coordinator to be responsible for implementing, monitoring, and reporting status of waste management work plan. Coordinator shall be present at Project site full time for duration of Project.
3. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work occurring at Project site.
 - a. Distribute waste management plan to everyone concerned within three days of submittal return.
 - b. Distribute waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.
4. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 - a. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged, recycled, reused, donated, and sold.
 - b. Comply with Division 01 Section "Temporary Facilities And Controls" for controlling dust and dirt, environmental protection, and noise control.

B. Salvaging Demolition Waste



1. Salvaged Items for Reuse in the Work:
 - a. Clean salvaged items.
 - b. Pack or crate items after cleaning. Identify contents of containers.
 - c. Store items in a secure area until installation.
 - d. Protect items from damage during transport and storage.
 - e. Install salvaged items to comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make items functional for use indicated.
 2. Salvaged Items for Sale and Donation: Not permitted.
 3. Salvaged Items for Owner's Use:
 - a. Clean salvaged items.
 - b. Pack or crate items after cleaning. Identify contents of containers.
 - c. Store items in a secure area until delivery to Owner.
 - d. Transport items to Owner's storage area on-site **OR** off-site **OR** designated by Owner, **as directed**.
 - e. Protect items from damage during transport and storage.
 4. Doors and Hardware: Brace open end of door frames. Except for removing door closers, leave door hardware attached to doors.
- C. Recycling Demolition And Construction Waste, General
1. General: Recycle paper and beverage containers used by on-site workers.
 2. Recycling Receivers and Processors: Refer to the Owner for available recycling receivers and processors.
 3. Recycling Incentives: Revenues, savings, rebates, tax credits, and other incentives received for recycling waste materials shall accrue to Owner **OR** accrue to Contractor **OR** be shared equally by Owner and Contractor, **as directed**.
 4. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to the maximum extent practical.
 - a. Provide appropriately marked containers or bins for controlling recyclable waste until they are removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.
 - 1) Inspect containers and bins for contamination and remove contaminated materials if found.
 - b. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - c. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
 - d. Store components off the ground and protect from the weather.
 - e. Remove recyclable waste off Owner's property and transport to recycling receiver or processor.
- D. Recycling Demolition Waste
1. Asphaltic Concrete Paving: Grind asphalt to maximum 1-1/2-inch (38-mm) **OR** 4-inch (100-mm), **as directed**, size.
 - a. Crush asphaltic concrete paving and screen to comply with requirements in Division 31 Section "Earth Moving" for use as general fill.
 2. Asphaltic Concrete Paving: Break up and transport paving to asphalt-recycling facility.
 3. Concrete: Remove reinforcement and other metals from concrete and sort with other metals.
 - a. Pulverize concrete to maximum 1-1/2-inch (38-mm) **OR** 4-inch (100-mm), **as directed**, size.
 - b. Crush concrete and screen to comply with requirements in Division 31 Section "Earth Moving" for use as satisfactory soil for fill or subbase.
 4. Masonry: Remove metal reinforcement, anchors, and ties from masonry and sort with other metals.
 - a. Pulverize masonry to maximum 3/4-inch (19-mm) **OR** 1-inch (25-mm) **OR** 1-1/2-inch (38-mm) **OR** 4-inch (100-mm), **as directed**, size.



- 1) Crush masonry and screen to comply with requirements in Division 31 Section "Earth Moving" for use as general fill **OR** satisfactory soil for fill or subbase, **as directed**.
 - 2) Crush masonry and screen to comply with requirements in Division 32 Section "Plants" for use as mineral mulch.
 - b. Clean and stack undamaged, whole masonry units on wood pallets.
 5. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.
 6. Metals: Separate metals by type.
 - a. Structural Steel: Stack members according to size, type of member, and length.
 - b. Remove and dispose of bolts, nuts, washers, and other rough hardware.
 7. Asphalt Shingle Roofing: Separate organic and glass-fiber asphalt shingles and felts. Remove and dispose of nails, staples, and accessories.
 8. Gypsum Board: Stack large clean pieces on wood pallets and store in a dry location. Remove edge trim and sort with other metals. Remove and dispose of fasteners.
 9. Acoustical Ceiling Panels and Tile: Stack large clean pieces on wood pallets and store in a dry location.
 - a. Separate suspension system, trim, and other metals from panels and tile and sort with other metals.
 10. Carpet and Pad: Roll large pieces tightly after removing debris, trash, adhesive, and tack strips.
 - a. Store clean, dry carpet and pad in a closed container or trailer provided by Carpet Reclamation Agency or carpet recycler.
 11. Equipment: Drain tanks, piping, and fixtures. Seal openings with caps or plugs. Protect equipment from exposure to weather.
 12. Plumbing Fixtures: Separate by type and size.
 13. Piping: Reduce piping to straight lengths and store by type and size. Separate supports, hangers, valves, sprinklers, and other components by type and size.
 14. Lighting Fixtures: Separate lamps by type and protect from breakage.
 15. Electrical Devices: Separate switches, receptacles, switchgear, transformers, meters, panelboards, circuit breakers, and other devices by type.
 16. Conduit: Reduce conduit to straight lengths and store by type and size.
- E. Recycling Construction Waste
1. Packaging:
 - a. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
 - b. Polystyrene Packaging: Separate and bag materials.
 - c. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
 - d. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.
 2. Site-Clearing Wastes: Chip brush, branches, and trees on-site **OR** at landfill facility, **as directed**.
 - a. Comply with requirements in Division 32 Section "Plants" for use of chipped organic waste as organic mulch.
 3. Wood Materials:
 - a. Clean Cut-Offs of Lumber: Grind or chip into small pieces.
 - b. Clean Sawdust: Bag sawdust that does not contain painted or treated wood.
 - 1) Comply with requirements in Division 32 Section "Plants" for use of clean sawdust as organic mulch.
 4. Gypsum Board: Stack large clean pieces on wood pallets and store in a dry location.
 - a. Clean Gypsum Board: Grind scraps of clean gypsum board using small mobile chipper or hammer mill. Screen out paper after grinding.
 - 1) Comply with requirements in Division 32 Section "Plants" for use of clean ground gypsum board as inorganic soil amendment.



F. Disposal Of Waste

1. General: Except for items or materials to be salvaged, recycled, or otherwise reused, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.
 - a. Except as otherwise specified, do not allow waste materials that are to be disposed of accumulate on-site.
 - b. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
2. Burning: Do not burn waste materials.
OR
Burning: Burning of waste materials is permitted only at designated areas on Owner's property, provided required permits are obtained. Provide full-time monitoring for burning materials until fires are extinguished.
3. Disposal: Transport waste materials and dispose of at designated spoil areas on Owner's property.
OR
Disposal: Transport waste materials off Owner's property and legally dispose of them.

END OF SECTION 01 74 19 00



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SECTION 02 41 19 13 - SELECTIVE DEMOLITION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for selective demolition. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Demolition and removal of selected portions of building or structure.
 - b. Demolition and removal of selected site elements.
 - c. Salvage of existing items to be reused or recycled.

C. Definitions

1. Remove: Detach items from existing construction and legally dispose of them off-site, unless indicated to be removed and salvaged or removed and reinstalled.
2. Remove and Salvage: Detach items from existing construction and deliver them to the Owner ready for reuse, **as directed**.
3. Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated.
4. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

D. Materials Ownership

1. Historic items, relics, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, antiques, and other items of interest or value to the Owner that may be encountered during selective demolition remain the Owner's property. Carefully remove and salvage each item or object in a manner to prevent damage and deliver promptly to the Owner.
 - a. Coordinate with the Owner's archaeologist **OR** historical adviser, **as directed**, who will establish special procedures for removal and salvage.

E. Submittals

1. Qualification Data: For demolition firm, professional engineer, refrigerant recovery technician, **as directed**.
2. Schedule of Selective Demolition Activities: Indicate the following:
 - a. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure the Owner's building manager's and other tenants' on-site operations are uninterrupted.
 - b. Interruption of utility services. Indicate how long utility services will be interrupted.
 - c. Coordination for shutoff, capping, and continuation of utility services.
 - d. Use of elevator and stairs.
 - e. Locations of proposed dust- and noise-control temporary partitions and means of egress, including for other tenants affected by selective demolition operations.
 - f. Coordination of the Owner's continuing occupancy of portions of existing building and of the Owner's partial occupancy of completed Work.
 - g. Means of protection for items to remain and items in path of waste removal from building.
3. Inventory: After selective demolition is complete, submit a list of items that have been removed and salvaged.



4. Predemolition Photographs or Videotapes: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by selective demolition operations. Submit before Work begins.
5. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.
 - a. Comply with submittal requirements in Division 01 Section "Construction Waste Management And Disposal".

F. Quality Assurance

1. Demolition Firm Qualifications: An experienced firm that has specialized in demolition work similar in material and extent to that indicated for this Project.
2. Refrigerant Recovery Technician Qualifications: Certified by an EPA-approved certification program.
3. LEED Requirements for Building Reuse:
 - a. Credit MR 1.1 and 1.2, **as directed**: Maintain existing building structure (including structural floor and roof decking) and envelope (exterior skin and framing, excluding window assemblies and nonstructural roofing material) not indicated to be demolished; do not demolish such existing construction beyond indicated limits.
 - b. Credit MR 1.3: Maintain existing interior nonstructural elements (interior walls, doors, floor coverings, and ceiling systems) not indicated to be demolished; do not demolish such existing construction beyond indicated limits.
 - c. Credit MR 1.2 and 1.3, **as directed**: Maintain existing nonshell, nonstructural components (walls, flooring, and ceilings) not indicated to be demolished; do not demolish such existing construction beyond indicated limits.
4. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
5. Standards: Comply with ANSI A10.6 and NFPA 241.
6. Predemolition Conference: Conduct conference at Project site. Review methods and procedures related to selective demolition including, but not limited to, the following:
 - a. Inspect and discuss condition of construction to be selectively demolished.
 - b. Review structural load limitations of existing structure.
 - c. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 - d. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
 - e. Review areas where existing construction is to remain and requires protection.

G. Project Conditions

1. the Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so the Owner's operations will not be disrupted.
2. Conditions existing at time of inspection for bidding purpose will be maintained by the Owner as far as practical.
 - a. Before selective demolition, items will be removed as directed by the Owner.
3. Notify the Owner of discrepancies between existing conditions and Drawings before proceeding with selective demolition.
4. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
 - a. Hazardous materials will be removed by the Owner before start of the Work **OR** have been removed by the Owner under a separate contract, **as directed**.
 - b. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify the Owner. the Owner will remove hazardous materials under a separate contract.

OR



5. Hazardous Materials: It is unknown whether hazardous materials will be encountered in the Work.
 - a. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify the Owner and the Owner. the Owner will remove hazardous materials under a separate contract.
6. Hazardous Materials (if asbestos abatement is part of Work of this Contract): Hazardous materials are present in construction to be selectively demolished. A report on the presence of hazardous materials is on file for review and use. Examine report to become aware of locations where hazardous materials are present.
 - a. Hazardous material remediation is specified elsewhere in the Contract Documents.
 - b. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified elsewhere in the Contract Documents.
7. Storage or sale of removed items or materials on-site is not permitted.
8. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.
 - a. Maintain fire-protection facilities in service during selective demolition operations.

H. Warranty

1. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties.

1.2 PRODUCTS (Not Used)

1.3 EXECUTION

A. Utility Services And Mechanical/Electrical Systems

1. Existing Services/Systems: Maintain services/systems indicated to remain and protect them against damage during selective demolition operations.
2. Service/System Requirements: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.
 - a. the Owner will arrange to shut off indicated services/systems when requested by Contractor.
 - b. Arrange to shut off indicated utilities with utility companies.
 - c. If services/systems are required to be removed, relocated, or abandoned, before proceeding with selective demolition provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
 - d. Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing.
 - 1) Where entire wall is to be removed, existing services/systems may be removed with removal of the wall.

B. Preparation

1. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
2. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 - a. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
 - b. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.



- c. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
- d. Cover and protect furniture, furnishings, and equipment that have not been removed.
- e. Comply with requirements for temporary enclosures, dust control, heating, and cooling.
- 3. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.
 - a. Strengthen or add new supports when required during progress of selective demolition.

C. Selective Demolition, General

1. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
 - a. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
 - b. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
 - c. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
 - d. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain fire watch and portable fire-suppression devices during flame-cutting operations.
 - e. Maintain adequate ventilation when using cutting torches.
 - f. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
 - g. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
 - h. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
 - i. Dispose of demolished items and materials promptly. Comply with requirements in Division 01 Section "Construction Waste Management And Disposal".
2. Reuse of Building Elements: Project has been designed to result in end-of-Project rates for reuse of building elements as follows. Do not demolish building elements beyond what is indicated on Drawings without the Owner's approval.
 - a. Building Structure and Shell: 75 **OR** 100, **as directed**, percent.
 - b. Nonshell Elements: 50 percent.
3. Removed and Salvaged Items:
 - a. Clean salvaged items.
 - b. Pack or crate items after cleaning. Identify contents of containers.
 - c. Store items in a secure area until delivery to the Owner.
 - d. Transport items to the Owner's storage area on-site **OR** off-site **OR** designated by the Owner **OR** indicated on Drawings, **as directed**.
 - e. Protect items from damage during transport and storage.
4. Removed and Reinstalled Items:
 - a. Clean and repair items to functional condition adequate for intended reuse. Paint equipment to match new equipment.
 - b. Pack or crate items after cleaning and repairing. Identify contents of containers.
 - c. Protect items from damage during transport and storage.



- d. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.
 5. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by the Owner, items may be removed to a suitable, protected storage location during selective demolition and cleaned, **as directed**, and reinstalled in their original locations after selective demolition operations are complete.
- D. Selective Demolition Procedures For Specific Materials
1. Concrete: Demolish in small sections. Cut concrete to a depth of at least 3/4 inch (19 mm) at junctures with construction to remain, using power-driven saw. Dislodge concrete from reinforcement at perimeter of areas being demolished, cut reinforcement, and then remove remainder of concrete indicated for selective demolition. Neatly trim openings to dimensions indicated.
OR
Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals, using power-driven saw, then remove concrete between saw cuts.
 2. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, then remove masonry between saw cuts.
 3. Concrete Slabs-on-Grade: Saw-cut perimeter of area to be demolished, then break up and remove.
 4. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI-WP and its Addendum.
 - a. Remove residual adhesive and prepare substrate for new floor coverings by one of the methods recommended by RFCI.
 5. Roofing: Remove no more existing roofing than can be covered in one day by new roofing and so that building interior remains watertight and weathertight. Refer to Division 07 for new roofing requirements.
 - a. Remove existing roof membrane, flashings, copings, and roof accessories.
 - b. Remove existing roofing system down to substrate.
 6. Air-Conditioning Equipment: Remove equipment without releasing refrigerants.
- E. Disposal Of Demolished Materials
1. General: Except for items or materials indicated to be recycled, **as directed**, reused, salvaged, reinstalled, or otherwise indicated to remain the Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.
 - a. Do not allow demolished materials to accumulate on-site.
 - b. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
 - c. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
 - d. Comply with requirements specified in Division 01 Section "Construction Waste Management And Disposal".
 2. Burning: Do not burn demolished materials.
OR
Burning: Burning of demolished materials will be permitted only at designated areas on the Owner's property, **as directed**, provided required permits are obtained. Provide full-time monitoring for burning materials until fires are extinguished.
 3. Disposal: Transport demolished materials and dispose of at designated spoil areas on the Owner's property.
OR
Disposal: Transport demolished materials off the Owner's property and legally dispose of them.
- F. Cleaning



1. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

G. Selective Demolition Schedule

1. Existing Items **OR** Construction, **as directed**, to Be Removed, as directed by the Owner.
2. Existing Items to Be Removed and Salvaged, as directed by the Owner.
3. Existing Items to Be Removed and Reinstalled, as directed by the Owner.
4. Existing Items to Remain, as directed by the Owner.

END OF SECTION 02 41 19 13



SECTION 02 41 19 13a - BUILDING DEMOLITION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for building demolition. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Demolition and removal of buildings and site improvements.
 - b. Abandoning in place **OR** Removing, **as directed**, below-grade construction.
 - c. Disconnecting, capping or sealing, and abandoning in-place **OR** removing, **as directed**, site utilities.
 - d. Salvaging items for reuse by the Owner.

C. Definitions

1. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged.
2. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to the Owner ready for reuse. Include fasteners or brackets needed for reattachment elsewhere.

D. Materials Ownership

1. Unless otherwise indicated, demolition waste becomes property of Contractor.
2. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to the Owner that may be uncovered during demolition remain the property of the Owner.
 - a. Carefully salvage in a manner to prevent damage and promptly return to the Owner.

E. Informational Submittals

1. Qualification Data: For refrigerant recovery technician.
2. Proposed Protection Measures: Submit informational report, including drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and, for noise control, **as directed**. Indicate proposed locations and construction of barriers.
 - a. Adjacent Buildings: Detail special measures proposed to protect adjacent buildings to remain.
3. Schedule of Building Demolition Activities: Indicate the following:
 - a. Detailed sequence of demolition work, with starting and ending dates for each activity.
 - b. Temporary interruption of utility services.
 - c. Shutoff and capping or re-routing of utility services.
4. Inventory: Submit a list of items to be removed and salvaged and deliver to the Owner prior to start of demolition.
5. Predemolition Photographs **OR** Video, **as directed**: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by building demolition operations. Submit before the Work begins.
6. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.
7. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that



recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

F. Quality Assurance

1. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.
2. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
3. Standards: Comply with ANSI/ASSE A10.6 and NFPA 241.
4. Predemolition Conference: Conduct conference at Project site.
 - a. Inspect and discuss condition of construction to be demolished.
 - b. Review structural load limitations of existing structures.
 - c. Review and finalize building demolition schedule and verify availability of demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 - d. Review and finalize protection requirements.
 - e. Review procedures for noise control and dust control.
 - f. Review procedures for protection of adjacent buildings.
 - g. Review items to be salvaged and returned to the Owner.

G. Project Conditions

1. Buildings to be demolished will be vacated and their use discontinued before start of the Work.
2. Buildings immediately adjacent to demolition area will be occupied. Conduct building demolition so operations of occupied buildings will not be disrupted.
 - a. Provide not less than 72 hours' notice of activities that will affect operations of adjacent occupied buildings.
 - b. Maintain access to existing walkways, exits, and other facilities used by occupants of adjacent buildings.
 - 1) Do not close or obstruct walkways, exits, or other facilities used by occupants of adjacent buildings without written permission from authorities having jurisdiction.
3. the Owner assumes no responsibility for buildings and structures to be demolished.
 - a. Conditions existing at time of inspection for bidding purpose will be maintained by the Owner as far as practical.
 - b. Before building demolition, the Owner will remove certain items, as directed by the Owner.
4. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
 - a. Hazardous materials will be removed by the Owner before start of the Work.
 - b. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and the Owner. Hazardous materials will be removed by the Owner under a separate contract.

OR

Hazardous Materials: Hazardous materials are present in buildings and structures to be demolished. A report on the presence of hazardous materials is on file for review and use. Examine report to become aware of locations where hazardous materials are present.

- a. Hazardous material remediation is specified elsewhere in the Contract Documents.
 - b. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified elsewhere in the Contract Documents.
 - c. the Owner will provide material safety data sheets for materials that are known to be present in buildings and structures to be demolished because of building operations or processes performed there.
5. On-site storage or sale of removed items or materials is not permitted.

H. Coordination

1. Arrange demolition schedule so as not to interfere with the Owner's on-site operations **OR** operations of adjacent occupied buildings, **as directed**.



1.2 PRODUCTS

A. Soil Materials

1. Satisfactory Soils: Satisfactory Soils: For soils which is to be used for backfilling voids that result from demolition operations in below-grade areas, comply with requirements in Division 31 Section "Earth Moving".

1.3 EXECUTION

A. Examination

1. Verify that utilities have been disconnected and capped before starting demolition operations.
2. Review Project Record Documents of existing construction provided by the Owner. the Owner does not guarantee that existing conditions are same as those indicated in Project Record Documents.
3. Inventory and record the condition of items to be removed and salvaged. Provide photographs **OR** video, **as directed**, of conditions that might be misconstrued as damage caused by salvage operations.
4. Perform **OR** Engage a professional engineer to perform, **as directed**, an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during building demolition operations.
 - a. Steel Tendons: Locate tensioned steel tendons and include recommendations for de-tensioning.
5. Verify that hazardous materials have been remediated before proceeding with building demolition operations.

B. Preparation

1. Refrigerant: Remove refrigerant from mechanical equipment according to 40 CFR 82 and regulations of authorities having jurisdiction before starting demolition.
2. Existing Utilities: Locate, identify, disconnect, and seal or cap off indicated utilities serving buildings and structures to be demolished.
 - a. the Owner will arrange to shut off indicated utilities when requested by Contractor.
OR
Arrange to shut off indicated utilities with utility companies, **as directed**.
 - b. If removal, relocation, or abandonment of utility services will affect adjacent occupied buildings, then provide temporary utilities that bypass buildings and structures to be demolished and that maintain continuity of service to other buildings and structures.
 - c. Cut off pipe or conduit a minimum of 24 inches (610 mm) below grade. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing according to requirements of authorities having jurisdiction.**OR**
Existing Utilities: Refer to Division 22 AND Division 26 for shutting off, disconnecting, removing, and sealing or capping utilities. Do not start demolition work until utility disconnecting and sealing have been completed and verified in writing, **as directed**.
3. Temporary Shoring: Provide and maintain interior and exterior shoring, bracing, or structural support to preserve stability and prevent unexpected movement or collapse of construction being demolished.
 - a. Strengthen or add new supports when required during progress of demolition.
4. Salvaged Items: Comply with the following:
 - a. Clean salvaged items of dirt and demolition debris.
 - b. Pack or crate items after cleaning. Identify contents of containers.
 - c. Store items in a secure area until delivery to the Owner.
 - d. Transport items to storage area designated by the Owner **OR** indicated on Drawings, **as directed**.
 - e. Protect items from damage during transport and storage.



C. Protection

1. Existing Facilities: Protect adjacent walkways, loading docks, building entries, and other building facilities during demolition operations. Maintain exits from existing buildings.
2. Existing Utilities: Maintain utility services to remain and protect from damage during demolition operations.
 - a. Do not interrupt existing utilities serving adjacent occupied or operating facilities unless authorized in writing by the Owner and authorities having jurisdiction.
 - b. Provide temporary services during interruptions to existing utilities, as acceptable to the Owner and authorities having jurisdiction.
 - 1) Provide at least 72 hours' notice to occupants of affected buildings if shutdown of service is required during changeover.
3. Temporary Protection: Erect temporary protection, such as walks, fences, railings, canopies, and covered passageways, where required by authorities having jurisdiction, and as indicated. Comply with requirements in Division 01 Section "Temporary Facilities And Controls".
 - a. Protect adjacent buildings and facilities from damage due to demolition activities.
 - b. Protect existing site improvements, appurtenances, and landscaping to remain.
 - c. Erect a plainly visible fence around drip line of individual trees or around perimeter drip line of groups of trees to remain.
 - d. Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 - e. Provide protection to ensure safe passage of people around building demolition area and to and from occupied portions of adjacent buildings and structures.
 - f. Protect walls, windows, roofs, and other adjacent exterior construction that are to remain and that are exposed to building demolition operations.
 - g. Erect and maintain dustproof partitions and temporary enclosures to limit dust, noise, and dirt migration to occupied portions of adjacent buildings.
4. Remove temporary barriers and protections where hazards no longer exist. Where open excavations or other hazardous conditions remain, leave temporary barriers and protections in place.

D. Demolition, General

1. General: Demolish indicated existing buildings and site improvements completely. Use methods required to complete the Work within limitations of governing regulations and as follows:
 - a. Do not use cutting torches until work area is cleared of flammable materials. Maintain portable fire-suppression devices during flame-cutting operations.
 - b. Maintain fire watch during and for a specified time after flame cutting operations as directed by the Owner.
 - c. Maintain adequate ventilation when using cutting torches.
 - d. Locate building demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
2. Engineering Surveys: During demolition, perform surveys to detect hazards that may result from building demolition activities.
3. Site Access and Temporary Controls: Conduct building demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 - a. Do not close or obstruct streets, walks, walkways, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
 - b. Use water mist and other suitable methods to limit spread of dust and dirt. Comply with governing environmental-protection regulations. Do not use water when it may damage adjacent construction or create hazardous or objectionable conditions, such as ice, flooding, and pollution.
4. Explosives: Use of explosives is not permitted, **unless directed otherwise**.



E. Demolition By Mechanical Means

1. Proceed with demolition of structural framing members systematically, from higher to lower level. Complete building demolition operations above each floor or tier before disturbing supporting members on the next lower level.
2. Remove debris from elevated portions of the building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
 - a. Remove structural framing members and lower to ground by method suitable to minimize ground impact and dust generation.
3. Salvage: Items to be salvaged are indicated on Drawings **OR** below, **as directed**:
 - a. Doors and door hardware.
 - b. Windows.
 - c. Cabinets.
 - d. Mirrors.
 - e. Chalkboards.
 - f. Tackboards.
 - g. Marker boards.
 - h. Plumbing fixtures.
 - i. Other items as directed.
4. Below-Grade Construction: Abandon foundation walls and other below-grade construction. Cut below-grade construction flush with grade.

OR

Below-Grade Construction: Demolish foundation walls and other below-grade construction that are within footprint of new construction and extending 5 feet (1.5 m) outside footprint indicated for new construction. Abandon below-grade construction outside this area.

 - a. Remove below-grade construction, including basements, foundation walls, and footings, completely **OR** to at least 6 inches (150 mm) below grade **OR** to at least 12 inches (300 mm) below grade **OR** to depths indicated, **as directed**.

OR

Below-Grade Construction: Demolish foundation walls and other below-grade construction.

 - b. Remove below-grade construction, including basements, foundation walls, and footings, completely **OR** to at least 6 inches (150 mm) below grade **OR** to at least 12 inches (300 mm) below grade **OR** to depths indicated, **as directed**.
5. Existing Utilities: Abandon existing utilities and below-grade utility structures. Cut utilities flush with grade.

OR

Existing Utilities: Demolish existing utilities and below-grade utility structures that are within 5 feet (1.5 m) outside footprint indicated for new construction. Abandon utilities outside this area.

 - a. Fill abandoned utility structures with satisfactory soil materials **OR** recycled pulverized concrete, **as directed**, according to backfill requirements in Division 31 Section "Earth Moving".
 - b. Piping: Disconnect piping at unions, flanges, valves, or fittings.
 - c. Wiring Ducts: Disassemble into unit lengths and remove plug-in and disconnecting devices.

OR

Existing Utilities: Demolish and remove existing utilities and below-grade utility structures.

 - a. Piping: Disconnect piping at unions, flanges, valves, or fittings.
 - b. Wiring Ducts: Disassemble into unit lengths and remove plug-in and disconnecting devices.

F. Demolition By Explosives – ONLY IF APPROVED BY THE OWNER

1. Explosives: Perform explosive demolition according to governing regulations.
 - a. Obtain written permission from authorities having jurisdiction before bringing explosives to, or using explosives on, Project site.
 - b. Do not damage adjacent structures, property, or site improvements when using explosives.
2. Comply with recommendation in Explosives Consultant's report.



G. Site Restoration

1. Below-Grade Areas: Rough grade below-grade areas ready for further excavation or new construction.

OR

Below-Grade Areas: Completely fill below-grade areas and voids resulting from building demolition operations with satisfactory soil materials **OR** recycled pulverized concrete **OR** recycled pulverized masonry, **as directed**, according to backfill requirements in Division 31 Section "Earth Moving".

2. Site Grading: Uniformly rough grade area of demolished construction to a smooth surface, free from irregular surface changes. Provide a smooth transition between adjacent existing grades and new grades.

H. Repairs

1. Promptly repair damage to adjacent buildings caused by demolition operations.

I. Disposal Of Demolished Materials

1. Remove demolition waste materials from Project site and legally dispose of them in EPA approved landfill acceptable to authorities having jurisdiction. See Division 01 Section "Construction Waste Management And Disposal" for recycling and disposal of demolition waste.
 - a. Do not allow demolished materials to accumulate on-site.
 - b. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
2. Do not burn demolished materials.

J. Cleaning

1. Clean adjacent structures and improvements of dust, dirt, and debris caused by building demolition operations. Return adjacent areas to condition existing before building demolition operations began.
 - a. Clean roadways of debris caused by debris transport.

END OF SECTION 02 41 19 13a

**SECTION 02 41 19 13b - PORTLAND CEMENT CONCRETE REMOVAL**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for portland cement concrete removal. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Section Includes:

1. Provide all labor, materials and equipment required for the removal work and disposal of existing Portland Cement Concrete indicated on the drawings and specified, including but not limited to the following:
 - a. Saw cutting existing concrete pavements, sidewalks, driveways, curbs and gutters noted on drawings to be removed.
 - b. Saw cutting existing concrete sidewalks for new tree pit openings (refer to drawings for locations).
 - c. Saw cutting existing bituminous paving noted on drawings to be removed.
 - d. Removal and disposal of demolished concrete sidewalks, driveways, curbs and gutters, including concrete removed for new tree pit openings.
 - e. Removal and disposal of demolished bituminous paving.
 - f. All excavating, rough grading and compacting as required to establish subgrade for new sidewalks, and Subgrade and Sub-Base for driveways.
 - g. Providing, placing and grading sand fill under new sidewalks. Top of compacted subgrades shall allow for the placement of sidewalks plus thickness of sand fill.
 - h. Removal and disposal of excavated material.

C. Special Requirements:

1. Protection: Provide protection barricades, maintain all lights and signals and other measures as required by federal, state, and municipal laws, for the full period of demolition operations and remove same when directed. In removing work, perform all work required to protect and maintain adjacent property, streets, alleys, sidewalks, curbs, and other structures remaining in place.

1.2 PRODUCTS

A. Backfilling Material:

1. Sand: Natural sand, with the following gradation: 100% passing the 1 sieve-, 65-100% passing the No. 4 sieve; 40-90% passing the No. 10 sieve- 30-80% passing the No. 16 sieve- 10-50% passing the No. 50 sieve; 0-30% passing the No. 100 sieve, and 0-10% passing the No. 200 sieve.
2. Crushed Stone: Crushed stone having a #57 crusher run gradation.

1.3 EXECUTION

A. Demolition:

1. The contractor shall accept the site as it finds it and shall inform itself as to the character and types of work to be removed. The Owner assumes no responsibility for the condition of the existing construction to be removed or demolished.
2. No demolition shall be commenced until a program of operations has been coordinated with the Owner, except that preparatory work may be started if specifically approved by the Owner.



3. Operations shall be done in such manner as to avoid hazards to persons and property and interference with use of adjacent areas or interruption of free passage to and from such areas. Maintain Pedestrian access to all private entrances where construction of new sidewalks is in progress. Provide temporary walk ways or other means as required to maintain entry into the private properties, complying with all laws and ordinances and as approved by the Owner. Care shall be taken to prevent the spread of dust and flying particles.
4. Demolition and removal work shall be executed in a careful and orderly manner. Accumulation of rubbish will not be permitted.
5. After work is started, it shall be continued to completion at a rate that will allow the balance of the work to be completed within the time specified. If extra shifts are necessary beyond regular working hours, the work shall proceed with a minimum of nuisance to surrounding properties.
6. Contractor shall determine the nature and extent of demolition that will be necessary by comparing the drawings with the existing field conditions. It is expressly understood that this contract includes all work of a demolition nature that may be required or necessary for a full and complete execution of the work, whether particularly referred to herein or not.

B. Removal And Excavation:

1. When removing existing sidewalks, driveways, curbs and gutters provisions shall be made for satisfactory transition between replacements and the portion remaining in place. The contractor shall saw cut to a minimum depth of 1-1/2 inches with a concrete sawing machine to prevent the surface from spalling when the concrete is broken out. This work shall be done in such a manner that a straight joint will be secured.
2. It shall be the responsibility of the contractor to determine the thickness of the existing sidewalk to be removed. No additional compensation will be allowed because of variations from the assumed thickness or from the thickness shown on the plans.
3. After existing concrete sidewalks and driveways have been removed, excavate to depth required for sand fill.
4. The bottoms of all excavations shall be properly leveled off and all loose materials shall be removed from excavations. All wood, timber and organic materials, that are exposed at the bottom of all excavations, shall be removed and the area backfilled with sand and compacted.
5. Any excess or unauthorized excavation shall be backfilled with sand and compacted, at no additional cost to the Owner.
6. No backfill shall be placed in standing water, on frozen ground or on surfaces which have not been approved by the Commissioner.
7. Backfilling for all areas shall be approved material. Backfill shall be compacted to 95% maximum density in accordance with ASTM D 1557.
8. Contractor shall determine the nature and extent of excavation work that will be necessary by comparing the drawings with the existing areas to be excavated. It is expressly understood that this contract includes all work of an excavation nature that may be required or necessary for a complete execution of all excavation work, whether particularly referred to herein or not.

C. Disposal Of Materials:

1. All demolished and unsuitable materials, including excavated earth removed to establish required grade elevations shall be disposed of legally in such a manner that public or private property will not be damaged or endangered.

D. Clean-Up:

1. On completion of the demolition work, excavation work and before acceptance by the Owner, clean the areas affected, including areas outside the limits of the contractor's work area where permission to work has been granted. Remove surplus construction material or debris resulting from the demolition work and excavation work, and dispose of legally off the site.
2. Access routes to and from the site shall be kept clean of debris resulting from the work.

END OF SECTION 02 41 19 13b



Task	Specification	Specification Description
02 41 19 13	01 71 23 16	Cutting and Patching
02 41 19 16	02 41 19 13	Selective Demolition
02 41 19 16	02 41 19 13a	Building Demolition
02 41 19 16	02 41 19 13b	Portland Cement Concrete Removal



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**SECTION 02 81 00 00 - EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for excavation and handling of contaminated material. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Shop Drawings: Separate cross-sections of each area before and after excavation and after backfilling.
2. Product Data: Work Plan within 30 calendar days after notice to proceed. No work at the site, with the exception of site inspections and surveys, shall be performed until the Work Plan is approved. The Contractor shall allow 30 calendar days in the schedule for the Owner's review. No adjustment for time or money will be made if resubmittals of the Work Plan are required due to deficiencies in the plan. At a minimum, the Work Plan shall include:
 - a. Schedule of activities.
 - b. Method of excavation and equipment to be used.
 - c. Shoring or side-wall slopes proposed.
 - d. Dewatering plan.
 - e. Storage methods and locations for liquid and solid contaminated material.
 - f. Borrow sources and haul routes.
 - g. Decontamination procedures.
 - h. Spill contingency plan.
3. Closure Report: Three (3) copies of the Closure Report within 14 calendar days of work completion at the site.
4. Test Reports
 - a. Backfill
 - b. Surveys
 - c. Confirmation Sampling and Analysis
 - d. Sampling of Stored Material
 - e. Sampling Liquid
 - f. Compaction
 - g. Test results.

C. Surveys

1. Surveys shall be performed immediately prior to and after excavation of contaminated material to determine the volume of contaminated material removed. Surveys shall also be performed immediately after backfill of each excavation. The Contractor shall provide cross-sections on 25 foot (7.6 meter) intervals and at break points for all excavated areas. Locations of confirmation samples shall also be surveyed and shown on the drawings.

D. Regulatory Requirements

1. Permits and Licenses: The Contractor shall obtain required federal, state, and local permits for excavation and storage of contaminated material. Permits shall be obtained at no additional cost the Owner.
2. Air Emissions: Air emissions shall be monitored and controlled in accordance with the Owner's Environmental Requirements.

E. Chemical Testing

1. Required sampling and chemical analysis shall be conducted in accordance with local requirements and the Owner's requirements.



F. Scheduling

1. The Contractor shall notify the Owner five (5) calendar days prior to the start of excavation of contaminated material. The Owner will **OR** The Contractor shall, **as directed**, be responsible for contacting regulatory agencies in accordance with the applicable reporting requirements.

1.2 PRODUCTS

A. Backfill

1. Backfill material shall be obtained from the location indicated on the drawings **OR** offsite sources approved by the Owner, **as directed**. Backfill shall be classified in accordance with ASTM D 2487 as GW, GP, GM, GC, SW, SP, SM, SC, ML, MH, CL, or CH and shall be free from roots and other organic matter, trash, debris, snow, ice or frozen materials. Backfill material shall be tested for the parameters listed below at a frequency of once per 3000 cubic yards (cubic meters). A minimum of one set of classification tests shall be performed per borrow source. One backfill sample per borrow source shall also be collected and tested for the chemical parameters listed below.

<u>Physical Parameter</u>	<u>Test Method</u>
Grain Size	ASTM D 422
Compaction	ASTM D 698

Backfill shall not be used until borrow source chemical and physical test results have been submitted and approved.

B. Spill Response Materials

1. The Contractor shall provide appropriate spill response materials including, but not limited to the following: containers, adsorbents, shovels, and personal protective equipment. Spill response materials shall be available at all times when contaminated materials/wastes are being handled or transported. Spill response materials shall be compatible with the type of materials and contaminants being handled.

1.3 EXECUTION

A. Existing Structures And Utilities

1. No excavation shall be performed until site utilities have been field located. The Contractor shall take the necessary precautions to ensure no damage occurs to existing structures and utilities. Damage to existing structures and utilities resulting from the Contractor's operations shall be repaired at no additional cost to the Owner. Utilities encountered that were not previously shown or otherwise located shall not be disturbed without approval from the Owner.

B. Clearing

1. Clearing shall be performed to the limits shown on the drawings in accordance with Division 2 Section "Site Clearing."

C. Contaminated Material Removal

1. Excavation: Areas of contamination shall be excavated to the depth and extent shown on the drawings and not more than 0.2 feet (60 mm) beyond the depth and extent shown on the drawings unless directed by the Owner. Excavation shall be performed in a manner that will limit spills and the potential for contaminated material to be mixed with uncontaminated material. An excavation log describing visible signs of contamination encountered shall be maintained for each area of excavation. Excavation logs shall be prepared in accordance with ASTM D 5434.
2. Shoring: If workers must enter the excavation, it shall be evaluated, shored, sloped or braced as required by U.S. Army Corps of Engineers (USACE) EM 385-1-1 and U.S. National Archives and Records Administration (NARA) 29 CFR 1926 section 650.



3. Dewatering: Surface water shall be diverted to prevent entry into the excavation. Dewatering shall be limited to that necessary to assure adequate access, a safe excavation, prevent the spread of contamination, and to ensure that compaction requirements can be met. No dewatering shall be performed without prior approval of the Owner.
- D. Confirmation Sampling And Analysis
1. the Owner shall be present to inspect the removal of contaminated material from each site. After all material suspected of being contaminated has been removed, the excavation shall be examined for evidence of contamination. If the excavation appears to be free of contamination, field analysis shall be used to determine the presence of contamination using a real time vapor monitoring instrument **OR** immunoassay field kits, **as directed**. Excavation of additional material shall be as directed by the Owner. After all suspected contaminated material is removed, confirmation samples shall be collected and analyzed.
 2. Samples shall be collected at a frequency as directed by the Owner. A minimum of one sample shall be collected from the bottom and each side wall of the excavation. Based on test results, the Contractor shall propose any additional excavation which may be required to remove material which is contaminated above action levels. Additional excavation shall be subject to approval by the Owner. Locations of samples shall be marked in the field and documented on the as-built drawings.
- E. Contaminated Material Storage
1. Material shall be placed in temporary storage immediately after excavation **OR** after treatment while awaiting test results, **as directed**. The following paragraphs describe acceptable methods of material storage. Storage units shall be in good condition and constructed of materials that are compatible with the material or liquid to be stored. If multiple storage units are required, each unit shall be clearly labeled with an identification number and a written log shall be kept to track the source of contaminated material in each temporary storage unit.
 2. Stockpiles
 - a. Stockpiles shall be constructed to isolate stored contaminated material from the environment. The maximum stockpile size shall be as directed by the Owner. Stockpiles shall be constructed to include:
 - 1) A chemically resistant geomembrane liner free of holes and other damage. Non-reinforced geomembrane liners shall have a minimum thickness of 20 mils (0.5 mm). Scrim reinforced geomembrane liners shall have a minimum weight of 40 lbs. per 1000 square feet (20 kg/100 square meters). The ground surface on which the geomembrane is to be placed shall be free of rocks greater than 0.5 inches (12 mm) in diameter and any other object which could damage the membrane.
 - 2) Geomembrane cover free of holes or other damage to prevent precipitation from entering the stockpile. Non-reinforced geomembrane covers shall have a minimum thickness of 10 mils (0.25 mm). Scrim reinforced geomembrane covers shall have a minimum weight of 26 lbs. per 1000 square feet (13 kg/100 square meters). The cover material shall be extended over the berms and anchored or ballasted to prevent it from being removed or damaged by wind.
 - 3) Berms surrounding the stockpile, a minimum of 12 inches (300 mm) in height. Vehicle access points shall also be bermed.
 - 4) The liner system shall be sloped to allow collection of leachate. Storage and removal of liquid which collects in the stockpile, in accordance with paragraph Liquid Storage.
 3. Roll-Off Units: Roll-off units used to temporarily store contaminated material shall be water tight. A cover shall be placed over the units to prevent precipitation from contacting the stored material. The units shall be located as shown on the drawings. Liquid which collects inside the units shall be removed and stored in accordance with paragraph Liquid Storage.
 4. Liquid Storage: Liquid collected from excavations and stockpiles shall be temporarily stored in 55 gallon barrels (220 L barrels) **OR** 500 gallon tanks (2000 L tanks), **as directed**. Liquid storage containers shall be water-tight and shall be located as shown on the drawings.



F. Sampling

1. Sampling of Stored Material

- a. Samples of stored material shall be collected at a frequency as directed by the Owner.
- b. Stored material with contaminant levels that exceed the action levels shall be treated offsite. Analyses for contaminated material to be taken to an offsite treatment facility shall conform to local, state, and federal criteria as well as to the requirements of the treatment facility. Documentation of all analyses performed shall be furnished to the Owner. Additional sampling and analyses to the extent required by the approved offsite treatment, storage or disposal (TSD) facility shall be the responsibility of the Contractor and shall be performed at no additional cost to the Owner **OR** subject to approval by the Owner, **as directed**.

OR

Stored material with contaminant levels that exceed the action levels shall be treated onsite.

2. Sampling Liquid

- a. Liquid collected from excavations **OR** storage areas **OR** decontamination facilities, **as directed**, shall be sampled at a frequency of once for every 500 gallons (2,000 L) of liquid collected.
- b. Liquid with contaminant levels that exceed action levels shall be treated offsite. Analyses for contaminated liquid to be taken to an offsite treatment facility shall conform to local, state, and federal criteria as well as to the requirements of the treatment facility. Documentation of all analyses performed shall be furnished to the Owner. Additional sampling and analysis to the extent required by the approved offsite treatment, storage or disposal (TSD) facility receiving the material shall be the responsibility of the Contractor and shall be performed at no additional cost to the Owner **OR** subject to approval by the Owner.

OR

Liquid with contaminant levels that exceed action levels shall be treated onsite.

3. Sampling Beneath Storage Units

- a. Samples from beneath each storage unit shall be collected prior to construction of and after removal of the storage unit. Samples shall be collected at a frequency as directed by the Owner from a depth interval of 0 to 0.5 feet (0 to 0.15 m).
- b. Based on test results, soil which has become contaminated above action levels shall be removed at no additional cost to the Owner. Contaminated material which is removed from beneath the storage unit shall be handled in accordance with paragraph Sampling of Stored Material. as directed by the Owner and at no additional cost to the Owner, additional sampling and testing shall be performed to verify areas of contamination found beneath stockpiles have been cleaned up to below action levels.

G. Spills

1. In the event of a spill or release of a hazardous substance (as designated in NARA 40 CFR 302), pollutant, contaminant, or oil (as governed by the Oil Pollution Act [OPA], 33 U.S.C. 2701 et seq.), the Contractor shall notify the Owner immediately. If the spill exceeds the reporting threshold, the Contractor shall follow the pre-established procedures as described in the Contingency Plan for immediate reporting and containment. Immediate containment actions shall be taken to minimize the effect of any spill or leak. Cleanup shall be in accordance with applicable federal, state, and local regulations. as directed by the Owner, additional sampling and testing shall be performed to verify spills have been cleaned up. Spill cleanup and testing shall be done at no additional cost to the Owner.

H. Backfilling

1. Confirmation Test Results: Excavations shall be backfilled immediately after all contaminated materials have been removed and confirmation test results have been approved. Backfill shall be placed and compacted to the lines and grades shown on the drawings.



2. Compaction: Approved backfill shall be placed in lifts with a maximum loose thickness of 8 inches (200 mm). Soil shall be compacted to 90 percent of ASTM D 698 **OR** ASTM D 1557, **as directed**, maximum dry density. Density tests shall be performed at a frequency of once per 10,000 square feet (930 square meters) per lift. A minimum of one density test shall be performed on each lift of backfill placed. Field in-place dry density shall be determined in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. If ASTM D 2922 is used, a minimum of one in ten tests shall be checked using ASTM D 1556 or ASTM D 2167. Test results from ASTM D 1556 or ASTM D 2167 shall govern if there is a discrepancy with the ASTM D 2922 test results.
 - I. Disposal Requirements
 1. Offsite disposal of contaminated material shall be in accordance with Division 2 Section "Disposal of Hazardous Materials."
 - J. Closure Report
 1. Three copies of a Closure Report shall be prepared and submitted within 14 calendar days of completing work at the site. The report shall be labeled with the contract number, project name, location, date, and name of general contractor. The Closure Report shall include the following information as a minimum:
 - a. A cover letter signed by a responsible company official **OR** Professional Engineer registered in the state of the work who is a responsible company official, **as directed**, certifying that all services involved have been performed in accordance with the terms and conditions of the contract documents and regulatory requirements.
 - b. A narrative report including, but not limited to, the following:
 - 1) site conditions, ground water elevation, and cleanup criteria;
 - 2) excavation logs;
 - 3) field screening readings;
 - 4) quantity of materials removed from each area of contamination;
 - 5) quantity of water/product removed during dewatering;
 - 6) sampling locations and sampling methods;
 - 7) sample collection data such as time of collection and method of preservation;
 - 8) sample chain-of-custody forms; and
 - 9) source of backfill.
 - c. Copies of all chemical and physical test results.
 - d. Copies of all manifests and land disposal restriction notifications.
 - e. Copies of all certifications of final disposal signed by the responsible disposal facility official.
 - f. Waste profile sheets.
 - g. Scale drawings showing limits of each excavation, limits of contamination, known underground utilities within 50 feet (15 m) of excavation, sample locations, and sample identification numbers. On-site stockpile, storage, treatment, loading, and disposal areas shall also be shown on the drawings.
 - h. Progress Photographs. Color photographs shall be used to document progress of the work. A minimum of four views of the site showing the location of the area of contamination, entrance/exit road, and any other notable site conditions shall be taken before work begins. After work has been started, activities at each work location shall be photographically recorded daily **OR** weekly, **as directed**. Photographs shall be a minimum of 3 x 5 inches (76.2 x 127.0 mm) and shall include:
 - 1) Soil removal and sampling.
 - 2) Dewatering operations.
 - 3) Unanticipated events such as spills and the discovery of additional contaminated material.
 - 4) Contaminated material/water storage, handling, treatment, and transport.
 - 5) Site or task-specific employee respiratory and personal protection.
 - 6) Fill placement and grading.



-
- 7) Post-construction photographs. After completion of work at each site, the Contractor shall take a minimum of four views of each excavation site. A digital version of all photos shown in the report shall be included with the Closure Report. Photographs shall be a minimum of 3 inches by 5 inches (76mm by 127 mm) and shall be mounted back-to-back in double face plastic sleeves punched to fit standard three ring binders. Each print shall have an information box attached. The box shall be typewritten and arranged as follows:
- Project Name: Direction of View:
 - Location: Date/Time:
 - Photograph No.: Description of View:

END OF SECTION 02 81 00 00



SECTION 02 81 00 00a - DISPOSAL OF HAZARDOUS MATERIALS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for disposal of hazardous materials. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definition

1. Hazardous materials shall be defined as asbestos containing materials, lead-based paint, PCBs, bird waste, and other materials categorized as hazardous by the EPA.

C. Submittals

1. Before start of work: At the pre-construction meeting, the Contractor shall submit the following to the Owner's Representative for review. Do not start work until these submittal are returned with Owner's Representative stamp indicating that the submittal is returned for unrestricted use.
 - a. Copy of State or local license for hazardous waste hauler.
 - b. Certificate of at least one on-site supervisor which has satisfactorily completed the OSHA 40 hour Health and Safety course for handling hazardous materials.
 - c. Certificates of workers which have successfully completed the OSHA 40-Hour Health and Safety Course for Hazardous Materials.
 - d. List of the employees scheduled to perform this work.
 - e. Schedule of start and finish times and dates for this work.
 - f. Name and address of landfill where these waste materials are to be deposited. Include contact person and telephone number.
 - g. Material Safety Data Sheet (MSDS) for all materials to be removed.
 - h. If contractor introduces any chemical into the work environment, a MSDS for that chemical must be presented to the Owner's Representative prior to use.
 - i. Transporter must have notified the EPA and/or other appropriate local government agency in advance of its intentions to transport hazardous materials and, if applicable, receive an identification number.
 - j. Contingency Plan for handling emergencies with spills or leaks.
 - k. Certificates of workers which have successfully completed the OSHA 24-Hour Health and Safety Course for Hazardous Materials.

1.2 PRODUCTS**A. Materials**

1. Drums: Recovery or salvage drums acceptable for disposal of hazardous waste. Prior approval of drums is required. Drums or containers must meet the required OSHA, EPA (40 CFR Parts 264-264 and 300), and DOT Regulations (49 CFR Parts 171-178). Use of damaged containers shall not be allowed.
2. Labels: As required by the EPA and OSHA for handling, transportation, and disposal of hazardous waste.
3. Absorbent Material: Clay, soil or any commercially available absorbent used for the purpose of absorbing hazardous or potentially hazardous materials.

1.3 EXECUTION



-
- A. All waste shall be transported and disposed of in accordance with all federal, state and local guidelines and regulations. The contractor is to obtain all permits, licenses, etc., which are necessary for the transporting and disposal of hazardous waste.
 - B. Waste haulers shall maintain waste manifest and shipment record forms.

END OF SECTION 02 81 00 00a

**SECTION 02 82 16 00 - ENCAPSULATION (LOCK-DOWN) OF ASBESTOS-CONTAINING MATERIALS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for encapsulation (lock-down) of asbestos-containing materials. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: Manufacturers technical information including label analysis and application instructions for each material proposed for use.
2. Installation Instructions: Manufacturer's installation instructions with specific project requirements noted.
3. Performance Warrantee: Manufacturers performance guarantee.
4. Material Safety Data Sheet: Material Safety Data Sheet in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200) for each surfactant and encapsulating material proposed for use on the work. Include a separate attachment for each sheet indicating the specific worker protective equipment proposed for use with the material indicated.

C. Delivery And Storage: Deliver materials to the job site in original, new and unopened packages and containers bearing manufacturer's name and label, and following information:

1. Name or title of material
2. Manufacturer's stock number and date of manufacture
3. Manufacturer's name
4. Thinning instructions
5. Application instructions
6. Deliver materials together with a copy of the OSHA Material
7. Safety Data Sheet for the material.

D. Job Conditions: Apply encapsulating materials only when environmental conditions in the work area are as required by the manufacturer's instructions.

E. Quality Assurance

1. Testing: Test material to be encapsulated using methods set forth in ASTM E1494 "Standard Practice for Encapsulants for Spray-or-Trowel-Applied Friable Asbestos- Containing Building Materials."

F. Warranty

1. Performance Warranty: Contractor shall submit written Performance Warranty, executed by the contractor, agreeing to repair/replace spray-on work which has cracked, fallen from substrate, or otherwise deteriorated to a condition where it would not perform effectively for its intended purposes due substantially to defective materials or workmanship and not due to abuse by occupants, improper maintenance, unforeseeable ambient exposures or other causes beyond anticipated conditions and contractors control. Warranty period shall be for at least one year after date of Final Completion.

1.2 PRODUCTS

A. Materials



1. Encapsulant system shall be an acrylic, elastomeric type, spray, brush or roller-applied, tinted penetrating or tinted bridging type, specifically designed for application to asbestos-containing material. System shall be equal to Global Encasement System as manufactured by GLOBAL Encasement Inc., 132-32nd Street, Union City, NJ 07087 U.S.A., Tel. (800) 266-3982/(201) 902-9770.
 - a. All encasement topcoat materials shall be warranted to be heavy-bodied, from the same manufacturer, and shall be long lasting, highly-pure (low VOC) materials that remain flexible, chalk resistant and resist cracking, peeling, algae and fungus that can cause future indoor air quality concerns.
 - b. To allow for building movement without cracking or disturbing fibrous materials, coating systems shall have passed testing to ASTM standards for adhesion, permeability, aged flexibility and with aged elasticity for the encasement system of over 250%.
 - c. Coatings shall be Class A Fire Rated, water-based, non-toxic, safe and easy to use, contain no hazardous ingredients by OSHA definition, comply with all known building codes and be non-flammable.
 - d. Coating materials shall have low VOC (Volatile Organic Compound) content.
 - e. Coating materials shall not release health threatening toxic smoke and fumes in a fire and shall comply with all known building codes.
 - f. Coating materials shall have passed the following testing standards:
 - 1) ASTM E 119 fire tests demonstrating that applying a multi-layer system over fireproofing does not adversely affect the fireproof rating of the fireproofing (3 hour test).
 - 2) UPITT Combustion Toxicity Test proving nothing toxic is released in a fire.
 - 3) ASTM E 84 and E162 fire tests for "Class A" - Surface Flammability and Burning Characteristics (Flame Spread = 0, Smoke Developed = 5).
 - 4) "Pull-off Adhesion" test per ASTM E736 equals or exceeds 9,950 lbs./sq. ft. (89.1 lbs./sq. in.).
 - 5) ASTM D 1653 and E96 "Water Vapor Permeability" (showing the rate that water vapor can pass through the system).
 - 6) Impact Resistance, "Tensile Strength" shall exceed 150 psi; "Elongation" shall exceed 250%.
 - 7) System shall be mildew resistant, impact resistant, scrub resistant, non-yellowing, non-chalking, highly blister resistant, rust resistant, highly chemical resistant and shall remain flexible after 1000 hour ASTM Accelerated Weather testing.
 - 8) Water-Based materials (low VOC) Volatile Organic Content of Primer-Sealer-Neutralizer = 0.1 g/L (0.001 lb./gal.) and Encasement Top Coat = 0.1 g/L (0.001 lb./gal.) as tested by EPA Method 24.
 - 9) Materials comply with applicable standards for installation on interior and/or exterior surfaces of a building.
 - 10) Encasement Systems shall provide additional water-proofing protection.
- B. Related Materials:
1. Elastomeric architectural sealants, caulking compounds, primers, and similar materials shall be approved by the manufacturer of the encasement coatings. All materials used shall be applied in accordance with its manufacturer's recommendations.
- C. Applicable Standards
1. Product shall be rated as acceptable for use intended when field tested in accordance with ASTM E 1494.

1.3 EXECUTION

A. General



1. Prior to applying any encapsulating material in Work Areas, Contractor shall obtain final visual inspection approval by the Project Administrator.
 2. Prior to applying any encapsulating material, Contractor shall ensure that application of the sealer will not cause the base material to fail and allow the sealed material to fall of its own weight or separate from the substrate. Should Contractor doubt the ability of the installation to support the sealant, request direction from the Owner's Representative before proceeding with the encapsulating work.
 3. Do Not Commence Application of encapsulating materials until all removal work within the work area has been completed.
- B. Worker Protection
1. Before beginning work with any material for which a Material Safety Data Sheet has been submitted provide workers with the required protective equipment. Require that appropriate protective equipment be used at all times.
- C. Application
1. Comply with all manufacturer's instructions for particular conditions of installation. Consult with manufacturer's technical representative for conditions not covered.
 2. Encapsulate all surfaces in full compliance with manufacturer's procedures.
 3. At completion of Encapsulation and before removal of Work Area enclosures and Pressure Differential System, decontaminate space in accordance with requirements of manufacturer's instructions.
 4. Remove all debris from the project site and restore area to proper conditions by cleaning all surfaces in accordance with manufacturer's written recommendations.
 5. At completion of work submit manufacturer's record of inspection of completed work and Manufacturers Performance Guarantee executed by both manufacturer and Contractor.

END OF SECTION 02 82 16 00



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SECTION 02 82 33 00 - REMOVAL OF FRIABLE ASBESTOS-CONTAINING MATERIALS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for removal of friable asbestos-containing materials. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Description

1. Furnish all labor, materials, facilities, equipment, services, employee training and testing, permits and agreements necessary to perform the work required for asbestos removal, encapsulation, repair, clean-up, decontamination, re-insulation and all other work in accordance with these specifications, in accordance with the latest regulations from the U.S. Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the recommendations of National Institute of Occupational Safety and Health (NIOSH), and any other applicable federal, state and local government regulations. Whenever there is a conflict or overlap of the above references, the most stringent provision is applicable.
2. The work specified herein shall be performed by competent persons trained, knowledgeable and qualified in the state-of-the-art techniques of asbestos abatement, handling and subsequent cleaning of contaminated areas.

C. Scope

1. The quantities of materials and limits of abatement work area(s) shall be verified by the asbestos contractor.

D. Asbestos Hazard

1. Asbestos-containing material when damaged or disturbed is subject to fiber releases. Wet methods are a primary means of controlling fiber release.
2. Strict compliance with each of the provisions outlined in these specifications for the encapsulation, repair and handling of asbestos-containing material is of great importance, because:
 - a. The inhalation of airborne asbestos fibers can cause a very serious and often fatal disease.
 - b. Workers may not be aware they are inhaling asbestos fibers.
 - c. Symptoms of the disease do not appear for many years.
 - d. Only the Contractor and its employees can prevent the inhalation of asbestos fibers, which can lead to the development of asbestos-related disease.
 - e. No insurance is available to provide for asbestos-related disease.

E. Other Hazardous Material

1. Contractor shall comply with OSHA 29 CFR 1926.62 - Lead in Construction when demolishing any equipment or architectural component identified as lead-containing or lead-based paint. The work of this project is considered a demolition activity.
2. the Owner anticipates that a substantial amount of the Project will involve lead paint.

F. Qualifications

1. the Owner and the Owner's Representative will verify and approve the experience of the Asbestos Abatement Contractor based upon submission at the time of bidding by Contractor evidence of the following:
 - a. Experience: Provide the names and locations of at least three asbestos abatement projects of comparable size and complexity comparable with this work. Provide the names and telephone numbers of contact person at previous projects. Provide the final air monitoring decontamination fiber levels achieved.



- b. Personnel: Provide the name(s) of "Competent Person" as defined by OSHA 29 CFR 1926.32(f) - Asbestos. Demonstrate the education and specialized training with successful completion of examination of an EPA approved course. Provide evidence of participation in five projects of complexity comparable with this project.
- c. Licensing and Certification: The Contractor must hold a current, valid asbestos license issued by the State in which the work is to be performed.

G. Notices And Record Keeping

1. Contractor shall maintain for at least 30 years, a record for each asbestos project in which the Contractor engages. Each record shall include the following information: name, address, and social security number of all personnel involved with the project, the name address and social security number of the OSHA "Competent Person" who will supervise the work, the amount of asbestos material that was removed, repaired, encapsulated or disturbed, the commencement and completion date of the work, copies of Hazardous Waste Manifest(s), personal air monitoring results and any other appropriate information.
2. The Contractor shall send written notification as required by USEPA National Emission Standards for Hazardous Air Pollutants (NESHAPS) Asbestos Regulations (40 CFR 61, Subpart M) to the Owner, at least 10 working days prior to beginning any work on asbestos-containing materials.
3. Include the following information:
 - a. Name and address of the Owner or operator.
 - b. Description of the facility being demolished or renovated, including the size, age, and prior use of the facility.
 - c. Estimate of the approximate amount of asbestos material present in the facility in terms of linear feet of pipe, and surface area on other facility components. For facilities in which the amount of asbestos materials is less than 80 linear meters (260 linear feet) on pipes and less than 15 square meters (160 square feet) on other facility components, explain techniques of estimation.
 - d. Location of the facility being demolished or renovated.
 - e. Scheduled starting and completion dates of demolition or renovation.
 - f. Nature of planned demolition or renovation and method(s) to be used.
 - g. Procedures to be used to comply with the requirements of USEPA National Emission Standards for Hazardous Air Pollutants (NESHAPS) Asbestos Regulations (40 CFR 61 Subpart M).
 - h. Name and location of the waste disposal site where the asbestos waste material will be deposited.
4. Prior to commencement of work, the Contractor shall submit the following documents to the Owner's Representative. No work will be allowed to start until these documents have been approved:
 - a. The schedule of the work, including manpower, length and number of work shifts. Schedule shall be coordinated with the Owner's full occupancy of all areas of the building.
 - b. Satisfactory proof that written notification has been provided to the EPA regional office and the Owner.
 - c. Proof that all required permits, disposal site locations, and arrangements for transportation and disposal of asbestos-contaminated materials, supplies and the like have been obtained.
 - d. Complete a worker certificate indicating that all employees have had instruction and training on the hazards of asbestos exposure, the use and fitting of respirators, protective dress, wet and dry decontamination procedures, entry and exit from work areas, and all aspects of work procedures and protective measures.
 - e. Documentation indicating that all employees have received appropriate medical examinations and have successfully passed fit testing for the respirator to be worn. As a minimum, medical exams must be consistent with OSHA 29 CFR 1926.1101(K)(9)(viii)(G)-Asbestos Regulation.



- f. Samples of signs to be used in and around the work area to comply with OSHA 29 CFR 1926.1101(K)(9)(viii)(I)- Asbestos regulations and as required by federal, state and municipal regulations.
 - g. Material Safety Data Sheets (OSHA form 174 or equivalent) for all chemicals used during work performed under this section.
 - h. Encapsulation data and encapsulation procedures.
 - i. Design of pressure differential system including calculation used to arrive at the number of machines necessary to achieve one air change per every 10 minutes.
 - j. Location of personnel and material decontamination units for each work area.
5. Contractor shall provide written notification to the Owner's Representative of its intent to start work at least five days in advance. In no case will the Contractor start work until authorization to proceed is given.
 6. During the work, Contractor shall maintain a daily log which will be kept at the job site. Items to be included in the daily log shall include but are not limited to the following:
 - a. Meetings, purpose, attendees, discussions, items of resolution.
 - b. Visitations, authorized and unauthorized.
 - c. Sign-in sheets of all personnel entering and leaving the work area.
 - d. Special or unusual events (i.e., barrier breeching equipment failures).
 - e. Personal air monitoring results.
 - f. Two copies of the daily log are required for Project Closeout.
- H. Terminology (Definitions)
1. Abatement - Procedures to control fiber release from asbestos-containing materials. Includes removal, enclosure or encapsulation.
 2. Air Lock - A system for permitting ingress or egress without permitting air movement between any two adjacent areas consisting of two curtained doorways. The air lock must be maintained in an uncontaminated condition at all times.
 3. Air Monitoring; - The process of measuring the asbestos fiber content of a specific volume of air in a stated period of time using methods approved or recommended by OSHA, EPA, NIOSH or other method approved by the Owner or the Owner's Representative.
 4. Amended water - Water to which a surfactant has been added.
 5. Asbestos - A generic name given to a number of naturally occurring hydrated mineral silicates that possess a unique crystalline structure, are incombustible in air, and are separable into fibers. Asbestos includes the asbestiform varieties of Chrysotile (serpentine), Crocidolite (Riebeckite), Amosite (Cummingtonite-Grunente), Anthophyllite, Actinolite, and Tremolite.
 6. Asbestos-containing material (ACM) - Any material that contains more than 1 percent asbestos by weight as determined by Polarized Light Microscopy (PLM).
 7. Authorized Visitor - the Owner or its designated representative, or a representative of any regulatory or other agency having jurisdiction over the project.
 8. Class I - Asbestos work means activities involving the removal of thermal systems insulation (TSI) and surfacing ACM and PACM.
 9. Class II - Asbestos work means activities involving the removal of ACM which is not TSI or surfacing material. This includes, but is not limited to, the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastics.
 10. Class III - Asbestos work means repair and maintenance operations where "ACM" including TSI and surfacing ACM and PACM is likely to be disturbed.
 11. Class IV - Asbestos work means maintenance and custodial activities during which employees contact but do not disturb ACM or PACM and activities to clean-up dust, waste and debris resulting from Class I, II and III activities.
 12. Critical Barrier - A unit of temporary construction which provides the only separation between an asbestos work area and an adjacent, potentially occupied, space. The critical barrier is composed of at least one intact sheet of polyethylene sheeting.
 13. Decontamination Enclosure System - A series of connected rooms with curtained doorways between any two adjacent rooms, for the decontamination of workers or of materials and equipment. A decontamination system contains at least two air locks.



14. Disposal - All procedures necessary to transport and deposit the asbestos-contaminated material stripped and removed from the building in a waste disposal site in compliance with applicable federal, state, and local regulations.
15. Disposal Site - A site approved by the EPA for the disposal of asbestos-containing wastes.
16. Encapsulant - A liquid which can be applied to asbestos-containing materials and which controls the possible release of fibers from the materials.
17. Encapsulation - The use of an agent to seal the surface (bridging encapsulant) or penetrate the bulk (penetrating encapsulant) of the asbestos-containing material.
18. HEPA -High Efficiency Particulate Air - A type of filter which is 99.97% efficient at filtering particles of 0.3 micrometers in diameter.
19. HEPA Vacuum Equipment - Vacuuming equipment equipped with a HEPA filter in the exhaust outlet, and so designed and maintained that 99.97% of all particles of 0.3 micrometer in diameter in the inlet air are collected and retained.
20. Negative Pressure Respirators - Respirators which function by the wearer breathing in air through a filter.
21. NIOSH - National Institute of Occupational Safety and Health.
22. the Owner's Representative - Authorized Consultants
23. Permissible Exposure Level (PEL) - A level of airborne fibers specified by OSHA as an occupational exposure standard for asbestos. It is 0.1 f/cc of air, eight-hour TWA, as measured by Phase Contrast Microscopy.
24. Repair - The restoration of damaged or deteriorated asbestos-containing material to intact condition.
25. Respirator Protection Program - A set of procedures and equipment required by OSHA if employees wear negative pressure respirators or if fiber levels are above the PEL.
26. Surfactant - Chemical wetting agent added to water to improve penetration, thus reducing the amount of water required for a given operation or area, and enhancing the effect of the water in reducing fiber release.
27. Thermal Systems Insulation - Material applied to pipes, fittings, boilers, breeching, tanks, ducts or other interior structural components to prevent heat loss or gain, or water condensation, or for other purposes.
28. Wet Cleaning - The process of eliminating asbestos contamination from building surfaces and objects by using cloths and mops or other cleaning tools that have been dampened with clean water and afterwards disposing of these cleaning tools as asbestos-contaminated waste.

I. Permits And Licenses:

1. The Contractor must maintain current licenses as required by applicable state or local jurisdictions for the removal, transporting, disposal or other regulated activity relative to the work of this contract.

J. Regulations

1. This section sets forth governmental regulations and industry standards which are included and incorporated herein by reference and made a part of the specifications. This section also sets forth those notices and permits which are known to the Owner and which either must be applied for and received, or which must be given to governmental agencies before start of work.
2. Except to the extent that more explicit or more stringent requirements are written directly into the contract documents, all applicable codes, regulations, and standards have the same force and effect (and are made a part of the contract documents by reference) as if copied directly into the contract documents, or as if published copies are bound herewith.
3. The Contractor shall assume full responsibility and liability for the compliance with all applicable federal, state, and local regulations pertaining to work practices, hauling, disposal, and protection of workers, visitors to the site, and persons occupying areas adjacent to the site. The Contractor is responsible for providing medical examinations and maintaining medical records of personnel as required by the applicable federal, state, and local regulations. The Contractor shall hold the Owner and the Owner's Representative harmless for failure to comply with any applicable work,



- hauling, disposal, safety, health or other regulation on the part of itself, its employees, or its Sub-Contractors.
4. Federal requirements which govern asbestos abatement work or hauling and disposal of asbestos waste materials include but are not limited to the following regulations:
 - a. U.S. Department of Labor, Occupational Safety and Health Administration, (OSHA), including but not limited to:
 - 1) U.S. Department of Labor, OSHA, including, but not limited to:
 - a) Occupational Exposure to Asbestos, Tremolite, Anthophyllite and Actinolite; Final Rules
Title 29, Part 1910, Section 1001
Part 1926, Section 1101 of the Code of Federal Regulations
 - b) Respiratory Protection
Title 29, Part 1910, Section 134 of the Code of Federal Regulations
 - c) Construction Industry
Title 29, Part 1926.1011, of the Code of Federal Regulation
 - d) Access to Employee Exposure and Medical Records
Title 29, Part 1910, Section 2 of the Code of Federal Regulations
 - e) Hazard Communication
Title 29, Part 1910, Section 1200 of the Code of Federal Regulations
 - f) Specifications for Accident Prevention Signs and Tags
Title 29, Part 1910, Section 145 of the Code of Federal Regulations
 - 2) U.S. Environmental Protection Agency (EPA) including, but not limited to:
 - a) Asbestos Abatement Projects Rule
40 CFR Part 762
CPTS 62044, FRL 2843-9
Federal Register, Vol. 50 No. 134, July 12, 1985
P28530-28540
 - b) Regulation for Asbestos
Title 40, Part 61, Subpart A of the Code of Federal Regulations
 - c) National Emission Standard for Asbestos
Title 40, Part 61, Subpart M (Revised Subpart B) of the Code of Federal Regulations
 - 3) State requirements which govern asbestos abatement work and/or hauling and disposal of asbestos waste materials.
 - 4) Contractor shall abide by all local requirements which govern asbestos abatement work or hauling and disposal of asbestos waste materials including the following:
 - a) American National Standards Institute (ANSI)
1430 Broadway
New York, NY 10018
(212) 354-3300
 - b) Fundamentals Governing the Design and Operation of Local Exhaust Systems
Publication Z9.2-79
 - c) Practices for Respiratory Protection Publication Z288.2-80
 - d) American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia, PA 19103
(215) 299-5400
 - e) Specification for Encapsulants for Friable Asbestos-Containing Building Materials
 - f) Safety and Health Requirements Relating to Occupational Exposure to Asbestos

K. the Owner's Representative

1. the Owner's Representative is authorized by the Owner to perform the following:
 - a. Have free access to all asbestos work areas.



- b. To assist in interpretation of procedures.
- c. To advise on all provisions of the contract documents pertaining to the control of asbestos.
- d. To stop work if, in the course of performing their monitoring duties, an instance of substantial nonconformance with the contract documents is observed.
- e. To stop work if a situation presenting a health hazard to workers or the Owner's employees or occupants of the building is observed.
- f. To act as the Owner's liaison in technical matters involving the asbestos-related work.
- g. To perform air sampling inside and outside the asbestos work area during the project. The Contractor shall cooperate fully with the Owner's Representative, its agents and employees, and ensure cooperation of its workers during collection of air samples and work area inspections.
- h. the Owner's Representative role in advising the Owner on environmental health matters does not relieve the Contractor's obligation to comply with all applicable health and safety regulations. Air monitoring results generated by the Owner's Representative shall not be used by the Contractor to represent compliance with regulatory agency requirements for monitoring of worker's exposure to airborne asbestos, nor shall any other activity on the part of the Owner's Representative represent the Contractor's compliance with applicable health and safety regulations.

L. Pre-Construction Conference

1. An initial progress meeting recognized as "Pre-Construction Conference" shall be held prior to start of any work. Contractor shall meet at project site, with General Superintendent, the Owner, the Owner's Representative, and other entities concerned with asbestos abatement work. Record discussions and agreements and furnish copy to each participant. Provide at least 72 hours advance notice to all participants prior to convening Pre-Construction Conference.
2. This is an organizational meeting, to review responsibilities and personnel assignments, to locate the containment and decontamination areas; and temporary facilities including power, light, water, etc.
3. Submit waivers on forms, and executed in a manner acceptable to the Owner. Administrative requirements that must proceed or coincide with Contractor's submittal for final payment shall consist of the following:
 - a. Completion of project closeout requirements.
 - b. Completion of items specified for completion beyond time of Final Completion (regardless of whether special payment application was previously made).
 - c. Assurance, satisfactory to the Owner, that unsettled claims will be settled and that work not actually completed and accepted will be completed without undue delay.
 - d. Transmittal of required project construction records to the Owner.
 - e. Landfill receipts for all asbestos-containing material.
 - f. Proof, satisfactory to the Owner, that taxes, fees and similar obligations of Contractor have been paid.
 - g. Removal of temporary facilities, services, surplus materials, rubbish and similar elements.
 - h. Consent of surety for final payment.

M. Project Closeout

1. Project closeout is the term used to describe certain collective project requirements that indicate completion of the work to be fulfilled near the end of the contract time. Also, in preparation for final acceptance of the work by the Owner, as well as, final payment to the Contractor and the normal termination of the Contract.
2. Include supporting documentation for completion as indicated in these contract documents.
3. Submit a statement on accounting of changes to the Contract Sum.
4. Advise the Owner of pending insurance change-over requirements.
5. Submit specific warranties, workmanship and maintenance bonds, maintenance agreements, final certifications and similar documents.



6. Obtain and submit releases enabling the Owner's full, unrestricted use of the work area and access to services and utilities. Where required, include occupancy permits, operating certificates and similar releases.
7. Results of the completed inspection will form the initial "punch-list" for final acceptance.
8. A complete record, certified by the testing laboratory, of all personal air monitoring results.
9. Complete the following cleaning operations as outlined in Paragraph "Decontamination Procedures" before requesting the Owner's Representative inspection for certification of Final Completion.
 - a. Remove exposed labels in finished spaces which are not required as permanent labels on materials supplied as part of the work, except for "Asbestos", "Asbestos Free", or Thermal Insulation Labels specified elsewhere.
 - b. Clean transparent materials, affected by the work including mirrors and window/door glass, to a polished condition, removing substances which are noticeably vision-obscuring materials. Replace broken glass and damaged transparent materials.
 - c. Clean exposed hard-surfaced finishes affected by the work, to a dirt-free condition, free of dust, stains, films and similar distracting substances. Except as otherwise indicated, avoid disturbance of natural weathering of exterior surfaces. Restore reflective surfaces to original reflective condition.
 - d. Clean plumbing fixtures affected by the work to a sanitary condition, free of stains including those resulting from water exposure.
 - e. Replace all HVAC filters using materials supplied by the Owner or clean non-replaceable filters after minimum of two days of operation of HVAC equipment.
 - f. Clean light fixtures and lamps, which have been affected by the work so as to function with full efficiency. Replace lamps where inoperable.
 - g. Repair any damage to wall, ceiling and floor surfaces caused by installation and removal of the polyethylene sheeting.

N. Personnel Protection

1. Prior to commencement of work, the workers shall be instructed and be knowledgeable in the areas described in Paragraph "Submittals and Notices" having to do with employees.
2. Worker Protection - shall comply with 29 CFR 1910.134 (Respiratory Protection).
 - a. Because there is no known safe level of exposure to asbestos, it is prudent to reduce worker's exposures to as low a level as possible. Proper respiratory protection is critical in minimizing exposure.
 - b. Workers shall be provided, as a minimum, with personally issued and marked respirators equipped with high efficiency particulate filters approved by NIOSH to be worn in the designated work area and/or whenever a potential exposure to asbestos exists. Sufficient filters shall be provided for replacement as required by the workers or applicable regulations. Disposable respirators shall not be used.
 - c. No worker shall be exposed to levels greater than 0.01 f/cc as determined by the protection factor of the respirator worn and the work area fiber levels.
 - d. Whenever powered purifying respirator protection is used, a sufficient supply of replacement batteries and HEPA filter cartridges shall be provided to the workers.
 - e. Air monitoring required by OSHA is work of the Contractor and not covered in this specification. Contractor shall post, on a daily basis, results of the air monitoring results from the previous shift. A complete record, certified by the testing laboratory, of all personal air monitoring tests and results will be furnished to the Owner and the Owner's Representative prior to Contractor's Request for Final Payment.
 - f. During encapsulation operations or usage of other organic base aerosols (e.g., spray glue, expanding foam), workers shall be provided with combination cartridges consisting of organic vapor and HEPA sections.
 - g. Workers shall be provided with sufficient sets of protective full-body clothing to be worn in the designated work area and/or whenever potential exposure to asbestos exists. Such clothing shall include, but not be limited to, full-body coveralls, headgear and gloves. Workers shall assure that hoods covering their hair are worn in the designated work areas



- at all times. Eye protection and hard hats shall be provided as required by applicable safety regulations. Eye protection shall be worn during encapsulation operations. Non-disposable type protective clothing and footwear shall be left in the work area until the end of the asbestos abatement work, at which time such items will be disposed of as asbestos waste.
- h. Non-skid footwear shall be provided to all abatement workers. Disposable clothing shall be adequately sealed to the footwear to prevent body contamination.
 - i. Protective clothing shall not be worn in lieu of street clothing outside the work area.
 - j. Visitor Clothing: The Contractor shall provide authorized visitors with suitable respirator, protective clothing, headgear, eye protection, and footwear as described herein, whenever they enter the work area.
3. Decontamination and Work Procedures: The decontamination and work procedures to be followed by workers shall be posted as described in these specifications.
 4. Worker and Authorized Visitor Protection Procedures:
 - a. Each worker and authorized visitor shall, upon entering the job site, remove street clothes in a designated clean change area and put on a respirator with new filters and clean protective clothing before entering the work area.
 - b. The Contractor's employees shall perform a positive/negative respirator fit test each time it enters the work area. If leakage occurs, the respirator must be re-adjusted or replaced.
 - c. Workers shall maintain their respirators in a safe operating condition. The condition of respirators shall be checked daily.
 - d. Workers and visitors shall complete the decontamination procedures as outlined in the specification upon exiting the work area.
 - e. Workers shall not eat, drink, smoke, or chew gum or tobacco in or near the asbestos work areas.
 - f. Workers shall be fully protected with respirators and protective clothing immediately prior to the first disturbance of asbestos-containing or contaminated materials and until final cleanup is completed.
- O. Air Monitoring
1. The airborne fiber counts outside the work area will be monitored to detect faults in the work area isolation such as contamination of the building outside of the work areas with airborne asbestos fibers, failure of filtration or rupture in the negative pressure system. Should any of the above occur, the Contractor shall immediately cease asbestos abatement activities until the fault is corrected. Work shall not recommence until authorized by the Owner's Representative. In the case of mini-enclosures the Owner's Representative will monitor air in a remote location of the residence to determine the baseline of asbestos.
 2. The airborne fiber counts in the work area will be monitored. The purpose of this air monitoring will be to detect airborne fiber counts which may significantly challenge the ability of the work area isolation procedures to protect the balance of the building or outside of the building from contamination by airborne fibers. In the case of mini-enclosures the Owner's representative may monitor air outside of several enclosures if they are in close proximity.
 3. Contractor shall maintain an average airborne count inside the work area of less than 0.5 f/cc. If the fiber counts rise above this figure for any sample taken, revise work procedures to lower fiber counts. If the TWA fiber count for any work shift or eight-hour period exceeds 0.5 f/cc, stop all work, leave pressure differential system in operation and notify the Owner's Representative. Do not recommence work until authorized in writing by the Owner's Representative.
 4. If airborne fiber counts exceed 1.0 f/cc for any period of time cease all work until fiber counts fall below 0.5 f/cc and notify the Owner's Representative. Do not recommence work until authorized in writing by the Owner's Representative.
 5. If any air sample taken outside of the work area exceeds the 0.01 f/cc of air, Contractor shall immediately and automatically stop all work. If this air sample was taken inside the building and outside of critical barriers around the work area, immediately erect new critical barriers to isolate the affected area from the balance of the building. Erect Critical Barriers at the next existing structural isolation of the involved space (e.g., wall, ceiling, and floor). Leave Critical Barriers in



- place until completion of work and insure that the operation of the negative pressure system in the work area results in a flow of air from the balance of the building into the affected area.
6. If the exit from the clean room of the personnel decontamination unit enters the affected area, establish a temporary decontamination facility consisting of a shower room and changing room. After cleaning and decontamination of the affected area remove the shower room and leave the changing room in place as an air lock.
 7. After certification of visual inspection in the work area, remove critical barriers separating the work area from the affected area. Final air samples will be taken within the entire area.
 8. The following procedure will be used to resolve any disputes regarding fiber types when a project has been stopped due to excessive airborne fiber counts. "Airborne Fibers" referred to above include all fibers regardless of composition as counted in the Phase Contrast Microscopy (PCM) NIOSH 7400 Method procedures. If work has stopped due to high airborne fiber counts, air samples will be secured in the same area by the Owner's Representative for analysis by electron microscopy. "Airborne fibers" counted in samples analyzed by Scanning or Transmission Electron Microscopy (TEM) shall be only asbestos fibers, but of any diameter and length. Subsequent to analysis by Electron Microscopy the number of airborne fibers shall be determined by multiplying the number of fibers, regardless of composition, counted by the PCM NIOSH 7400 Method procedure by a number equal to asbestos fibers counted divided by all fibers counted in the electron microscopy analysis.
 9. If electron microscopy is used to arrive at the basis for determining airborne fiber counts in accordance with the above paragraph, and if the average of airborne asbestos fibers in all samples taken exceeds 0.1 f/cc, or if any one sample exceeds 0.2 f/cc, then the cost of such analysis will be born by the Contractor, at no additional cost to the Owner.
 10. the Owner's Representative will secure at least the following air samples to establish a base line before start of work involving large enclosures:

Location Sampled	Number of Samples	Analysis Method	Detection Limit f/cc	Minimum Volume Liters	Rate LPM
Each Work Area	1	PCM	0.01	1,900	2-16
Outside Each Work Area	1-3	PCM	0.01	1,900	2-16

11. Base Line is an action level expressed in f/cc, which is ten percent greater than the largest of the following:
 - a. Average of the samples collected on cellulose ester filters outside each work area.
 - b. Average of the samples collected on cellulose ester filters outside the building.
 - c. 0.01 fibers per cubic centimeter.
12. Daily: From start of work of Paragraph "Temporary Enclosure" through the work of Paragraph "Project Decontamination," the Owner may be taking the following samples on a daily basis. The location of each air sample will be determined by the Owner's Representative.
 - a. Baseline
 - b. Work Area
13. For larger enclosures samples will be collected on 25 mm cassettes with the following filter media:

PCM: 0.8 micrometer mixed cellulose ester.

Location Sampled	Number of Samples	Analysis Method	Detection Limit f/cc	Minimum Volume Liters	Rate LPM
Each Work Area	2	PCM	0.01	1,900 as required by conditions	2-16
Outside Each Work Area Critical Barrier	1	PCM	0.01	1,900	2-16
Clean Room	1	PCM	0.01	1,900	2-16
Equip Decon	1	PCM	0.01	1,900	2-16



14. Additional samples may be taken at the Owner or the Owner's Representative discretion. If airborne fiber counts exceed allowed limits, additional samples will be taken as necessary to monitor fiber levels.
15. The services of a testing laboratory will be employed by the Owner to perform laboratory analysis of the air samples. Samples will be sent daily so that verbal reports on air samples can be obtained in a timely manner. A complete record, certified by the testing laboratory, of all air monitoring tests and results will be furnished to the Owner's Representative, the Owner and the Contractor.
16. Air samples may be analyzed on site by the Owner's Representative, if they are to be analyzed by the NIOSH 7400 Method.
17. Cellulose ester filters will be analyzed using the PCM NIOSH 7400 Method. Thus analysis will be carried out at a laboratory located off the job site.
18. At the completion of the work in occupied areas and prior to the dismantling of the isolation system, final air clearance will be conducted by the Owner's Representative.
19. Decontamination of the work area will be considered complete when all samples indicate fiber levels are less than 0.01 f/cc of air as analyzed by PCM NIOSH 7400 Method or an average of less than 70 structures per square millimeter of filter area as analyzed by TEM; Level II AHERA Method.
20. The Contractor may conduct its own air monitoring and laboratory testing. If it elects to do this the cost of such air monitoring and laboratory testing shall be included in the Contract Sum.

P. Equipment Removal Procedures

1. Clean all external surfaces of contaminated waste containers and equipment thoroughly by wet sponging or HEPA vacuuming before moving such items into the equipment decontamination enclosure system washroom for final cleaning and removal to uncontaminated areas. Ensure that personnel do not leave the work areas through the equipment decontamination enclosure system.

Q. Disposal Activities

1. It is the responsibility of the Contractor to comply with current federal, state and local regulations concerning the waste handling, transportation, and disposal of asbestos-containing material (ACM) and accompanying solvents or residues.
2. The Contractor will document actual disposal of the waste at the designated landfill by completing Disposal Certificate or submitting proof of landfill receipt.

1.2 PRODUCTS

A. Materials

1. All Contractor's equipment delivered to the site shall be free of asbestos contamination.
2. Store all materials subject to damage off the ground, away from wet or damp surfaces, and under cover sufficient to prevent damage or contamination.
3. Damaged or deteriorating materials shall not be used and shall be removed from the premises. Materials that become contaminated shall be disposed of in accordance with applicable regulations.
4. Polyethylene flame retardant sheet of 6-mil thickness shall be used unless otherwise specified. Polyethylene sheeting shall be sized to minimize the frequency of joints. Polyethylene sheeting must satisfy the National Fire Prevention Association Standard 701, "Small Scale Fire Test for Flame Resistant Textile and Film."
5. Adhesive tape shall be capable of sealing joints of adjacent sheets of polyethylene and for use in attachment of polyethylene sheet to finished or unfinished surfaces of similar materials and shall be capable of adhering under dry and wet conditions, including use of amended water. Contractor shall use adhesive tape compatible with finished surfaces.



6. Protective devices such as, but not limited to, disposable clothing, respirators, gloves, hard hats, etc. shall be used.
7. Wetting agent shall be a mixture of 50/50 polyoxyethylene ether and polyglycol ester or equivalent commercial product.
8. Encapsulant materials shall be the bridging and penetrating type and conform with the following characteristics:
 - a. Encapsulants shall not be solvent-based or utilize a hydrocarbon in the liquid in which the solid parts of the encapsulant are suspended.
 - b. Encapsulant shall not be flammable.
9. A non-hardening lagging sealer for enclosing and sealing raw exposed edges and surfaces of asbestos-containing materials.
10. Pre-mixed or job mixed insulating plaster manufactured for use on plumbing equipment shall be used when repairing damaged thermal insulation material.
11. Non-woven fibrous glass mat and open weave glass fiber mat cloth for repair of thermal systems insulation.
12. Fire retardant sealant shall prevent fire, smoke, water and toxic fumes from penetrating through sealants. Sealant shall have a flame spread, smoke and fuel contribution of zero, and shall be ASTM and Underwriter's Laboratory (UL) rated for three hours for standard method of fire test for fire stop systems.

B. Tools And Equipment

1. Provide suitable tools for repair and encapsulation of asbestos-containing materials and for removal of asbestos-containing materials that are beyond repair. Wire brushes shall not be used as a means of removing or cleaning asbestos-containing materials from surfaces, if they are used as the surface is being sprayed with water or amended water.
2. Provide sufficient number of HEPA-filtered vacuum cleaners equipped with pick-up adapters, steel floor wands, crevice tools, and carpet tools.
3. Airless sprayers capable of spraying amended water shall be provided in sufficient number to allow continuous uninterrupted work.
4. Asbestos filtration devices shall utilize high efficiency particulate air (HEPA) filtration systems.
5. Transportation equipment, as required, shall be suitable for loading, temporary storage, and unloading of contaminated waste without exposure to persons or property, and shall be quiet in motion if used within the building.

1.3 EXECUTION

A. Safety Procedures For Power And Lighting

1. The use of wet methods for removal, repair, encapsulation or cleaning procedures increases the potential for electrical shock when working around electrical panels, conduit, light fixtures, alarm systems, junction boxes, transformers, etc. In coordination with the Owner, de-energize as much electrical equipment as possible to prevent electrical shock to employees performing the work. The Contractor shall use the following precautions:
 - a. Use non-conductive tools and vacuum attachments.
 - b. Utilize "hot line" covers over energized cables and power lines when possible.
 - c. Ensure all electrical equipment in use is properly grounded before the job starts. Check outlets, wiring, extension cords and power pickups.
 - d. Avoid stringing wiring across floors. Elevate wiring if possible.
 - e. Ensure electrical outlets are tightly sealed and taped to avoid water spray.
 - f. Determine operating voltages of equipment and lines before working on or near energized parts.
 - g. Energized parts must be insulated or guarded from employee contact and other conductive objects. Extension cords must be three-wire type and connected to a Ground Fault Interrupter (GFI) circuit.
 - h. Lock or secure de-energized circuits at panel and post warning signs.



- i. Seal heating vents with two layers of polyethylene sheeting prior to the start of work. The Contractor shall repair any damage caused by Contractor's operations to duct work, grilles, dampers, louvers or HVAC equipment at the completion of the work at Contractor's expense. Coordinate all lock out and or de-energizing with the Owner.

B. Temporary Facilities

1. Use qualified tradesmen for installation of temporary services and facilities. Locate temporary services and facilities where they will serve the entire project adequately and result in minimum interference with the performance of the work and operations of the building. Coordinate all installations and shut downs with building owner.
2. Relocate, modify and extend services and facilities as required during the course of work so as to accommodate the entire work of the project.
3. Provide new or used materials and equipment that are undamaged and in serviceable condition. Provide only materials and equipment that are recognized as being suitable for the intended use, by compliance with appropriate standards.
4. During the erection and/or moving of scaffolding, care must be exercised so that the polyethylene floor covering is not damaged.
5. Clean, as necessary, debris from non-slip surfaces.
6. At the completion of abatement work, clean all construction aids within the work area, wrap in one layer of 6-mil polyethylene sheet and seal before removal from the work area.
7. Temporary water service connections to the Owner's water system shall include back flow protection. Valves shall be temperature and pressure rated for operation of the temperatures and pressures encountered.
8. Employ heavy-duty abrasion-resistant hoses with a pressure rating 50 percent greater than the maximum pressure of the water distribution system to provide water into each work area and to each Decontamination Unit. Provide fittings as required to allow for connection to existing wall hydrants or spouts, as well as temporary water heating equipment, branch piping, showers, shut-off nozzles and equipment.
9. Electrical Services shall comply with applicable NEMA, NECA and UL standards and governing regulations for materials and layout of temporary electric service.
10. Provide a weatherproof, grounded temporary electric power service and distribution system of sufficient size, capacity, and power characteristics to accommodate performance of work during the construction period. Install temporary lighting adequate to provide sufficient illumination for safe work and traffic conditions in every area of work.
11. Provide receptacle outlets equipped with ground fault interrupters, reset button and pilot light, for plug-in connection of power tools and equipment.
12. Use only grounded extension cords; use "hard-service" cords where exposed to abrasion and traffic. Use single lengths or use waterproof connectors to connect separate lengths of electric cords, if single lengths will not reach areas of work. All cords shall be elevated off the floor inside the containment area.
13. Temporary wiring in the work area shall be type UL non-metallic sheathed cable located overhead and exposed for surveillance. Do not wire temporary lighting with plain, exposed (insulated) electrical conductors. Provide liquid tight enclosures or boxes for wiring devices.
14. Provide Type "A" fire extinguishers for temporary offices and similar spaces where there is minimal danger of electrical or grease-oil-flammable liquid fires. In other locations provide type "ABC" dry chemical extinguishers, or a combination of several extinguishers of NFPA recommended types for the exposures in each case.
15. Use of the Owner's existing toilet facilities, as indicated, will be permitted, so long as these facilities are properly cleaned and maintained in a condition acceptable to the Owner. At Final Completion, restore these facilities to the condition prevalent at the time of initial use. All provisions of these specifications regarding leaving the work area must be met.
16. When mini-enclosures area being used all of the requirements above will be enforced by the Owner's Representative. The construction and set-up of the mini-enclosures may be done by the Abatement Contractor.



C. Pressure Differential System

1. Before start of work Contractor shall submit design of pressure differential system to the Owner's Representative for review. Do not begin work until system has been approved by the Owner's Representative. Include in the submittal the following:
 - a. Number of pressure differential machines required and the calculations necessary to determine the number of machines.
 - b. Description of projected air-flow within work area and methods required to provide adequate air flow in all portions of the work area.
2. If the enclosure is not a mini-enclosure, the Contractor must supply the required number of asbestos air filtration units to the site in accordance with these specifications. Each unit shall include the following:
 - a. Cabinet constructed of steel or other durable materials able to withstand damage from rough handling and transportation. The width of the cabinet should be less than 30 inches to fit through standard-size doorways. Cabinet shall be factory sealed to prevent asbestos-containing dust from being released during use, transport, or maintenance. Access to and replacement of all air filters shall be from intake end. Unit shall be mounted on casters or wheels.
 - b. Rate capacity of fan according to useable air-moving capacity under actual operating conditions. Use centrifugal-type fan.
 - c. The final filter shall be the HEPA type. The filter media (folded into closely pleated panels) must be completely sealed on all edges with a structurally rigid frame.
 - d. A continuous rubber gasket shall be located between the filter and the filter housing to form a tight seal.
 - e. Provide HEPA Units that are individually tested and certified on site by an independent testing agency to have an efficiency of not less than 99.97 percent when challenged with 0.3 m dioctylphthlaate (DOP) particles when tested in accordance with Military Standard Number 2182 and Army Instruction Manual 136-300-175A. Provide filters that bear a UL586 label to indicate ability to perform under specified conditions.
 - f. Pre-filters, which protect the final filter by removing the larger particles, are required to prolong the operating life of the HEPA filter. Two stages of pre-filtration are required. The first-stage pre-filter shall be a low-efficiency type (e.g., for particles 10 microns and larger). The second-stage (or intermediate) filter shall have a medium efficiency (e.g., effective for particles down to 5 microns). Pre-filters and intermediate filters shall be installed either on or in the intake grid of the unit and held in place with special housings or clamps.
 - g. Each unit shall be equipped with a Magnahelic gauge or manometer to measure the pressure drop across filters and indicate when filters have become loaded and need to be changed. A table indicating the useable air-handling capacity for various static pressure readings on the Magnahelic gauge shall be affixed near the gauge for reference, or the Magnahelic reading indicating at what point the filters should be changed, noting Cubic Feet per Minute (CFM) air delivery at that point. Provide units equipped with an elapsed time meter to show the total accumulated hours of operation.
 - h. The unit shall have an electrical (or mechanical) lockout to prevent fan from operating without a HEPA filter. Units shall be equipped with automatic shutdown system to stop fan in the event of a major rupture in the HEPA filter or blocked air discharge. Warning lights are required to indicate normal operation, too high a pressure drop across the filters (i.e., filter overloading), and too low of a pressure drop (i.e., major rupture in HEPA filter or obstructed discharge).
 - i. Electrical components shall be approved by the National Electrical Manufacturers Association (NEMA) and Underwriters' Laboratories (UL). Each unit shall be equipped with overload protection sized for the equipment. The motor, fan, fan housing, and cabinet shall be grounded.
 - j. If a mini-enclosure is used the air filtration unit may be a HEPA filtered vacuum with a flow rate of at least 100 cubic feet per minute (CFM).
3. Provide a fully operational pressure differential system within the work area maintaining continuously a pressure differential across work area enclosures of 0.02 inches of water for glove



- bag operations and mini-containments. Demonstrate to the Owner's Representative the pressure differential by use of pressure differential meter or a manometer, before disturbance of any asbestos-containing materials. In the case of a mini-enclosure visual evidence of pressure differential through the use of a smoke generation tube shall be sufficient as in paragraph C.13 of this section.
4. Continuously monitor and record the pressure differential between the work area and the building outside of the work area.
 5. Provide fully operational negative pressure systems supplying a minimum of one air change every ten minutes (six changes per hour), less in the instance of a mini-enclosure. Determine the volume in cubic feet of the work area by multiplying floor area by ceiling height. Determine total ventilation requirement in cubic feet per minute (cfm) for the work area by dividing this volume by the air change rate.
 6. Ventilation Required (CFM) = Volume of work area (cu. ft.)/10 min.
 7. Determine number of units needed to achieve ten-minute change rate by dividing the ventilation requirement (CFM) above capacity of exhaust unit(s) used. Capacity of a unit for purposes of this section is the capacity in cubic feet per minute with fully loaded filters (pressure differential which causes loaded filter warning light to come on) in the machines labeled operating characteristics.
 8. Add one additional unit as a backup in case of equipment failure or machine shutdown for filter changing.
 9. Locate exhaust unit(s) so that makeup air enters work area primarily through decontamination facilities and traverses work area as much as possible. This may be accomplished by positioning the unit(s) at a maximum distance from the worker access opening or other makeup air sources.
 10. Vent to outside of building, unless authorized in writing by the Owner's Representative.
 11. Each unit shall be serviced by a dedicated minimum 115v-20A circuit with overload device tied into an existing building electrical panel which has sufficient spare capacity to accommodate the load of all pressure differential units connected. Dedication of an existing circuit may be accomplished by shutting down existing loads on the circuit.
 12. Test pressure differential system before any asbestos-containing material is wetted or removed. After the work area has been prepared, the decontamination facility set up, and the exhaust unit(s) installed, start the unit(s) (one at a time). Demonstrate operation and testing of pressure differential system to the Owner's Representative.
 13. Demonstrate of operations of the pressure differential system to the Owner's Representative will include, but not be limited to, the following:
 - a. Plastic barriers and sheeting move lightly in toward work area.
 - b. Curtain of decontamination units move lightly in toward work area.
 - c. There is a noticeable movement of air through the decontamination unit. Use stroke tube to demonstrate air movement from clean room, and from equipment room to work area.
 - d. Use smoke tubes to demonstrate a positive motion of air across all area in which work is to be performed.
 - e. Use a differential pressure meter or manometer to demonstrate a pressure difference of at least 0.02 inches (as allowed) of water across every barrier separating the work area from the balance of the building or outside. This is not required in the case of a mini enclosure.
 14. Start exhaust units before beginning work (before any asbestos-containing material is disturbed). After abatement work has begun, run units continuously to maintain a constant negative pressure until decontamination of the work area is complete. Do not turn off units at the end of the work shift or when abatement operations temporarily stop.
 15. Do not shut down pressure differential system during encapsulating procedures, unless authorized by the Owner's Representative in writing. Start abatement work at a location farthest from the exhaust units and proceed toward them. If an electric power failure occurs, immediately stop all abatement work and do not resume until power is restored and exhaust units are operating again.
 16. At completion of abatement work, allow exhaust units to run as specified to remove airborne fibers that may have been generated during abatement work and cleanup and to purge the work area with clean makeup air. The units may be required to run for a longer time after decontamination, if



dry or only partially wetted asbestos material was encountered during any abatement work. In the case of a mini-enclosure the vacuum may be removed and the entrance sealed following encapsulation until the clearance sample is collected.

- 17. Prior to final air test, remove pre-filter and wipe out inside lip of negative air machine.
- 18. When a final inspection and the results of final air tests indicate that the area has been decontaminated, exhaust units may be removed from the work area. Before removal from the work area, remove and properly dispose of pre-filter, and seal Intake to the machine with 6-mil polyethylene to prevent environmental contamination from the filters.

D. Work Area Preparation

- 1. The work area is the location where asbestos-abatement work occurs. It is a variable of the extent of work of the contract. It may be a portion of a room, a single room, or a complex of rooms. A "work area" is considered contaminated during the work, and must be isolated from the balance of the building, and decontaminated at the completion of the asbestos-control work.
- 2. Pre-clean fixed objects, walls and floor surfaces within the proposed work areas using HEPA filtered vacuum equipment and wet cleaning methods as appropriate.
- 3. Seal all openings, supply and exhaust vents, and convectors within ten feet of the work area with 6-mil polyethylene sheeting secured and completely sealed with plastic adhesion tape.
- 4. Contact fire control agencies to review procedures prior to start of work.
- 5. Provide flame resistant polyethylene sheeting that conforms to requirements set forth by the National Fire Protection Association Standard 701, Small Scale Fire Test for Flame-resistant Textiles and Films. Provide largest size possible to minimize seams, four- or six- mils thick, frosted or black.
- 6. Provide spray adhesive in aerosol cans which is specifically formulated to stick tenaciously to sheet polyethylene and supporting surface.
- 7. Completely isolate the work area from other parts of the building so as to prevent asbestos-containing dust or debris from passing beyond the isolated area. Should the area beyond the work area(s) become contaminated with asbestos-containing dust or debris as a consequence of the work, clean those areas in accordance with the procedures indicated in Paragraph "Decontamination Procedures." All such required cleaning or decontamination shall be performed at no additional cost to the Owner.
- 8. Place all tools (i.e., scaffolding, staging) necessary for the work in the area to be isolated prior to erection of plastic sheeting temporary enclosure.
- 9. Disable ventilation systems or any other system bringing air into or out of the work area. Disable system by disconnecting wires, removing circuit breakers, by lockable switch or other positive means that will prevent accidental premature restarting of equipment.
- 10. Remove and dispose of all electrical and mechanical items, such as lighting fixtures, clocks, diffusers, registers, escutcheon plates, etc., which cover any part of the surface on which work is to be performed.
- 11. All general construction items such as cabinets, casework, doors and window trim, moldings, ceilings, trim, etc., which cover the surface of the work as required to prevent interference with the work. To be performed by the Owner: clean, decontaminate and reinstall all such materials, upon completion of all removal work with materials, finishes, and workmanship to match existing installations before start of work.
- 12. Permit Access to the work area only through the Decontamination Unit. All other means of access shall be closed off and sealed and warning signs displayed on the clean side of the sealed access.
- 13. Provide Warning Signs at each visual and physical barriers reading as follows in both English and Spanish:

<u>Legend</u>	<u>Notation</u>
KEEP OUT	3" Sans Serif Gothic or Block
BEYOND THIS POINT	1" Sans Serif Gothic or Block
ASBESTOS ABATEMENT WORK	1" Sans Serif Gothic or Block



IN PROGRESS
BREATHING ASBESTOS DUST MAY BE
HAZARDOUS TO YOUR HEALTH

1" Sans Serif Gothic or Block
14 Point Gothic

14. Alternate methods of containing the work area may be submitted to the Owner's Representative for approval. Do not proceed with any such method(s) without prior written approval of the Owner's Representative.
15. Individually seal all ventilation openings (supply and exhaust), lighting fixtures, clocks, doorways, windows, convectors and speakers, and other openings into the work area with plastic adhesion tape alone or with polyethylene sheeting at least 4-mil in thickness, taped securely in place with plastic adhesion tape. Maintain seal until all work including Project Decontamination is completed. Take care in sealing off lighting fixtures to avoid melting or burning of sheeting.
16. Provide sheet plastic barriers at least 6-mil in thickness as required to completely seal openings from the work area into adjacent areas. Seal the perimeter of all sheet plastic barriers with plastic adhesion tape or spray cement.
17. Where applicable, construct framing of the containment out of fire treated wood or aluminum studs. Mini-enclosure frames may be constructed of Polyvinyl Chloride (PVC) tubing.
18. Cover all walls in work area extending to the underside of the ceiling grid system with one layer of polyethylene sheeting, at least 6-mil in thickness, mechanically supported and sealed with plastic adhesion tape or spray-glue in the same manner as "Critical Barrier" sheet plastic barriers. Tape all joints with plastic adhesion tape. Contractor shall be responsible for repair of damaged wall finishes.
19. Cover floor with two layers of 6-mil polyethylene sheeting (exclude for floor tile and adhesive).
20. Provide Pressure Differential System per Paragraph "Pressure Differential System."
21. If the enclosure barrier is breached in any manner that could allow the passage of asbestos debris or airborne fibers, then add the affected area to the work area, enclose it as required by this section of the specification and decontaminate it as described in Paragraph "Decontamination Procedures."
22. Establishing a Mini-Containment area:
 - a. Establish work area so that unauthorized entry is prevented; Construct a two-compartment fire treated wood frame around work area; install one layer 6-mil polyethylene sheeting to structural members and two layers 6 mil polyethylene sheeting to the floor. Exception: no floor required if mini-containment is being constructed to perform a floor tile activity. Seal all edges to wall, ceiling, and floor surfaces with duct tape. Install viewing inspection windows, where feasible.
 - b. Seal all penetrations with duct tape such as pipes, electrical conduit, or ducts contained within the mini-containment.
 - c. Install triple 6-mil polyethylene flaps at both doorways. Place portable sprayer with clean water, disposable towels, and pre-labeled disposal bag in air lock.
 - d. Install appropriate signs on outside of mini-containment area.
 - e. Install HEPA vacuum; extend hose into mini-containment area for general vacuuming, negative air, and cleaning of disposal suit.
 - f. Accumulate all loose materials for disposal. Place in approved container. Apply appropriate labels. Adequately wet clean all wall, floor, tool and equipment surfaces.
 - g. Abatement worker must wear two disposable suits. Remove outer suit in work area and place in a plastic bag. Enter air lock.
 - h. In air lock, wet wipe respirator and wash hands with clean water. Remove respirator and place in a clean plastic bag. Proceed to remote shower unit where inner suit may be removed.

E. Worker Protection

1. This section describes the equipment and procedures required for protecting workers against asbestos contamination and other work place hazards except for respiratory protection.
2. Respiratory Protection is specified in Paragraph "Respiratory Protection."



3. Train in accordance with EPA's Model Accreditation Plan, 40 CFR 763 - Asbestos, all workers in the dangers inherent in handling asbestos and breathing asbestos dust and in proper work procedures and personal and area protective measures. Include but do not limit the topics covered in the course to the following:
 - a. Methods of recognizing asbestos.
 - b. Health effects associated with asbestos.
 - c. Relationship between smoking and asbestos in producing lung cancer.
 - d. Nature of operations that could result in exposure to asbestos.
4. Importance of and instruction in the use of necessary protective controls, practices and procedures to minimize exposure including:

Engineering controls
Work practices
Respirators
Housekeeping procedures
Hygiene facilities
Protective clothing
Decontamination procedures
Emergency procedures
Waste disposal procedures
Appropriate work practices for the work
Requirements of medical surveillance program
Review of OSHA 29 CFR 1926.1101(k)(9)(viii)(G) - Asbestos
Pressure differential systems
Work practices including hands on or on job training
Personal decontamination procedures
Air monitoring, personal and area

5. Provide medical examinations for all workers who may encounter an airborne fiber level of 0.1 f/cc or greater for an 8 hour time weighted average. In the absence of specific airborne fiber data, provide medical examination for all workers who will enter the work area for any reason. Examination shall, at minimum, meet OSHA requirements as set forth in 29 CFR 1926.1101(k)(9)(viii)(G) - Asbestos. In addition, provide an evaluation of the individual's ability to work in environments capable of producing heat stress in the worker.
6. Before start of work Contractor shall submit the following to the Owner's Representative for review. Do not start work until receipt of the Owner's Representative.
 - a. An original signed copy of the Certificate of Worker's Acknowledgement found at the end of this specification, for each worker who is to be at the job site or enter the work area.
 - b. Courses outline or name of institution providing the worker training course.
 - c. Report from medical examination conducted within last 12 months as part of compliance with OSHA medical surveillance requirements for each worker who is to enter the work area.
7. Provide disposable full-body coveralls and disposable head covers, and require that they be worn by all workers in the work area. Provide a sufficient number for all required changes, for all workers in the work area.
8. Provide work boots with non-skid soles, and where required by OSHA, foot protectives, for all workers. Provide boots at no cost to workers. Paint uppers of all boots red with water proof enamel. Do not allow boots to be removed from the work area for any reason, after being contaminated with asbestos-containing material. Dispose of boots as asbestos contaminated waste at the end of the work.
9. Provide head protectives (hard hats) as required by OSHA for all workers, and provide four spares for use by the Owner's Representative, and the Owner. Label hats with same warning labels as used on disposal bags. Require hard hats to be worn at all times that work is in progress that may potentially cause head injury. Provide hard hats with plastic strap type suspension. Require hats



to remain in the work area throughout the work. Thoroughly clean, decontaminate and bag hats before removing them from work area at the end of the work.

10. Provide eye protectives (goggles) as required by OSHA for all workers involved in scraping, spraying, or any other activity which may potentially cause eye injury.
11. Provide work gloves to all workers and require that they be worn at all times in the work area. Do not remove gloves from work area. Dispose of gloves as asbestos contaminated waste at the end of the work.
12. Respirators, disposable coveralls, head covers, and footwear covers shall be provided by the contractor for the Owner, the Owner's Representative, and other authorized representatives who may inspect the job site.
13. Provide worker protection as required by the most stringent OSHA and/or EPA standards applicable to the work. The following procedures are minimums to be adhered to regardless of fiber count in the work area.
14. Each time work is entered, remove all street clothes in the changing room of the Personnel Decontamination Unit and put on new disposable coverall, new head cover, and a clean respirator. Proceed through shower room to equipment room and put on work boots.
15. In the event a mini-enclosure is used refer to Paragraph "Work Area Preparation" for personal decontamination procedures.

F. Respiratory Protection

1. Instruct and train each worker involved in asbestos abatement or maintenance and repair of friable asbestos-containing materials in proper respiratory use and require that each worker always wear a respirator, properly fitted on the face in the work area from the start of any operation which may cause airborne asbestos fibers until the work area is completely decontaminated. Use respiratory protection appropriate for the fiber level encountered in the work place or as required for other toxic or oxygen-deficient situations encountered.
2. Except to the extent that more stringent requirements are written directly into the Contract Documents, the following regulations and standards have the same force and effect (and are made a part of the Contract Documents by reference) as if copied directly into the Contract Documents, or as if published copies were bound herewith. Where there is a conflict in requirements set forth in these regulations and standards meet the more stringent requirement.
 - a. OSHA - U.S. Department of Labor Occupational Safety and Health Administration, Safety and Health Standards 29 CFR 1910, Section 1001 and Section 1910.134.29 CFR 1926.
 - b. ANSI - American National Standard Practices for Respiratory Protection. ANSI Z88.2-1980.
 - c. NIOSH - National Institute for Occupational Safety and Health.
 - d. MSHA - Mine Safety and Health Administration.

G. Type Of Respiratory Protection Required

1. Provide Respiratory Protection as indicated in paragraph below. Where paragraph below does not apply, determine the proper level of protection by dividing the expected or actual airborne fiber count in the work area by the "protection factors" given below. The level of respiratory protection which supplies an airborne fiber level inside the respirator, at the breathing zone of the wearer, at or below 0.01 fibers/cubic centimeter is the minimum level of protection allowed.
2. Eight-hour Time Weighted Average (TWA) of asbestos fibers to which any worker may be exposed shall not exceed 0.1 fibers/cubic centimeter.
3. For purposes of this section fibers are defined as all fibers regardless of composition as counted in the OSHA Reference Method (ORM), NIOSH P&CAM 239 or 7400 procedure, or asbestos fibers of any size as counted using either a scanning or transmission electron microscope.
4. Require that respiratory protection be used at all times that there is any possibility of disturbance of asbestos-containing materials whether intentional or accidental.
5. Require that a respirator be worn by anyone in a work area at all times, regardless of activity, during a period that starts with any operation which could cause airborne fibers until the area has been cleared for re-occupancy.



H. Respiratory Protection Factor

<u>Respirator Type</u>	<u>Protection Factor</u>
Air purifying: Negative pressure respirator High efficiency filter Half facepiece	10
Air purifying: Negative pressure respirator High efficiency filter Full facepiece	50
Powered-air purifying (PAPR): Positive pressure respirator High efficiency filter Half or Full facepiece	100
Type C supplied air: Positive pressure respirator continuous-flow Half or full facepiece	100
Type C supplied air: Positive pressure respirator pressure demand Full facepiece	1000
Type C supplied air: Positive pressure respirator pressure demand Full facepiece Equipped with an auxiliary positive pressure Self-contained breathing apparatus (SCBA)	over 1000
Self-contained breathing apparatus (SCBA): Positive Pressure respirator Pressure demand Full facepiece	over 1000

I. Air Purifying Respirator

1. Provide half face or full face type respirators. Equip full-face respirators with a nose cup or other anti-fogging device as would be appropriate for use in air temperatures less than 32 degrees Fahrenheit.
2. Provide, at a minimum, HEPA type filters labeled with NIOSH and MSHA certification for "Radionuclides, Radon Daughters, Dust, Fumes, Mists including Asbestos-Containing Dusts and Mists" and color coded in accordance with ANSI Z228.2 (1980). In addition, a chemical cartridge section may be added, if required, for solvents, etc., in use. In this case, provide cartridges that have each section of the combination canister labeled with the appropriate color code and NIOSH/MSHA Certification.
3. Supply with a sufficient quantity of respirator filters approved for asbestos, so that workers can change filters during the work day. Require that respirators be wet-rinsed, and filters discarded, each time a worker leaves the work area. Require that new filters be installed each time a worker re-enters the work area. Store respirators and filters at the job site in the changing room and protect totally from exposure to asbestos prior to their use. Do not use single use, disposable or quarterface respirators.



- J. Powered Air Purifying Respirator (PAPR)
1. Provide full-facepiece type respirators. Provide nose-cups for full-facepiece respirators. Provide, at a minimum, HEPA type cartridges approved by NIOSH/MSHA and certified for use in atmospheres containing asbestos dusts.
 2. Provide, at a minimum, one extra battery pack for each respirator so that one can be charging while one is in use.
 3. Provide non-cloth belts capable of being decontaminated in shower.
 4. Supply with a sufficient quantity of high efficiency respirator filters approved for asbestos so that workers can change filters at any time that flow through the face piece decreases to the level at which the manufacturer recommends filter replacement. Require that regardless of flow, filter cartridges be replaced after 40 hours of use. Require that HEPA elements in filter cartridges be protected from wetting during showering. Require entire exterior housing of respirator including blower unit, filter cartridges, hoses, battery pack, face mask, belt, and cords to be washed each time a worker leaves the work area. Caution should be used to avoid shorting battery pack during washing.
- K. Required Respiratory Protection
1. Regardless of airborne fiber levels, require the following minimum level of respiratory protection:
 - a. Half-face air purifying respirators may be used during set-up of the containment and removal of the material so long as fiber counts inside the respirator do not exceed .01 f/cc fibers per cubic centimeter.
- L. Decontamination Units -Three-Stage
1. Provide a Personnel Decontamination Unit consisting of a serial arrangement of rooms or spaces, Changing Room, Shower Room, Equipment Room adjacent to each full containment area.
 2. Require all persons without exception to pass through this decontamination unit for entry into and exiting from the work area for any purpose. Do not remove equipment or materials through Personnel Decontamination Unit.
 3. Changing (Clean) Room:
 - a. Provide a room that is physically and visually separated from the rest of the building for the purpose of changing into protective clothing.
 - b. Locate so that access to work area from changing room is through shower room.
 - c. Separate changing room from the building by a double-sheeted polyethylene flapped doorway.
 - d. Provide sub-panel at changing room to accommodate all removal equipment. Power sub-panel directly from a building electrical panel. Connect all electrical branch circuits in decontamination unit and particularly any pumps in shower room to a ground-fault circuit protection device.
 4. Shower Room:
 - a. Provide a completely water tight operational shower to be used for transit by cleanly dressed workers heading for the work area from the changing room, or for showering by workers headed out of the work area after undressing in the equipment room.
 - b. Construct room by providing a shower pan and two shower walls in a configuration that will cause water running down walls to drip into pan. Install a freely draining wood floor in shower pan at elevation of top of pan.
 - c. Separate this room from rest of building, drying room and airlock with airtight walls fabricated of 6-mil polyethylene.
 - d. Provide splash proof entrances to Drying Room and Airlock.
 5. Equipment Room (contaminated area):
 - a. Require work equipment, footwear and additional contaminated work clothing to be left here. This is a change and transit area for workers. Separate this room from the work area by a 6-mil polyethylene flap doorway.
 - b. Separate this room from the rest of the building, the shower room and work area with air tight walls fabricated of 6-mil polyethylene.



- 6. Clean Room: Provide Clean Room to isolate the holding room from the building exterior.
- 7. Load-out Area:
 - a. The load-out area is the transfer area from the building to a truck or dumpster.
 - b. Wet wipe bags before they are passed through the equipment decon-chamber.
 - c. When cleaning is complete pass items into holding room. Close all doorways except the doorway between the holding room and the Clean Room.
 - d. Workers from the area outside the containment area enter holding area and remove decontaminated equipment and/or containers for disposal.
 - e. Require these workers to wear full protective clothing and appropriate respiratory protection.
 - f. At no time is a worker from an uncontaminated area to enter the enclosure when a removal worker is inside.
 - g. Post an approximately 20 inch x 14 inch manufactured caution sign at each entrance to the work area displaying the following legend with letter sizes and styles of a visibility required by OSHA 29 CFR 1926.1101(k)(9)(viii)(J) - Asbestos.

LEGEND
DANGER

ASBESTOS

CANCER AND LUNG DISEASE HAZARD
RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED
IN THIS AREA

- h. Provide spacing between respective lines at least equal to the height of the respective upper line.
- i. Additional Signage: Shall also be posted in accordance with OSHA 29 CFR 1926.1101(k)(9)(viii)(J) - Asbestos

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD

AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA

DANGER
ASBESTOS
CANCER AND LUNG HAZARD
KEEP OUT

- j. Post an approximately 10 inch by 14 inch manufactured sign at each entrance to each work area displaying the following legend with letter sizes and styles of a visibility at least equal to the following:

<u>LEGEND</u>	<u>NOTATION</u>
No Food, Beverages or Tobacco Permitted	3/4 inch Block
All Persons Shall Don Protective Clothing (Coverings) Before Entering the Work Area	3/4 inch Block
All Persons Shall Shower Immediately After Leaving Work Area and Before Entering the Changing Area	3/4 inch Block



M. Decontamination Procedures

1. Contractor shall require all workers and visitors to adhere to the following personal decontamination procedures whenever they leave the work area:
 - a. Require that all workers use the following decontamination procedure as a minimum requirement whenever leaving the work area.
 - b. When exiting area, remove disposable coveralls, disposable head covers, and disposable footwear covers or boots in the Equipment Room.
 - c. Still wearing respirators, proceed to showers. Showering is mandatory. Care must be taken to follow reasonable procedures in removing the respirator to avoid asbestos fibers while showering. The following procedure is required as a minimum:
 - 1) Thoroughly wet body including hair and face. If using a PAPR, hold blower unit above head to keep canisters dry.
 - 2) With respirator still in place thoroughly wash body, hair, respirator face piece, and all parts of the respirator except the blower unit and battery pack on a PAPR. Pay particular attention to seal between face and respirator and under straps.
 - 3) Take a deep breath, hold it and/or exhale slowly, completely wet hair, face, and respirator. While still holding breath, remove respirator and hold it away from face before starting to breathe.
 - 4) Carefully wash face-piece of respirator inside and out.
 - d. If using PAPR, shut down in the following sequence, first cap inlets to filter cartridges, then turn off blower unit (this sequence will help keep debris which has collected on the inlet side of filter from dislodging and contaminating the outside of the unit). Thoroughly wash blower unit and hoses. Carefully wash battery pack with wet rag. Be extremely cautious of getting water in battery pack as this will short out and destroy battery.
 - 1) Shower completely with soap and water.
 - 2) Rinse thoroughly.
 - 3) Rinse shower room walls and floor prior to exit.
 - 4) Proceed from shower to changing room and change into street clothes or into new disposable work items.
 - e. Require that all workers use the following decontamination procedure as a minimum requirement whenever leaving the work area with a half or full face cartridge type respirator:
 - 1) When exiting area, remove disposable coveralls, disposable headcovers, and disposable footwear covers or boots in the equipment room.
 - 2) Still wearing respirators, proceed to showers. Showering is mandatory. Care must be taken to follow reasonable procedures in removing the respirator and filters to avoid asbestos fibers while showering. The following procedure is required as a minimum:
 - 3) Thoroughly wet body from neck down.
 - 4) Wet hair as thoroughly as possible without wetting the respirator filter if using an air purifying type respirator.
 - 5) Take a deep breath, hold it and/or exhale slowly, complete wetting of hair, thoroughly wetting face, respirator and filter (air purifying respirator). While still holding breath, remove respirator and hold it away from face before starting to breath.
 - 6) Dispose of wet filters from air purifying respirator.
 - 7) Carefully wash facepiece of respirator inside and out.
 - 8) Shower completely with soap and water.
 - 9) Rinse thoroughly.
 - 10) Rinse shower room walls and floor prior to exit.
 - 11) Proceed from shower to changing room and change into street clothes or into new disposable work items.

N. Project Decontamination

1. If the asbestos abatement work is on damaged or friable materials, then the building space is deemed contaminated before start of the work and in need of decontamination. In this case, the



- procedure includes two cleanings of the primary barrier plastic prior to its removal and two cleanings of the room surfaces to remove any new or existing contamination.
2. Work of this section includes the decontamination of air in the work area which has been, or may have been contaminated by the elevated airborne asbestos fiber levels generated during abatement activities, or which may previously have had elevated fiber levels due to friable materials in the space.
 3. Work of this section also includes the cleaning, decontamination, and removal of temporary facilities installed prior to abatement work and decontamination of all surfaces (ceiling, walls, floor) of the work area, and all furniture or equipment in the work area.
 4. First Cleaning
 - a. Carry out a first cleaning of all surfaces of the work area including items of remaining sheeting, tools, scaffolding and/or staging by use of damp-cleaning and mopping, and/or a HEPA filtered vacuum. (Note: A HEPA vacuum will fail if used with wet material). Do not perform dry dusting or dry sweeping. Use each surface of a cleaning cloth one time only and then dispose as contaminated waste. Continue this cleaning until there is no visible debris from removed materials on plastic sheeting or other surfaces. Upon authorization of the Owner's Representative proceed with encapsulation of substrate.
 - b. Perform encapsulation of substrate where required at this time. Maintain pressure differential system in operation during encapsulation work. Allow encapsulant to dry before proceeding with removal of Secondary layer of plastic.
 5. Second Cleaning
 - a. Upon authorization of the Owner's Representative, remove all Primary Barrier sheeting and Material Decontamination Unit, if there is one, leaving only the following:
 - 1) Critical Barrier which forms the sole barrier between the work area and other portions of the building or outside.
 - 2) Critical Barrier Sheeting over lighting fixtures and clocks, ventilation openings, doorways, convectors, speakers and other openings.
 - 3) Personnel Decontamination Unit.
 - 4) Pressure Differential System in continuous operation.
 - b. Remove all filters in Air Handling System(s) and dispose of as asbestos-containing waste.
 6. Final Cleaning: Carry out a final cleaning of all surfaces in the work in the same manner as the first cleaning immediately after removal of primary plastic. This cleaning is now being applied to existing room surfaces. Take care to avoid water marks or other damage to surfaces.
 7. Visual Inspection: Perform a complete visual inspection with the Owner's Representative of the entire work area including decontamination unit, all plastic sheeting, seals over ventilation openings, doorways, windows, and other openings; look for debris from any sources, residue on surfaces, dust or other matter. If any such debris, residue, dust or other matter is found repeat cleaning and continue decontamination procedure from that point. When the area is visually clean, complete the certification at the end of this section.
 8. Final Air Sampling
 - a. After the work area is found to be visually clean, air samples will be taken and analyzed in accordance with the procedures set forth in Paragraph "Powered Air Purifying Respirator (PAPR).
 - b. If Release Criteria are not met, repeat cleaning and continue decontamination procedure from that point.
 - c. If Release Criteria is met, remove the interior of the decontamination unit leaving in place only the Critical Barriers separating the work area from the rest of the building and the operating negative pressure system.
 - d. Any small quantities of residual material found upon removal of the plastic sheeting shall be removed with a HEPA filtered vacuum cleaner and local area protection. If significant quantities, as determined by the Owner's Representative, are found then the entire area affected shall be decontaminated as specified herein for the cleaning.

- O. Work Area Clearance
1. Air Monitoring



- a. Visual Inspection is required as a prerequisite of air testing.
 - b. To determine if the elevated airborne asbestos structure concentration during abatement operations have been reduced to the specified level, the Owner's Representative will secure samples and analyze them according to the following procedures.
2. Aggressive Sampling
- a. All air samples will be taken using aggressive sampling techniques as follows. (There are no standards available for flow rate of leaf blowers or large fans. However, this information is not critical to the success of the procedure).
 - b. Before sampling pumps are started, the exhaust from forced-air equipment (leaf blower with at least 1 horsepower electric motor) will be swept against all walls, ceilings, floors, ledges and other surfaces in the room. This procedure will be continued for five minutes per 10,000 cubic feet of room volume.
 - c. Air samples will be collected in areas subject to normal air circulation away from room corners, obstructed locations, and sites near windows, doors or vents.
3. Schedule of Air Samples
- a. General: The number and volume of air samples taken and analytical methods used by the Owner's Representative will be in accordance with the following schedule. Sample volumes given may vary depending upon the analytical instruments used. In each homogeneous work area after completion of all cleaning work, samples will be taken and analyzed by either PCM or TEM analysis.
 - b. Transmission Electron Microscopy (TEM) Samples:
 - 1) In each homogeneous work area after completion of all cleaning work, samples will be taken and analyzed by either PCM or TEM analysis as follows:
 - 2) Samples will be collected on 25 mm cassettes with filter media: TEM - 0.45 micrometer mixed cellulose ester or 0.40 micrometer polycarbonate, with 5.0 micron mixed cellulose ester backing filter.

Location Sampled	Number of Samples	Detection Limit (f/cc)	Minimum Volume (Liters)	Rate LPM
Each Work Area	5	0.005	1,300	2-10

- 3) TEM Analysis will be performed using the analysis method set forth in the AHERA Regulation 40 CFR Part 763 Appendix A.
 - 4) Asbestos Structures referred to in this Section include asbestos fibers, bundles, clusters, or matrices, as defined by method of analysis.
 - 5) Decontamination of the work site is complete when all the sample results are below 0.01 fibers per cubic centimeters (f/cc) of air or 70 structures per square millimeter.
- c. Phase Contrast Microscopy (PCM) Samples:
- 1) In each homogeneous work area after completion of all cleaning work, samples may be taken and analyzed as follows:
 - 2) Samples will be analyzed by PCM for clearance in areas where ceiling tile and/or pipe insulation are removed
 - 3) Samples will be collected on 25 mm cassettes with filter media: PCM - 0.8 micrometer mixed cellulose ester.

Location Sampled	Number of Samples	Detection Limit (s/cc)	Minimum Volume (Liters)	Rate LPM
Each Work Area	1-5	0.01	2,400	2-10

- 4) PCM Analysis: Fibers on each filter will be measured using the NIOSH 7400 Method entitled "Fibers" published in the NIOSH Manual of Analytical Methods, 3rd Edition, Second Supplement, August 1987.



- 5) Fibers: Referred to in this section include fibers regardless of composition as counted by the phase contrast microscopy method used
 - 6) Decontamination of the work site is complete when all the sample results are below 0.01 fibers per cubic centimeters (f/cc) of air or 70 structures per square millimeter.
4. Failure of Clearance Sampling: Should results from analysis of final clearance air samples not meet the specified criteria, Contractor will be responsible for the payment of all costs, including Consultant's time for subsequent clearance air sampling. The costs associated with subsequent re-sampling for final clearance shall be deducted from the Contractor's final payment of the contract amount.

P. Removal Of Pipe Insulation

1. The work of this section applied to the removal of asbestos-containing Pipe Insulation.
 - a. Place one layer of 6-mil fire retardant polyethylene sheeting directly below the work. The sheet shall be of sufficient size to completely wrap the pipe once it has been removed.
 - b. Thoroughly wet the ends of the pipe with amended water and scrape off a minimum of 6 inches of asbestos wrap from both ends of the pipe. Immediately place the wetted material into pre-labeled asbestos disposal bag(s).
 - c. Detach the pipe at each scraped end and place the pipe onto one sheet of 6-mil fire retardant polyethylene sheeting. Wrap the pipe with the 6-mil fire retardant polyethylene sheeting. Contractor shall wrap the pipe with a second sheet of 6-mil, fire retardant polyethylene sheeting and label as asbestos-containing material. Dispose of the bag(s) and duct in accordance with the Paragraph "Handling and Disposal of Asbestos Contaminated Waste" of this specification.
 - d. Upon clearance from the Owner's Representative, Contractor shall remove the 6-trail, fire retardant polyethylene sheeting from the openings.

Q. Glove Bag Removal

1. The work of this section applies to full containment or glovebag removal.
2. Isolate the area in accordance with Paragraph "Temporary Facilities."
3. Construct a decontamination unit as described in Paragraph "Decontamination Units" and attach to the work area.
4. Set up pressure differential isolation and ventilation of the work area in accordance to Paragraph "Pressure Differential System."
 - a. Upon approval of the enclosure by the Owner's Representative, Contractor may proceed to remove the material using the following method.
 - b. Thoroughly wet to satisfaction of the Owner's Representative, asbestos-containing insulation to be removed prior to stripping and/or tooling to reduce fiber dispersal into the air. Accomplish wetting by a fine spray (mist) of amended water or removal encapsulant. Saturate material sufficiently to wet the substrate without causing excess dripping. Allow time for removal encapsulant to penetrate material thoroughly. If amended water is used, spray material repeatedly during the work process to maintain a continuously wet condition. If a removal encapsulant is used, apply in strict accordance with manufacturer's written instructions. If insulation is covered with canvas, Contractor will wet the exterior covering and slice it with utility knife while saturating the material.
 - c. Mist work area continuously with amended water whenever necessary to reduce airborne fiber levels using commercially available "foggers."
 - d. Remove saturated asbestos-containing material in small sections from all areas. Do not allow material to dry out. As it is removed, simultaneously pack material while still wet into disposal bags. Twist neck of bags, bend over and seal with minimum three wraps of duct tape. Clean outside and move to wash down station adjacent to material decontamination unit.
 - e. Evacuate air from disposal bags with a HEPA filtered vacuum cleaner before sealing.
 - f. Contractor must always clean area of visible asbestos debris prior to end of shift.
5. These procedures shall be followed to remove pipe insulation elbows:
 - a. Install critical barriers to isolate the work site. Install 2 or 3 Stage Decontamination Units.



- b. HEPA vacuum the work site.
 - c. Provide negative air machine in addition to those required, in the vicinity of the work. Arrange so that exhaust is into the work area, oriented in a direction away from the work. Extend a 2-inch diameter flexible non-collapsing duct from the intake end to a point no more than 4'-0" from any scraping or brushing activity.
 - d. Locate intake of duct so that airflow is horizontally and slightly downward into intake. Replace primary filter on negative air machine at an interval of no greater than 30 minutes. Allow no more than one scraping or brushing activity per negative air machine.
 - e. Check pipe where the work will be performed. Wrap damaged (broken lagging, hanging, etc.), pipe in 6 mil plastic and "candy-stripe" with duct tape. Place one layer of duct tape around undamaged pipe at each end where the glovebag will be attached.
 - f. Place necessary tools into pouch located inside glovebag. This will usually include: bone saw, utility knife, rags, scrub brush, wire cutters, tin snips and pre-wetted cloth.
 - g. Place one strip of plastic adhesion tape along the edge of the open top slit of glove bag for reinforcement.
 - h. Place the glove bag around section of pipe to be worked on and staple top together through reinforcing tape. Next, tape the ends of glovebag to pipe itself, where previously covered with plastic or tape.
 - i. Use smoke tube and aspirator bulb to test seal. Place tube into water sleeve (two-inch opening to glovebag) squeezing bulb and filling bag with visible smoke. Remove smoke tube and twist water sleeve closed. While holding the water sleeve tightly, gently squeeze glovebag and by using a flashlight, look for smoke leaking out, (especially at the top and ends of the glovebag). If leaks are found, tape closed using plastic adhesion tape and re-test.
 - j. Insert wand from garden sprayer through water sleeve. Plastic adhesion tape water sleeve tightly around the wand to prevent leakage.
 - k. One person places its hands into the long-sleeved gloves while the second person directs garden sprayer at the work.
 - l. Use bone saw, if required, to cut insulation at each end of the section to be removed. A bone saw is a serrated heavy gauge wire with ring-type handles at each end. Throughout this process, spray amended water or removal encapsulant on the cutting area to keep dust to a minimum.
 - m. Remove insulation using putty knives or other tools. Place pieces in bottom of bag without dropping.
 - n. Rinse all tools with water inside the bag and place back into pouch.
 - o. Using scrub brush, rags and water, scrub and wipe down the exposed pipe. (Inexpensive horse rub-down mittens work well for this).
 - p. Remove water wand from water sleeve and attach the small nozzle from HEPA-filtered vacuum. Turn on the vacuum only briefly to collapse the bag.
 - q. Remove the vacuum nozzle, twist water sleeve closed and seal with plastic adhesion tape.
- R. Handling And Disposal Of Asbestos-Containing Waste
1. All waste and asbestos contaminated waste shall be double bagged in pre-labeled 6-mil airtight puncture resistant bags. Labeling shall be in accordance with OSHA and EPA requirements.
 - a. Bags of asbestos-containing waste shall be sealed with tape in the work area. Asbestos waste shall not be allowed to dry out prior to sealing bags. While in the work area, bags shall be decontaminated of any bulk debris by wet wiping. Bags shall be pre-labeled in accordance with OSHA and EPA.
 - b. The Contractor shall ensure that the sealed bags are transported to the waste disposal site.
 2. The Contractor shall establish a manifest system to enable the Owner to report the quantity of asbestos waste being deposited at the landfill. Contractor shall report the quantity of waste in pounds or tons as appropriate. The Contractor must be able to demonstrate custody over all asbestos waste from the time it is removed from the work area until it is deposited at the land fill.



- a. Copies of the manifest and any receipts generated during the handling and disposal process shall be provided to the Owner's Representative and the Owner.
 - b. Final manifest and documents must be provided to the Owner's Representative and the Owner within two weeks of the removal of the asbestos materials from the site by the waste hauler.
- S. Encapsulation Of Asbestos-Containing Materials
1. General provisions of Contract, including General and Supplementary Conditions and Division 01, apply to work of this section.
 - a. The work includes the sealing of all piping or vessels from which asbestos-containing insulation has been removed with one coat of a lock down encapsulant.
 - b. Where repair work is being performed, the end will be sealed with a minimum of one coat of bridging encapsulant.
 2. Submittals
 - a. Product Data: Submit manufacturer's technical information including label analysis and application instructions for each material proposed for use.
 - b. Installation Instructions: Submit manufacturer's installation instructions with specific project requirements noted.
 - c. Performance Warrantee: Submit manufacturer's performance guarantee.
 - d. Certification: Submit written approval of entity installing the encapsulant from encapsulant manufacturer.
 - e. Material Safety Data Sheet: Submit the Material Safety Data Sheet, or equivalent, in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200) for each surfactant and encapsulating material proposed for use on the work. Include a separate attachment for each sheet indicating the specific worker protective equipment proposed for use with the material indicated.
 3. Deliver materials to the job site in original, new and unopened packages and containers bearing manufacturer's name and label, and following information:
 - a. Name or title of material
 - b. Manufacturer's stock number and date of manufacture
 - c. Manufacturer's name
 - d. Thinning Instructions
 - e. Application Instructions
 4. Deliver materials together with a copy of the OSHA Material Safety Data Sheet for the material.
 5. Job Conditions
 - a. Apply encapsulating materials only when environmental conditions in the work area are as required by the manufacturer's instructions.
 6. Quality Assurance
 - a. Installation of Spray-on Encapsulation Materials: Install spray-on materials by a firm and personnel approved by the manufacturer of the primary materials.
 - b. Testing: Test material to be encapsulated using methods set forth in ASTM E1494 "Standard Practice for Encapsulants Spray-or-Trowel-Applied for Friable Asbestos-Containing Building Materials."
 - c. Performance Warranty: Submit written Performance Warranty, executed by the manufacturer and co-signed by the Contractor, agreeing to repair/replace spray-on work which has cracked, fallen from substrate, or otherwise deteriorated to a condition where it would not perform effectively for its intended purposes due substantially to defective materials or workmanship and not due to abuse by occupants, improper maintenance, non-foreseeable ambient exposures or other causes beyond anticipated conditions and manufacturer's/contractor's control.
 - d. Compatibility: Selection and use of encapsulant shall be compatible with replacement materials. Submit manufacturer's data indicating compatibility with replacement materials.
 7. Product Selection
 - a. Encapsulants: Provide penetrating or bridging type encapsulants specifically designed for application to asbestos-containing material.



- b. Standards: Product shall be rated as acceptable for use intended when field tested in accordance with ASTM E1494 "Standard Practice for Encapsulants Spray-or-Trowel-Applied for Friable Asbestos-Containing Building Materials."
 - c. Fire Safety: Use only materials that have a flame spread index of less than 25, when dry, when tested in accordance with ASTM E84.
8. Manufacturers
- a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products, which may be incorporated in the work, include, but are not limited to the following:
 - 1) Penetrating Encapsulants: As currently accepted by the EPA. Refer to most recent EPA approval list.
 - 2) Bridging Encapsulants: As currently accepted by the EPA. Refer to most recent EPA approval list.
9. General
- a. Prior to applying any encapsulating material, ensure that application of the sealer will not cause the base material to fail and allow the sealed material to fall of its own weight or separate from the substrate. Should Contractor doubt the ability of the installation to support the sealant, request direction from the Owner's Representative before proceeding with the encapsulating work.
 - b. Do Not Commence Application of encapsulating materials until all removal work within the work area has been completed.
10. Worker Protection
- a. Before beginning work with any material for which a Material Safety Data Sheet has been submitted, provide workers with the required protective equipment. Require that appropriate protective equipment be used at all times.
 - b. In addition to protective breathing equipment required by OSHA requirements or by this specification, use painting pre-filters on respirators to protect the dust filters when organic solvent based encapsulants are used.
11. Substrate
- a. Apply lock down encapsulant to all substrate after all asbestos-containing materials have been removed. Apply in strict accordance with the manufacturer's printed instructions for use of the encapsulation as an asbestos coating. Any deviations from such printed instructions shall be approved by the Owner's Representative in writing prior to commencing work.
 - b. Apply encapsulant with an airless spray gun with air pressure and nozzle orifice as recommended by the encapsulant manufacturer.
- T. Removal Of Floor Tile
- 1. This section applies to the removal of floor tile.
 - a. Prior to start of work, wet wipe all surfaces including floor tile to remove any visible dust.
 - b. Isolate the room by sealing hallway or doors and installing critical barriers on all ducting, windows and other penetrations of the room, in the specified area. Install a splash guard a minimum of 4 feet high on the walls of the room with one layer of 6-mil fire retardant poly.
 - c. Install a two-stage decontamination configuration contiguous (under certain conditions may be remote) with the work in accordance with Paragraph "Decontamination Units."
 - d. Using water or amended water in a Hudson-type sprayer or garden sprayer, lightly mist the area where the material is to be removed. This may take several passes with the hose of the sprayer. Allow time for the water to soak into the material.
 - e. Immediately place individual tiles in proper asbestos disposal bags. Vacuum collapse the bag, twist the neck of the bag, tape with duct tape, fold the twisted portion over onto itself and tape again. Wipe the outside of the bag with clean damp cloths and place the bag into a second prelabeled disposal bag. Tape shut the second bag.
- U. Removal Of Fireproofing



1. The work of this section applies to the removal of all asbestos containing fireproofing including all over-spray that may be located on concrete block, columns, metal deck, beams, fixtures conduit and ducting.
 - a. Isolate the floor per Paragraph "Temporary Enclosure."
 - b. Construct a decontamination unit as described in Paragraph "Decontamination Units" and attach to the work area.
 - c. Set up pressure differential isolation and ventilation of the work area in accordance to Paragraph "Temporary Pressure Differential and Air Circulation System."
 - d. Upon approval of the enclosure by the Owner's Representative, contractor may proceed to remove the material using the following method.
 - e. Pre-clean columns, beams, electrical, mechanical and plumbing systems in the work area using wet wipe and HEPA vacuuming methods. Mask off with flame retardant polyethylene sheeting to protect from contamination during bulk abatement.
 - f. Thoroughly wet to satisfaction of the Owner's Representative, asbestos-containing fireproofing to be removed prior to stripping and/or tooling to reduce fiber dispersal into the air. Accomplish wetting by a fine spray (mist) of amended water or removal encapsulant. Saturate material sufficiently to wet the substrate without causing excess dripping. Allow time for removal encapsulant to penetrate material thoroughly. If amended water is used, spray material repeatedly during the work process to maintain a continuously wet condition. If a removal encapsulant is used, apply in strict accordance with manufacturer's written instructions.
 - g. Mist work area continuously with amended water whenever necessary to reduce airborne fiber levels using commercially available "foggers."
 - h. Remove saturated asbestos-containing material in small sections from all areas. Do not allow material to dry out. As it is removed, simultaneously pack material while still wet into disposal bags. Twist neck of bags, bend over and seal with minimum three wraps of duct tape. Clean outside and move to wash down station adjacent to material decontamination unit.
 - i. Evacuate air from disposal bags with a HEPA filtered vacuum cleaner before sealing.
 - j. Provide Pressure Differential Machine in addition to those required in Paragraph "Pressure Differential System," in the vicinity of the work. Arrange so that exhaust is into the work area, oriented in a direction away from the work. Extend a 12" diameter flexible non-collapsing duct from the intake end to a point no more than 4'-0" from any scraping or brushing activity.
 - k. Locate intake of duct so that air flow is horizontally and slightly down-ward into intake. Replace primary filter on pressure differential machine at an interval of no greater that 30 minutes. Allow no more than one scraping or brushing activity per pressure differential machine.

- V. Removal Of Wall Plaster: HEPA vacuum work site.
 1. Place two layers of 6-mil flame retardant polyethylene sheeting on the floor adjacent to the wall to be demolished. Pull the wall down in manageable sections onto the polyethylene sheeting. Control dust and fiber release by misting the air and lightly wetting the material with amended water from a Hudson-type sprayer or garden sprayer as it is demolished.
 2. Wrap the first layer of polyethylene sheeting around the material and seal with duct tape. Wrap the second layer of polyethylene sheeting around the bundle and seal with duct tape.
 3. Label and dispose of the entire bundle.
 4. Provide Pressure Differential Machine in addition to those required in Paragraph "Pressure Differential System," in the vicinity of the work. Arrange so that exhaust is into the work area, oriented in a direction away from the work. Extend a 12-inch diameter flexible non-collapsing duct from the intake end to a point no more than 4'-0" from any scraping or brushing activity.
 5. Locate intake of duct so that air flow is horizontally and slightly down-ward into intake. Replace primary filter on negative air machine at an interval of no greater that 30 minutes.

W. Clean-Up Of Asbestos-Containing Debris On Ceiling Tile Or Solid Ceiling



1. This section applies to the decontamination of the entire plaster ceiling, removal of existing fiberglass on duct work and removal of all batt insulation covering the existing plaster ceiling.
 - a. Isolate the floor per Paragraph "Temporary Facilities."
 - b. Construct a decontamination unit as described in Paragraph "Decontamination Units" and attach to the work area. General Contractor will give direction regarding exact location of decontamination unit(s).
 - c. Set up pressure differential isolation and ventilation of the work area in accordance to Paragraph "Temporary Pressure Differential and Air Circulation System."
 - d. Upon approval of the enclosure by the Owner's Representative, contractor may proceed to remove the material using the following method:
 2. These procedures shall be followed to for clean up of asbestos-containing debris on existing plaster ceiling:
 - a. This work will be performed prior to the removal of fireproofing. The isolation of the work area is considered essential to the pre-cleaning activities for the total area. Isolate the area in accordance with Paragraph "Temporary Facilities."
 - b. Remove asbestos-containing debris and fiberglass batt and duct insulation and decontaminate the area using the following procedures:
 - 1) Remove all small debris with the HEPA vacuum.
 - 2) Gently mist all fiberglass insulation, remove from ducts and ceiling and place into pre-labeled hazardous disposal bags and dispose of in accordance with Paragraph "Disposal of Asbestos Containing Waste Material."
 - 3) Exposure of ducting will expose all fireproofing overspray, this material may be removed during the removal of fireproofing from decks and beams.
 - 4) Pick up all large visible debris on the ceiling or any horizontal surfaces and place in the bottom of a 6-mil polyethylene disposal bag conforming to the requirements of Paragraph "Disposal of Asbestos-Containing Waste." Place pieces in the bag without dropping and avoiding unnecessary disturbance and release of material.
 - 5) HEPA vacuum the entire plaster ceiling surface.
 - c. Upon completion of the decontamination of the area request a visual inspection of the ceiling and other horizontal surfaces. This area will be considered a portion of work area for the duration of the work and will be included in the final encapsulation of the area.
- X. Removal Of Adhesive: This section applies to the removal of all asbestos-containing floor tile and adhesive, sheet vinyl flooring, vinyl floor tile, and baseboard adhesive, etc.
1. Ensure that workers are equipped with proper respiratory protection. In addition to the HEPA cartridges, respirators must also be equipped with organic solvent cartridges.
 2. Provide HEPA filtered fan units in the vicinity of the work. Arrange so that units exhaust outside the building. Replace primary filters on HEPA filtered fan units at an interval of no greater than 30 minutes.
 3. Apply adhesive removal solvent as recommended by manufacturer after removal of floor tile has been completed.
 4. Provide tile adhesive (mastic) remover that meets the following criteria:
 - a. Flash Point: 122E or greater.
 - b. Special Precautions: No heavy smoke generated if ignited.
 - c. Health Effects: Limited to mild skin rash or eye irritation.
 - d. Respiratory Protection: MSHA - NIOSH approved Organic vapor cartridges in conjunction with standard HEPA filters.
 - e. Petroleum Distillates: None.
 - f. Odor: Pine, Citrus or none.

Use of diesel fuel in the removal of tile and baseboard adhesive is strictly prohibited.

5. Remove adhesive in small sections from all areas. Do not allow material to dry out. As adhesive is removed, simultaneously pack rags contaminated with adhesive material into disposal bags. Twist



neck of bags, bend over and seal with minimum three wraps of duct tape. Clean outside of bag and move to material decontamination unit.

6. Upon completion of adhesive removal, thoroughly clean bare substrate of all solvent residue.
7. Place adhesive residue in proper asbestos disposal bags. Vacuum collapse the bag, twist the neck of the bag, tape with duct tape, fold the twisted portion over onto itself and tape again. Wipe the outside of the bag with clean damp cloths and place bag into second pre-labeled disposal bag. Tape shut the second bag.



CERTIFICATE OF WORKER'S ACKNOWLEDGEMENT

PROJECT NAME: _____

PROJECT ADDRESS: _____

CONTRACTOR: _____

WORKING WITH ASBESTOS CAN BE DANGEROUS. INHALING ASBESTOS FIBERS HAS BEEN LINKED WITH VARIOUS TYPES OF CANCER IF YOU SMOKE AND INHALE ASBESTOS FIBERS, THE CHANCE THAT YOU WILL DEVELOP LUNG CANCER IS GREATER THAN THAT OF THE NON-SMOKING PUBLIC.

Your employer's contract with the Owner for the above project requires that: You be supplied with the proper respirator and be trained in its use. You be trained in safe work practices and in the use of the equipment found on the job. You receive a medical examination. These things are to have been done at no cost to you. By signing this certification you are assuring the Owner that your employer has met these obligations to you.

RESPIRATORY PROTECTION: I have been trained in the proper use of respirators, and informed of the type respirator to be used on the above referenced project. I have a copy of the written respiratory protection manual issued by my employers. I have been equipped at no cost with the respirator to be used on the above project.

TRAINING COURSE: I have been trained in the dangers inherent in handling asbestos and breathing asbestos dust and in proper work procedures and personal and area protective measures. The topics covered in the course included the following:

- Physical characteristics of asbestos
- Health hazards associated with asbestos
- Respiratory protection
- Use of protective equipment
- Pressure differential systems
- Work practices including hands-on or on-the-job training
- Personal decontamination procedures
- Air monitoring, personal and area

MEDICAL EXAMINATION: I have had a medical examination within the last 12 months which was paid for by my employer. This examination included: health history, pulmonary function tests and may have included an evaluation of a chest x-ray.

Signature _____ Witness _____

Printed Name _____ Social Security Number _____



CERTIFICATION OF VISUAL INSPECTION

AREA _____

In accordance with Paragraph "Project Decontamination" the Contractor hereby certifies that it has visually inspected the work area (all surfaces including pipes, beams, ledges, walls, ceiling and floor, Decontamination Unit, sheet plastic, etc.) and has found no dust, debris or residue.

By: _____

Signature _____ Date _____

Print Name _____

Print Title _____

OWNER'S REPRESENTATIVE CERTIFICATION

the Owner's Representative hereby certifies that it has accompanied the Contractor on its visual inspection and verifies that this inspection has been thorough and to the best of its knowledge and belief, the Contractor's certification above is a true and honest one.

Signature _____ Date _____

Print Name _____

Print Title _____



RESPIRATORY PROTECTION PROGRAM

Project Name _____

Location _____

Date _____

Based upon airborne asbestos-fiber counts encountered on previous projects of similar type working on materials similar to those found on the above referenced project. The following level of respiratory protection is proposed for the indicated operations to maintain an Airborne Fiber Count (as measured by the NIOSH 7400 Method) below the specified Permissible Exposure Limit (PEL) inside the respirator face piece.

Operation	Anticipated f/cc	Respiratory Protection	Protection Factor	f/cc in Mask
Installing sheet plastic				
Removing trim in contact with asbestos-containing material				
Removal of architectural finish or fireproofing				
Removal of pipe insulation				
Removal of fitting insulation				
Encapsulation of pipe and boiler insulation				
Gross debris removal				
Cleaning "primary" sheet plastic				
Cleaning "critical" barrier				
Removing Decontamination Unit				
Other				

The Contractor certifies that to the best of its knowledge and belief the above represent a true and accurate representation of Airborne Fiber Counts to be expected for the operations indicated, and are based upon airborne fiber data from past projects with similar materials and operations.

Contractor _____

Signature _____ Date _____

Print Name _____ Title _____

END OF SECTION 02 82 33 00



SECTION 02 82 33 00a - REMOVAL OF NONFRIABLE ASBESTOS-CONTAINING MATERIALS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for removal of nonfriable asbestos-containing materials. Products shall be as follows or as directed by the the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definitions

1. ACM: Asbestos Containing material which is any material containing more than one percent asbestos.
2. Amended Water: Water containing a wetting agent or surfactant with a maximum surface tension of 2.9 Pa 29 dynes per centimeter when tested in accordance with ASTM D 1331.
3. Area Sampling: Sampling of asbestos fiber concentrations which approximates the concentrations of asbestos in the theoretical breathing zone but is not actually collected in the breathing zone of an employee.
4. Asbestos: The term asbestos collectively refers to a naturally occurring mineral known by the following specific names: chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.
5. Asbestos control Area: That area where asbestos removal operations are performed. The area shall be isolated by physical boundaries to assist in the prevention of the uncontrolled access by non-qualified persons.
6. Asbestos Fibers: Those fibers having an aspect ratio of at least 3:1 and longer than-5 micrometers as determined by National Institute for Occupational Safety and Health (NIOSH) Method 7400.
7. Asbestos Permissible Exposure Limit: 0.1 fibers per cubic centimeter of air as an e-hour time weighted average measured in the breathing zone as by defined 29 CFR 1926.1101 or other Federal legislation having legal jurisdiction for the protection of workers health.
8. Background: The ambient airborne asbestos concentration in an uncontaminated area as measured prior to any asbestos hazard abatement efforts. Background concentrations for contaminated areas are measured in similar but asbestos free locations.
9. Contractor: The Contractor is that individual, or entity under contract to the Owner to perform the herein listed work.
10. Contractor/Supervisor (Asbestos abatement): A person who has successfully completed training and is therefore accredited as a Contractor/Supervisor under a State Model Accreditation Plan or EPA Model Accreditation Plan as described in 40 CFR 763.
11. Critical Barrier: The layer of polyethylene sheeting that covers an opening or penetration in a room or area that is to become a negative pressure enclosure.
12. Encapsulation: The abatement of an asbestos hazard through the appropriate use of chemical encapsulants.
13. Encapsulants: Specific materials in various forms used to chemically or physically entrap asbestos fibers in various configurations to prevent these fibers from becoming airborne. There are four types of encapsulants as follows which must comply with performance requirements as specified herein.
 - a. Removal Encapsulant (can be used as a wetting agent)
 - b. Bridging Encapsulant (used to provide a tough, durable surface coating to asbestos containing material)
 - c. Penetrating Encapsulant (used to penetrate the asbestos containing material encapsulating all asbestos fibers and preventing fiber release due to routine mechanical damage)
 - d. Lock-Down Encapsulant (used to seal off or "lock-down" minute asbestos fibers left on surfaces from which asbestos containing material has been removed).
14. Friable Asbestos Material: Any material containing more than one percent asbestos that can be crumbled, pulverized, or reduced to powder by hand pressure when dry.



15. Glovebag Technique: Those asbestos removal and control techniques put forth in 29 CFR 1926.1101.
16. HEPA Filter Equipment: High efficiency particulate air (HEPA) filtered vacuum and/or exhaust ventilation equipment with a filter system capable of collecting and retaining asbestos fibers. Filters shall retain 99.97 percent of particles 0.3 microns or larger as indicated in UL 586.
17. the Owner: That qualified person employed directly by the Owner to monitor, sample, inspect the work, and advise the Owner.
18. Negative Pressure Enclosure (NPE): That engineering control technique described as a negative pressure enclosure in 29 CFR 1926.1101.
19. Non-friable Asbestos Material: Material that contains asbestos in which the fibers have been immobilized by a bonding agent, coating, binder, or other material so that the asbestos is well bound and will not normally release asbestos fibers during any appropriate use, handling, storage or transportation. It is understood that asbestos fibers may be released under other conditions such as demolition, renovation, removal, or mishap.
20. Personal Sampling: Air sampling which is performed to determine asbestos fiber concentrations within the breathing zone of a specific employee, as performed in accordance with 29 CFR 1926.1101.
21. Competent Person (CP): A person who has successfully completed training and is therefore accredited under a legitimate State Model Accreditation Plan or EPA Model Accreditation Plan as described in 40 CFR 763 as a Contractor/Supervisor and shall be appropriately licensed according to the Statutes of the State in which the work is to be performed.
22. TEM: Refers to Transmission Electron Microscopy.
23. Time Weighted Average (TWA): The TWA is an 8-hour time weighted average airborne concentration of asbestos fibers.
24. Wetting Agent: A chemical added to water to reduce the water's surface tension thereby increasing the water's ability to soak into the material to which it is applied. An equivalent wetting agent must have a surface tension of at most 2.9 Pa 29 dynes per centimeter when tested in accordance with ASTM D 1331.

C. Requirements

1. Description of Work: The work covered by this section includes the handling and control of asbestos containing materials and describes some of the resultant procedures and equipment required to protect workers, the environment and occupants of the building or area, or both, from contact with airborne asbestos fibers. The work also includes the disposal of any asbestos containing materials generated by the work. More specific operational procedures shall be outlined in the Asbestos Hazard Abatement Plan called for elsewhere in this specification. The asbestos work includes the use of non-friable removal technique(s) which is governed by 40 CFR 763 as indicated. Provide non-friable removal technique(s) as outlined in this specification for the locations indicated.
2. Medical Requirements: Provide medical requirements including but not limited to medical surveillance and medical record keeping as listed in 29 CFR 1926.1101.
 - a. Medical Examinations: Before exposure to airborne asbestos fibers, provide workers with a comprehensive medical examination as required by 29 CFR 1926.1101 or other pertinent State or local directives. This requirement must have been satisfied within the 12 months prior to the start of work on this contract. The same medical examination shall be given on an annual basis to employees engaged in an occupation involving asbestos and within 30 calendar days before or after the termination of employment in such occupation. Specifically identify x-ray films of asbestos workers to the consulting radiologist and mark medical record jackets with the word "ASBESTOS."
 - b. Medical Records: Maintain complete and accurate records of employees' medical examinations, medical records, and exposure data for a period of 30 years after termination of employment and make records of the required medical examinations and exposure data available for inspection and copying to: The Assistant Secretary of Labor for Occupational



- Safety and Health (OSHA), or authorized representatives of them, and an employee's physician upon the request of the employee or former employee.
- c. Medical Certification: Submit written certification for each worker and contractor/supervisor, signed by a licensed physician indicating that the worker and contractor/supervisor has met or exceeded all of the medical prerequisites listed herein and in 29 CFR 1926.1101 and 29 CFR 1910.134 as prescribed by law.
3. Training: Train all personnel involved in the asbestos control work in accordance with United States Environmental Protection Agency (USEPA) Asbestos Hazard Emergency Response Act (AHERA) training criteria or State training criteria whichever is more stringent. The Contractor shall document the training by providing a copy of a current training certification to the the Owner for each person assigned to work on this project. Furnish each employee with respirator training and fit testing documentation as required by 29 CFR 1910.134. Provide instruction on the engineering and other hazard control techniques and procedures to be used on this project.
 - a. Employee Training: Submit copies of training certificates for each employee indicating that the employee has received training at the appropriate level in accordance with 40 CFR 763.
 4. Permits, Licenses, and Notifications: Notify the local air pollution control district/agency and the the Owner in writing 10 working days prior to commencement of work in accordance with 40 CFR 61-SUBPART M or applicable state and local regulations. Obtain necessary permits or licenses in conjunction with asbestos removal, encapsulation, hauling, and disposal. Post the permit and/or license at the work site, visible from a non-controlled area. Notify the local fire department 3 days prior to removing fire-proofing material from the building including notice that the material contains asbestos.
 5. Environment, Safety and Health Compliance: Comply with the applicable requirements of the current issue of 29 CFR 1926.1101, 40 CFR 61-SUBPART A, and 40 CFR 61-SUBPART M or applicable State or local regulations regarding handling, storing, transporting, and disposing of asbestos waste materials. Submit matters of interpretation of standards to the appropriate administrative agency for resolution before starting the work. Where the requirements of this specification, applicable regulations, or referenced documents vary, the most stringent requirement shall apply.
 - a. Site Inspection: While performing asbestos engineering control work, the Contractor shall be subject to on-site inspection by the Federal, State, or local regulatory agencies and the Contracting Officer or its designated representative. If the work is found to be in violation of Federal, State, or local regulations or this specification, the Contracting Officer or its representative will issue a stop work order to be in effect immediately and until the violation is resolved. All related costs including standby time required to resolve the. violation shall be at the Contractor's expense.
 6. Respiratory Protection Program: Establish and implement a respirator program as required by ANSI 288.2 and 29 CFR 1910.134. Submit a written program manual or operating procedure including methods of compliance with regulatory statutes.
 - a. Respirator Program Records: Submit records of the respirator program as required by ANSI 288.2 and 29 CFR 1910.134.
 7. Contractor/Supervisor (Asbestos Abatement): The Contractor shall be represented on-site by a trained contractor/Supervisor. This person shall be on-site at all times when asbestos work is in progress. The Qualified Person, as defined herein, can be the Contractor/Supervisor.
 8. Hazard Communication: Adhere to all parts of 29 CFR 1910.1200 and 29 CFR 1926.59. Provide the Contracting Officer with a copy of the Material Safety Data Sheets (MSDS) for all materials brought to the site. Review the Asbestos Survey Report(s) provided by the the Owner, if any.
 9. Asbestos Hazard Abatement Plan: Submit a detailed plan of the safety precautions such as lockout, tag-out, tryout, fall protection, and confined space entry procedures and equipment and work procedures to be used in the removal of materials containing asbestos. The plan shall be prepared by the Contractor (and reviewed and signed by an asbestos consultant (LAC) licensed according to the Statutes of the State in which the work is to be performed) for review and recommendation for approval by the the Owner. The plan shall be forwarded to the the Owner for final approval at least 10 days prior to beginning abatement activities. The plan shall include but not be limited to the detailed description of personal protective equipment and work practices to



be used including, but not limited to, respiratory protection, type of whole-body protection, the location of asbestos control areas including clean and dirty areas, buffer zones, showers, storage areas, change rooms, removal method, interface of trades involved in the construction, sequencing of asbestos related work, disposal plan, type of wetting agent and asbestos encapsulant to be used, locations of local exhaust equipment, planned air sampling strategies, and a detailed description of the method to be employed in order to control environmental pollution. The plan shall also include both fire and medical emergency response plans. The Asbestos Hazard Abatement Plan must be approved in writing prior to starting any asbestos work.

10. Testing Laboratory: Submit the name, address, and telephone number of each testing laboratory selected for the sampling, analysis, and reporting of airborne concentrations of asbestos fibers along with evidence that each laboratory selected holds the appropriate State license and/or permits and certification that each laboratory is American Industrial Hygiene Association (AIHA) accredited and that persons counting the samples have been judged proficient by current inclusion on the AIHA Asbestos Analysis Registry (AAR) and successful participation of the laboratory in the Proficiency Analytical Testing (PAT) Program. Where analysis to determine asbestos content in bulk materials or transmission electron microscopy is required, submit evidence that the laboratory is accredited by the National Institute of Science and Technology (NIST) under National Voluntary Laboratory Accreditation Program (NVLAP) for asbestos analysis.
11. Landfill Approval: Submit written evidence that the landfill for disposal is approved for asbestos disposal by the USEPA and State and local regulatory agency(s).
12. Waste Shipment Records/Asbestos Waste Manifest: Submit waste shipment records and/or asbestos manifest records, prepared in accordance with applicable Federal, State, or local regulations, signed and dated by an agent of the landfill, certifying the amount of asbestos materials delivered to the landfill, within 3 days after delivery.
13. Negative Exposure Assessment: Submit objective data demonstrating that the method(s) used for the specified non-friable ACM removal does not release airborne concentrations of asbestos fibers exceeding the TWA PEL or excursion limit. This data may be from previous work within the last 12 months or from initial exposure assessments on this project. Data from previous work must have been gathered by the firm employed on this contract, using workers trained to the same level, with the ACM and workplace conditions "closely resembling" the conditions for this contract.
14. Contractor Daily Reports: Prepare a written report for each day that asbestos work is being accomplished. The report should be submitted to the the Owner monthly. The report as a minimum shall include the following, where applicable:
 - a. Daily Visual Inspection Reports: Prepare a written report documenting compliance with the Asbestos Hazard Abatement Plan and Federal, State, or local regulations.
 - b. Air Sampling Reports: Complete fiber counting within 24 hours of the "time off" of the sample pump. Notify the the Owner immediately of any airborne levels of asbestos fibers in excess of the acceptable limits. Sampling results shall be submitted to the the Owner the day following receipt. The affected employees will be provided copies of the results where required by law within 3 working days. These results shall be signed by the air sampler and the testing laboratory employee that analyzed the sample.
 - c. Pressure Differential Recordings for Local Exhaust System-Not Used
 - d. Asbestos Disposal Quantity Report: The Contractor shall record and report daily the amount of asbestos containing material removed and the amount transported for disposal. Deliver the report for the previous day and cumulative totals with amounts of material removed reported in linear meters or square meters linear feet or square feet as described initially in this specification and the amounts of material transported for disposal reported in cubic meters yards.

D. Submittals

1. Submit the following in accordance with Section "Submittal Procedures."
 - a. Vacuums and tools



- b. Respirators
- c. Wetting Agent
- d. Material Safety Data Sheets (MSDS) for all materials proposed for transport to the project site
- e. Local exhaust system
- f. Pressure differential automatic recording instrument
- g. Daily Reports
- h. Asbestos hazard abatement plan
- i. Testing laboratory
- j. Training Certificates
- k. Landfill approval
- l. Employee training
- m. Medical certification requirements
- n. Waste shipment records/Asbestos waste manifest
- o. Respiratory Protection Program
- p. Negative Exposure Assessment
- q. Local Exhaust system
- r. Show compliance with ANSI Z9.2 by providing manufacturers' certifications.
- s. Permits, licenses, and Notifications
- t. Rental equipment
- u. Respirator program records
- v. Protective clothing decontamination quality control records
- w. Protective clothing decontamination facility notification.

E. Quality Assurance

- 1. Glovebags-Not Used
- 2. Rental Equipment: Provide a copy of the written notification to the rental company concerning the intended use of the equipment and the possibility of asbestos contamination of the equipment.
- 3. Protective Clothing Decontamination Quality Control Records: Provide all records that document quality control for the decontamination of reusable outer protective clothing.
- 4. Protective Clothing Decontamination Facility Notification: Submit written evidence that persons who decontaminate, store, or transport asbestos contaminated clothing used in the performance of this contract were duly notified in accordance with 29 CFR 1926.1101.

1.2 PRODUCTS

A. Encapsulants

- 1. See Division 21 Section "Facility Fire-suppression Water-service Piping".

1.3 EXECUTION

A. Equipment

- 1. Respirators: Select respirators from those approved by the National Institute for Occupational Safety and Health (NIOSH). Provide personnel engaged in pre-cleaning, cleanup, handling, and removal of asbestos containing materials with the appropriate respiratory protection as specified in 29 CFR 1910.134.
- 2. Exterior Whole Body Protection
 - a. Outer Protective Clothing: Provide personnel exposed to asbestos with disposable "non-breathable," or reusable "non-breathable" whole body outer protective clothing, head coverings, gloves, and foot coverings. Provide disposable plastic or rubber gloves to protect hands. Cloth gloves may be worn inside the plastic or rubber gloves for comfort, but shall not be used alone. Make sleeves secure at the wrists, make foot coverings secure at the ankles, and make clothing secure at the neck by the use of tape. Reusable whole body



- outer protective clothing shall be either disposed of as asbestos contaminated waste upon exiting from the asbestos regulated work area or be properly decontaminated.
- b. Work Clothing-Not Used
 - c. Decontamination of Reusable Outer Protective Clothing: When reusable outer protective clothing is used, transport the double bagged clothing to a previously notified commercial/industrial decontamination facility for decontamination. Perform non-destructive testing to determine the effectiveness of asbestos decontamination. If representative sampling is used, ensure the statistical validity of the sampling results. If representative sampling is used, reject any entire batch in which any of the pieces exceed 40 fibers per square millimeter. Inspect reusable protective clothing prior to use to ensure that it will provide adequate protection and is not or is not about to become ripped, torn, deteriorated, or damaged, and that it is not visibly contaminated. Notify, in writing, all personnel involved in the decontamination of reusable outer protective clothing as indicated in 29 CFR 1926.1101.
 - d. Eye Protection: Provide goggles to personnel engaged in asbestos abatement operations when the use of a full face respirator is not required.
3. Warning Signs and Labels: Provide bilingual warning signs printed in English and Spanish at all approaches to asbestos control areas. Locate signs at such a distance that personnel may read the sign and take the necessary protective steps required before entering the area. Provide labels and affix to all asbestos materials, scrap, waste, debris, and other products contaminated with asbestos.
- a. Warning Sign: Provide vertical format conforming to 29 CFR 1926.1101 minimum 20 by 14 inches (500 by 355 mm) displaying the following legend in the lower panel:

<u>Legend</u>	<u>Notation</u>
Danger	25 mm one inch Sans Serif Gothic or Block
Asbestos	25 mm one inch Sans Serif Gothic or Block
Cancer and Lung Disease Hazard	6 mm 1/4 inch Sans Serif Gothic or Block
Authorized Personnel only Respirators and Protective Clothing are Required in this Area	6 mm 1/4 inch Gothic 6 mm 1/4 inch Gothic

Spacing between lines shall be at least equal to the height of the upper of any two lines.

- b. Warning Labels: Provide labels conforming to 29 CFR 1926.1101 of sufficient size to be clearly legible, displaying the following legend:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD
BREATHING ASBESTOS DUST MAY
CAUSE SERIOUS BODILY HARM

- 4. Vacuums and Tools: Vacuums shall be leak proof to the filter and equipped with HEPA filters. Filters on vacuums shall conform to ANSI Z9.2 and UL 586. Do not use power tools to remove asbestos containing materials unless the tool is equipped with effective, integral HEPA filtered exhaust ventilation systems. Remove all residual asbestos from reusable tools prior to storage or reuse.

B. General



1. Pre-Asbestos Work Conference: The Contractor and the Contractor/Supervisor shall meet with the Contracting officer prior to beginning work, to discuss in detail the Asbestos Hazard Abatement Plan, including work procedures and safety precautions. Once approved by the Owners Engineer, the plan will be enforced as if a part of this specification. Any changes required in the specification as a result of the plan shall be identified specifically in the plan to allow for free discussion and approval by the Owners Engineer prior to starting work.
 2. Asbestos Control Area Requirements: The Contractor shall demarcate the asbestos control area(s) using physical barriers and signs to prevent access by unauthorized personnel. This area is defined by 29 CFR 1926.1101 as the regulated area.
 3. Work Procedure: Perform asbestos related work in accordance with 29 CFR 1926.1101, 40 CFR 61-SUBPART M, applicable State or local regulation, and as specified herein. Use wet removal procedures. Personnel shall wear and utilize protective clothing and equipment as specified herein. Eating, smoking, drinking, chewing gum or tobacco, or applying cosmetics shall not be permitted in the asbestos control area(s). Personnel of other trades not engaged in the removal of asbestos containing material shall not be exposed at any time to airborne concentrations of asbestos. If an asbestos fiber release or spill, stop work immediately, correct the condition to the satisfaction of the Owners Engineer, including clean-up and clearance sampling, if appropriate, prior to resumption of work.
 4. Furnishings: Furniture will be removed from the area of work by the Owner before asbestos work begins.
 5. Pre-cleaning: Wet wipe and HEPA vacuum all surfaces potentially contaminated with asbestos prior to establishment of an enclosure.
- C. Removal Procedures: Wet asbestos containing material with a fine spray of amended water during removal, cutting, or other handling so as to reduce the emission of airborne fibers. Remove material and immediately place in 0.15 mm 6 mil plastic disposal bags. Remove asbestos containing material in a gradual manner, with continuous application of the amended water in such a manner that no asbestos material is disturbed prior to being adequately wetted. Where unusual circumstances prohibit the use of 0.15 mm 6 mil plastic bags, submit an alternate proposal for containment of asbestos fibers to the Owner's Engineer for approval. Asbestos containing material shall be containerized while wet. At no time shall asbestos containing material be allowed to accumulate or become dry. Handle asbestos containing material as indicated in 40 CFR 61-SUBPART M, applicable State or local regulation, and 29 CFR 1926.1101.
1. Exposed Pipe Insulation Edges-Not Used
 2. Negative Pressure Enclosure: Block and seal openings in areas where the release of airborne asbestos fibers can be expected. Establish an asbestos negative pressure enclosure with the use of curtains, portable partitions, or other enclosures in order to prevent the escape of asbestos fibers from the contaminated asbestos work area.
 - a. Personnel/Equipment Decontamination Unit: Provide a temporary facility with a separate equipment/dirty change room and clean change room. Provide a shower that complies with 29 CFR 1926.51 in between the dirty room and clean room for personnel required to wear whole body protective clothing. Provide two separate lockers for each asbestos worker, one in each locker room. Keep street clothing and street shoes in the clean locker. HEPA vacuum and remove asbestos contaminated disposable protective clothing while still wearing respirators at the boundary of the asbestos work area and seal in impermeable bags or containers for disposal. Do not wear work clothing between home and work. All employees shall shower before changing into street clothes. Collect used shower water and filter with approved water filtration equipment to remove asbestos contamination. Dispose of filters and residue as asbestos waste. Discharge clean water to the sanitary system. Dispose of asbestos contaminated work clothing as asbestos contaminated waste or properly decontaminate as specified in the Asbestos Hazard Abatement Plan.
 - b. Waste Load-Out Unit: Provide a separate temporary area expressly for short-term storage of bagged asbestos containing material that is ready for disposal. The unit shall be the only port used to transfer waste to a truck, dumpster, or other approved on-site storage facility. It



shall not be used for personnel egress. A waste load-out unit shall be integral to each negative pressure enclosure.

3. Non-friable Removal Procedures:

- a. Under normal conditions EPA Category II, non-friable asbestos containing materials may not be considered hazardous; however, this material may release airborne asbestos fibers during demolition and removal; therefore it must be handled in a manner to prevent the release of asbestos fibers. At no time will this material be mechanically chipped, sawed, sanded, or ground.
- b. Prior to beginning removal, establish an Asbestos Control Area and install Critical Barriers as specified elsewhere in this section. Submit a Negative Exposure Assessment which is less than 12 months old to the the Owner for approval or conduct air sampling as specified elsewhere in this section to establish the exposure levels for the exact removal method being used. The Contractor will establish the correct level of Personal Protective Equipment required.
- c. Acceptable methods of removal include, but are not limited to, the use of dry ice, a heat gun or lamp, citrus-based solvents, and hand tools with amended water. Removal shall be accomplished to keep the ACM substantially intact. Breakage into small pieces is an unacceptable work practice. The method shall be detailed in the Asbestos Abatement Plan and shall not be changed during the removal without Contracting Officer approval.
- d. Upon completion of the removal and clean-up, but prior to removal of critical barriers, the Contractor Testing company shall conduct a visual inspection of all areas affected by the removal. Re-clean as required.

D. Field Quality Control Requirements

1. Visual Inspections: The the Owner will conduct periodic inspections of all areas where asbestos removal and activities are in progress to ensure compliance with the approved Asbestos Hazard Abatement Plan and Federal/State regulatory requirements. This inspection shall include confirmation of proper control/containment/enclosure, worker protection, housekeeping, exhaust equipment operation, decontamination procedures, proper wetting and disposal, and inspection of work progress and work practices. Each activity will be documented as acceptable or noted as unacceptable with justification for the non-compliance.
2. Air Sampling: Sampling of airborne concentrations of asbestos fibers shall be performed in accordance with 29 CFR 1926.1101 and as specified herein. Unless otherwise specified, use NIOSH Method 7400 for sampling and analysis. Air Sampling may be duplicated by the Government at the discretion of the Contracting Officer. If the air sampling results obtained by the Government differ from those results obtained by the Contractor, the Government will determine which results predominate.
 - a. Sampling Prior to Asbestos Work (Not Used)
 - b. Sampling During Asbestos Work
 - 1) The Contractor's testing company shall perform area sampling as indicated in 29 CFR 1926.1101 and governing environmental regulations. Perform area sampling at least once every week close to the work inside the enclosure, outside the personnel/equipment decontamination unit entrance to the enclosure.
 - 2) If sampling outside the enclosure shows airborne levels have exceeded background or 0.01 fibers per cubic centimeter, whichever is greater, stop all work, correct the condition(s) causing the fiber release, and notify the the Owner immediately. Determine by testing if adjacent areas are contaminated. If so the Contractor shall clean the contaminated areas, visually inspect, and sample the areas as specified herein.
 - 3) The Contractor shall conduct personal sampling of at least 25% of the workers engaged in asbestos handling (removal, disposal, transport and other associated work) throughout the duration of the project. If the quantity of airborne asbestos fibers monitored at the breathing zone of the workers at any time exceeds 0.1 fibers



per cubic centimeter, notify the PQP immediately, evaluate work practices, and take corrective action to reduce airborne asbestos fibers.

E. Clean-Up And Disposal

1. Housekeeping

- a. Essential parts of asbestos dust control are housekeeping and clean-up procedures. Maintain surfaces of the asbestos control area free of accumulations of asbestos fibers. Give meticulous attention to restricting the spread of dust and debris; keep waste from being distributed over the general area. Use HEPA filtered vacuum cleaners. **DO NOT BLOW DOWN THE SPACE WITH COMPRESSED AIR.** All asbestos waste shall be placed in an approved on-site storage facility or transported for disposal daily. When asbestos removal is complete, all asbestos waste is removed from the work-site, and final clean-up is completed, the PQP shall visually inspect the asbestos control area for cleanliness. After final clean-up and acceptable pre-clearance airborne concentrations are attained but before the local exhaust system is turned off and the negative pressure enclosure removed), remove all pre-filters on the building HVAC system and provide new pre-filters.
- b. Dispose of filters as asbestos contaminated materials. Reestablish HVAC, mechanical, and electrical systems in proper working order.

2. Title to Materials: All waste materials, except as specified otherwise, shall become the property of the Contractor and shall be disposed of as specified in applicable Federal, State, and local regulations and herein.

3. Disposal of Asbestos

- a. Collect all removed asbestos containing material, contaminated materials, contaminated water, scrap, debris, bags, containers, expendable equipment, and asbestos contaminated clothing which may produce airborne asbestos fibers and place in sealed fiber-proof, waterproof, non-returnable containers (e.g. double plastic bags 0.15 mm 6 mils thick, cartons, drums or cans). Wastes within the containers must be adequately wet in accordance with 40 CFR 61-SUBPART M. Affix a warning and Department of Transportation (DOT) label to each container including the bags or use at least 0.15 mm 6 mils thick bags with the approved warnings and DOT labeling preprinted on the bag.
- b. Each container or bag shall clearly indicate that the waste generator is the Owner and the development at which the waste is generated, and the Job Order number of the project.
- c. Prevent contamination of the transport vehicle (especially if the transport vehicle is a rented truck likely to be used in the future for non-asbestos purposes). These precautions include lining the vehicle cargo area with plastic sheeting (similar to work area enclosure) and thorough cleaning of the cargo area after transport and unloading of asbestos debris is complete. Dispose of waste asbestos material at an Environmental Protection Agency (EPA) or State-approved asbestos landfill off the Owner's property. For temporary storage, store sealed impermeable bags in asbestos waste drums or skids. An area for interim storage of asbestos waste-containing drums or skids will be coordinated with the the Owner. Procedure for hauling and disposal shall comply with 40 CFR 61-SUBPART M, State, regional, and local standards. Sealed plastic bags may be dumped from drums into the burial site unless the bags have been broken or damaged. Damaged bags shall remain in the drum and the entire contaminated drum shall be buried. Uncontaminated drums may be recycled. Workers unloading the sealed drums shall wear appropriate respirators and personal protective equipment when handling asbestos materials at the disposal site.

END OF SECTION 02 82 33 00a



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Task	Specification	Specification Description
02 82 33 00	01 22 16 00	No Specification Required
02 82 33 00	02 81 00 00a	Disposal Of Hazardous Materials
02 82 33 00	02 82 16 00	Encapsulation (Lock-Down) Of Asbestos-Containing Materials



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**SECTION 02 83 19 13 - REMOVAL AND DISPOSAL OF LEAD-CONTAINING PAINT**

1.1 GENERAL

A. Description Of Work

1. This specification covers the removal and disposal of lead-based or lead-containing paint. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definitions

1. Action Level: Employee exposure, without regard to use of respirators, to an airborne concentration of lead of 30 micrograms per cubic meter of air averaged over an 8 hour period in an occupational/industrial environment.
2. Area Sampling: Sampling of lead concentrations within the lead control area and inside the physical boundaries which is representative of the airborne lead concentrations but is not collected in the breathing zone of personnel.
3. Competent Person (CP): As used in this section, refers to a person employed by the Contractor who is trained in the recognition and control of lead hazards in accordance with current federal, State, and local regulations. An industrial hygienist or safety professional certified for comprehensive practice by the American Board of Industrial Hygiene or by the Board of Certified Safety Professionals is the best choice.
4. Contaminated Room: Room for removal of contaminated personal protective equipment (PPE).
5. Decontamination Shower Facility: That facility that encompasses a clean clothing storage room, and a contaminated clothing storage and disposal rooms, with a shower facility in between.
6. Eight-Hour Time Weighted Average (TWA): Airborne concentration of lead to which an employee is exposed, averaged over an 8 hour workday as indicated in 29 CFR 1926.62.
7. High Efficiency Particulate Air (HEPA) Filter Equipment: HEPA filtered vacuuming equipment with a UL 586 filter system capable of collecting and retaining lead-contaminated paint dust. A high efficiency particulate filter means 99.97 percent efficient against 0.3 micron or larger size particles.
8. Lead: Metallic lead, inorganic lead compounds, and organic lead soaps.
9. Lead-Based Paint (LBP): Paint or other surface coating that contains lead in excess of 1.0 milligrams per centimeter squared or 0.5 percent by weight.
10. Lead-Based Paint Hazard (LBP Hazard): Any condition that causes exposure to lead from lead-contaminated dust, lead-contaminated soil, lead-based paint that is deteriorated or present in accessible surfaces, friction surfaces, or impact surfaces that would result in adverse human health effects.
11. Lead-Containing Paint (LCP): Lead-based paint or other similar surface coating containing lead or lead compound in excess of 0.06 percent by weight of the total nonvolatile content of the paint.
12. Lead Control Area: An enclosed area or structure, constructed as a temporary containment equipped with HEPA filtered local exhaust, which prevents the spread of lead dust, paint chips, or debris existing as a condition of lead-based paint removal operations. The lead control area is also isolated by physical boundaries to prevent unauthorized entry of personnel.
13. Lead Permissible Exposure Limit (PEL): Fifty micrograms per cubic meter of air as an 8 hour time weighted average as determined by 29 CFR 1926.62. If an employee is exposed for more than eight hours in a work day, the PEL shall be determined by the following formula:
$$\text{PEL (micrograms/cubic meter of air)} = 400/\text{No. hrs. worked per day.}$$
14. Personal Sampling: Sampling of airborne lead concentrations within the breathing zone of an employee to determine the 8 hour time weighted average concentration in accordance with 29 CFR 1926.62. Samples shall be representative of the employees' work tasks. Breathing zone shall be considered an area within a hemisphere, forward of the shoulders, with a radius of 6 to 9 inches (150 to 225 mm) and centered at the nose or mouth of an employee.



15. Physical Boundary: Area physically roped or partitioned off around an enclosed lead control area to limit unauthorized entry of personnel. As used in this section, "inside boundary" shall mean the same as "outside lead control area but inside boundary."

C. Submittals: Submit the following:

1. Product Data:
 - a. Vacuum filters
 - b. Respirators
2. Test Reports
 - a. Sampling results
 - b. Assessment data report
3. Certificates
 - a. Qualifications of CP
 - b. Testing laboratory</SUB> qualifications
 - c. Third party consultant qualifications
 - d. Lead-Based Paint/Lead-Containing Paint Removal Plan including CP approval (signature, date, and certification number)
 - e. Rental equipment notification
 - f. Respiratory protection program
 - g. Hazard communication program
 - h. EPA approved hazardous waste treatment or disposal facility for lead disposal
 - i. Hazardous waste management plan
 - j. Vacuum filters
4. Manufacturer's Instructions
 - a. Chemicals and equipment
 - b. Materials
 - c. Material safety data sheets for all chemicals
5. Closeout Submittals
 - a. Completed and signed hazardous waste manifest from treatment or disposal facility
 - b. Certification of medical examinations
 - c. Employee training certification

D. Qualifications Of CP

1. Submit name, address, and telephone number of the CP selected to perform responsibilities specified in paragraph entitled "Competent Person (CP) Responsibilities." Provide previous experience of the CP. Submit proper documentation that the CP is trained and licensed and certified in accordance with Federal, State, and local laws.

E. Third Party Consultant Qualifications

1. Submit the name, address, and telephone number of the third party consultant selected to perform the wipe sampling for determining concentrations of lead in dust or soil sampling. Submit proper documentation that the consultant is trained and certified as an inspector technician or inspector/risk assessor by the USEPA authorized State (or local) certification and accreditation program.

F. Testing Laboratory

1. Submit the name, address, and telephone number of the testing laboratory selected to perform the air and wipe and soil sampling, testing, and reporting of airborne concentrations of lead. Use a laboratory accredited under the EPA National Lead Laboratory Accreditation Program (NLLAP) by either the American Association for Laboratory Accreditation (A2LA) or the American Industrial Hygiene Association (AIHA) and that is successfully participating in the Environmental Lead Proficiency Analytical Testing (ELPAT) program to perform sample analysis.

G. Lead-Based Paint/Lead-Containing Paint Removal Plan (LBP/LCPRP)



1. Submit a detailed job-specific plan of the work procedures to be used in the removal of LBP/LCP. The plan shall include a sketch showing the location, size, and details of lead control areas, location and details of decontamination facilities, viewing ports, and mechanical ventilation system. Include in the plan, eating, drinking, smoking and sanitary procedures, interface of trades, sequencing of lead related work, collected waste water and paint debris disposal plan, air sampling plan, respirators, personal protective equipment, and a detailed description of the method of containment of the operation to ensure that airborne lead concentrations of 30 micrograms per cubic meter of air and baseline lead dust/soil concentrations are not reached or exceeded outside of the lead control area. Include site preparation and cleanup procedures. Include occupational and environmental sampling, training and strategy, sampling methodology, frequency, duration of sampling, and qualifications of sampling personnel in the air sampling portion of the plan.
- H. Occupational And Environmental Sampling Results
1. Submit occupational and environmental sampling results to the the Owner within three working days of collection, signed by the testing laboratory responsible official, the employee that performed the sampling, and the CP.
 - a. The sampling results shall represent each job classification, or if working conditions are similar to previous jobs by the same employer, provide previously collected exposure data that can be used to estimate worker exposures in accordance with 29 CFR 1926.62. The data shall represent the worker's regular daily exposure to lead.
 - b. Submit worker exposure data conducted during the task based trigger operations of 29 CFR 1926.62.
 - c. The initial monitoring shall determine the requirements for further monitoring and the need to fully implement the control and protective requirements including the compliance program (LBP/LCP) in accordance with 29 CFR 1926.62.
- I. Occupational And Environmental Assessment Data Report:
1. Some LBP/LCP removal work may not require full implementation of the requirements of 29 CFR 1926.62. Based on the experience of the Contractor and/or the use of a specific process or method for performing the work, the Contractor may be able to provide historic data (previous 12 months) to demonstrate that airborne exposures are controlled below the action level. Such methods or controls shall be fully presented in the LBP/LCPRP. To reduce the full implementation of 29 CFR 1926.62, the Contractor shall provide documentation in an Assessment Data Report.
 2. Submit occupational and environmental assessment report to the the Owner prior to start of work, signed by the testing laboratory responsible official, and the CP.
 - a. Submit a report that supports the determination regarding the reduction of the need to fully implement the requirements of 29 CFR 1926.62 and supporting the LBP/LCP. The exposure assessment shall represent each job classification, or if working conditions are similar to previous jobs by the same employer, provide previously collected exposure data that can be used to estimate worker exposures in accordance with 29 CFR 1926.62. The data shall represent the worker's regular daily exposure to lead for stated work.
 - b. Submit worker exposure data conducted during the task based trigger operations of 29 CFR 1926.62 with a complete process description in supporting a negative assessment.
 - c. The initial assessment shall determine the requirement for further monitoring and the need to fully implement the control and protective requirements including the compliance program (LBP/LCPRP) in accordance with 29 CFR 1926.62.
- J. Quality Assurance
1. Medical Examinations: Initial medical surveillance as required by 29 CFR 1926.62 shall be made available to all employees exposed to lead at any time (1 day) above the action level. Full medical surveillance shall be made available to all employees on an annual basis who are or may be exposed to lead in excess of the action level for more than 30 days a year or as required by 29 CFR 1926.62. Adequate records shall show that employees meet the medical surveillance requirements of 29 CFR 1926.33, 29 CFR 1926.62, and 29 CFR 1926.103.



- a. Medical Records: Maintain complete and accurate medical records of employees for a period of at least 30 years or for the duration of employment plus 30 years, whichever is longer.
- b. Medical Surveillance: Provide medical surveillance to all personnel exposed to lead as indicated in 29 CFR 1926.62.
2. Competent Person (CP) Responsibilities
 - a. Certify training as meeting all federal, State, and local requirements.
 - b. Review and approve lead-based paint/lead-containing paint removal plan for conformance to the applicable referenced standards.
 - c. Continuously inspect lead-based paint removal work for conformance with the approved plan.
 - d. Perform air and wipe sampling.
 - e. Ensure work is performed in strict accordance with specifications at all times.
 - f. Control work to prevent hazardous exposure to human beings and to the environment at all times.
 - g. Certify the conditions of the work as called for elsewhere in this specification.
3. Training: Train each employee performing paint removal, disposal, and air sampling operations prior to the time of initial job assignment and annually thereafter, in accordance with 29 CFR 1926.21, 29 CFR 1926.62, and State and local regulations.
 - a. Training Certification: Submit a certificate for each employee, signed and dated by the approved training source, stating that the employee has received the required lead training.
4. Respiratory Protection Program
 - a. Furnish each employee required to wear a negative pressure respirator or other appropriate type with a respirator fit test at the time of initial fitting and at least annually thereafter as required by 29 CFR 1926.62.
 - b. Establish and implement a respiratory protection program as required by ANSI Z88.2, 29 CFR 1926.103, 29 CFR 1926.62, and 29 CFR 1926.55.
5. Hazard Communication Program: Establish and implement a Hazard Communication Program as required by 29 CFR 1926.59.
6. Hazardous Waste Management: The Hazardous Waste Management Plan shall comply with applicable requirements of federal, State, and local hazardous waste regulations and address:
 - a. Identification and classification of hazardous wastes associated with the work.
 - b. Estimated quantities of wastes to be generated and disposed of.
 - c. Names and qualifications of each contractor that will be transporting, storing, treating, and disposing of the wastes. Include the facility location and operator and a 24-hour point of contact. Furnish two copies of EPA, or State and local hazardous waste permit applications or permits or manifests, as required, and EPA Identification numbers.
 - d. Names and qualifications (experience and training) of personnel who will be working on-site with hazardous wastes.
 - e. List of waste handling equipment to be used in performing the work, to include cleaning, volume reduction, and transport equipment.
 - f. Spill prevention, containment, and cleanup contingency measures including a health and safety plan to be implemented in accordance with 29 CFR 1926.65.
 - g. Work plan and schedule for waste containment, removal and disposal. Wastes shall be cleaned up and containerized daily.
 - h. Unit cost for hazardous waste disposal according to this plan.
7. Environmental, Safety and Health Compliance: In addition to the detailed requirements of this specification, comply with laws, ordinances, rules, and regulations of Federal, State, and local authorities regarding removing, handling, storing, transporting, and disposing of lead waste materials. Comply with the applicable requirements of the current issue of 29 CFR 1926.62. Submit matters regarding interpretation of standards to the the Owner for resolution before starting work. Where specification requirements and the referenced documents vary, the most stringent requirement shall apply.



8. Pre-Construction Conference: Along with the CP, meet with the the Owner to discuss in detail the hazardous waste management plan and the lead-based paint/lead-containing paint removal plan, including work procedures and precautions for the removal plan.

K. Equipment

1. Respirators: Furnish appropriate respirators approved by the National Institute for Occupational Safety and Health (NIOSH), Department of Health and Human Services, for use in atmospheres containing lead dust. Respirators shall comply with the requirements of 29 CFR 1926.62.
2. Special Protective Clothing: Furnish personnel who will be exposed to lead-contaminated dust with proper disposable uncontaminated, reusable protective whole body clothing, head covering, gloves, and foot coverings as required by 29 CFR 1926.62. Furnish proper disposable plastic or rubber gloves to protect hands. Reduce the level of protection only after obtaining approval from the CP.
3. Rental Equipment Notification: If rental equipment is to be used during lead-based paint handling and disposal, notify the rental agency in writing concerning the intended use of the equipment. Furnish a copy of the written notification to the the Owner.
4. Vacuum Filters: UL 586 labeled HEPA filters.
5. Equipment for Owner's Personnel: Furnish the the Owner with two complete sets of personal protective equipment (PPE) daily, as required herein, for entry into and inspection of the paint removal work within the lead controlled area. Personal protective equipment shall include disposable whole body covering, including appropriate foot, head, and hand protection. PPE shall remain the property of the Contractor. Respiratory protection for the the Owner will be provided by the Owner.

L. Removal

1. Title to Materials: Materials resulting from demolition work, except as specified otherwise, shall become the property of the Contractor and shall be disposed of in accordance with Division 02 Section(s) "Selective Structure Demolition" OR "Structure Demolition", except as specified herein.

1.2 PRODUCT

A. Chemicals

1. Submit applicable Material Safety Data Sheets for all chemicals used in paint removal work. Use the least toxic product approved by the the Owner.

B. Materials

1. The soluble metal content and the total metal content shall not exceed values which would cause a material to be classified as a hazardous waste.

1.3 EXECUTION

A. Protection

1. Notification: Notify the the Owner 20 days prior to the start of any paint removal work.
2. Lead Control Area Requirements
 - a. If LBP will be removed by means which will not likely create airborne, lead-containing dust (such as careful wet scraping or chemical stripping), establish a lead control area by situating critical barriers and physical boundaries around the area or structure where LBP/LCP removal operations will be performed.
 - b. If removal practice will create airborne, lead-containing dust (such as sanding, abrasive blasting, thermal cutting, demolition, or needle gun use), utilize full containment procedures - Contain removal operations by the use of critical barriers and HEPA filtered exhaust **OR** a negative pressure enclosure system with decontamination facilities and with HEPA filtered exhaust if required by the CP, **as directed**. For containment areas larger than 1,000 square feet (100 square meters) install a minimum of two 18 inch (450 mm) square viewing



- ports. Locate ports to provide a view of the required work from the exterior of the enclosed contaminated area. Glaze ports with laminated safety glass.
3. Protection of Existing Work to Remain: Perform paint removal work without damage or contamination of adjacent areas. Where existing work is damaged or contaminated, restore work to its original condition or better.
 4. Boundary Requirements: Provide physical boundaries around the lead control area by roping off the area designated in the work plan or providing curtains, portable partitions or other enclosures to ensure that airborne concentrations of lead will not reach 30 micrograms per cubic meter of air outside of the lead control area.
 - a. Physical Boundary: Provide physical boundaries around the lead control area by roping off the area designated in the work plan or providing curtains, portable partitions or other enclosures to ensure that airborne concentrations of lead will not reach 30 micrograms per cubic meter of air outside of the lead control area.
 - b. Warning Signs: Provide warning signs at approaches to lead control areas. Locate signs at such a distance that personnel may read the sign and take the necessary precautions before entering the area. Signs shall comply with the requirements of 29 CFR 1926.62.
 5. Furnishings:
 - a. The Owner will remove furniture and equipment from the building before lead-based paint removal work begins.
OR
 Furniture and equipment will remain in the building. Protect and cover furnishings or remove furnishings from the work area and store in a location approved by the the Owner.
OR
 Existing furniture and equipment is lead contaminated, decontaminate, dispose of as lead contaminated waste.
 6. Heating, Ventilating and Air Conditioning (HVAC) Systems: Shut down, lock out, and isolate HVAC systems that supply, exhaust, or pass through the lead control areas. Seal intake and exhaust vents in the lead control area with 6 mil (0.15 mm) plastic sheet and tape. Seal seams in HVAC components that pass through the lead control area. Provide temporary HVAC system for areas in which HVAC has been shut down outside the lead control area.
 7. Decontamination Shower Facility: Provide clean and contaminated change rooms and shower facilities in accordance with this specification and 29 CFR 1926.62.
 8. Eye Wash Station: Where eyes may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes shall be provided within the work area.
 9. Mechanical Ventilation System
 - a. Use adequate ventilation to control personnel exposure to lead in accordance with 29 CFR 1926.62.
 - b. To the extent feasible, use fixed local exhaust ventilation connected to HEPA filters or other collection systems, approved by the CP. Local exhaust ventilation systems shall be designed, constructed, installed, and maintained in accordance with ANSI Z9.2.
 - c. Vent local exhaust outside the building only and away from building ventilation intakes.
 - d. Use locally exhausted, power actuated, paint removal tools.
 10. Personnel Protection: Personnel shall wear and use protective clothing and equipment as specified herein. Eating, smoking, or drinking or application of cosmetics is not permitted in the lead control area. No one will be permitted in the lead control area unless they have been appropriately trained and provided with protective equipment.
- B. Work Procedures: Perform removal of lead-based paint in accordance with approved lead-based paint/lead-containing paint removal plan. Use procedures and equipment required to limit occupational and environmental exposure to lead when lead-based paint is removed in accordance with 29 CFR 1926.62, except as specified herein. Dispose of removed paint chips and associated waste in compliance with Environmental Protection Agency (EPA), federal, State, and local requirements.
1. Personnel Exiting Procedures: Whenever personnel exit the lead-controlled area, they shall perform the following procedures and shall not leave the work place wearing any clothing or equipment worn during the work day:



- a. Vacuum themselves off.
 - b. Remove protective clothing in the contaminated change room, and place them in an approved impermeable disposal bag.
 - c. Shower **OR** Wash hands and face at the site, **as directed**, don appropriate disposable or uncontaminated reusable clothing; move to an appropriate facility; shower.
 - d. Change to clean clothes prior to leaving the physical boundary designated around the lead control area.
2. Air and Wipe Sampling
- a. Air sample for lead in accordance with 29 CFR 1926.62 and as specified herein. Air and wipe sampling shall be directed or performed by the CP.
 - 1) The CP shall be on the job site directing the air and non-clearance wipe sampling and inspecting the lead-based paint removal work to ensure that the requirements of the contract have been satisfied during the entire lead-based paint removal operation.
 - 2) Collect personal air samples on employees who are anticipated to have the greatest risk of exposure as determined by the CP. In addition, collect air samples on at least 25 percent of the work crew or a minimum of two employees, whichever is greater, during each work shift.
 - 3) Submit results of air samples, signed by the CP, within 72 hours after the air samples are taken. Notify the the Owner immediately of exposure to lead at or in excess of the action level of 30 micrograms per cubic meter of air outside of the lead control area.
 - 4) For high profile, sensitive work such as present in family housing, child care facilities, administrative buildings, kitchens, barracks, etc., surface dust sampling to determine clearance (i.e., that the work has not contaminated surfaces within and adjacent to the control area) should be performed by a third party to reduce a conflict of interest. Samples must be conducted by an individual not paid or employed or otherwise compensated by the LBP/LCP removal Contractor. State or local regulations may require third party testing if the LBP/LCP removal operation is considered a lead hazard reduction activity.
 - 5) Before any work begins, collect and analyze baseline or soil wipe samples in accordance with methods defined in federal, State, and local standards inside and outside of the physical boundary to assess the degree of dust contamination in the facility prior to lead-based paint removal.
 - b. Air Sampling During Paint Removal Work: Conduct area air sampling daily, on each shift in which lead-based paint removal operations are performed, in areas immediately adjacent to the lead control area. Sufficient area monitoring shall be conducted to ensure unprotected personnel are not exposed at or above 30 micrograms per cubic meter of air. If 30 micrograms per cubic meter of air is reached or exceeded, stop work, correct the condition(s) causing the increased levels. Notify the the Owner immediately. Determine if condition(s) require any further change in work methods. Removal work shall resume only after approval is given by the CP and the the Owner. For outdoor operations, at least one sample on each shift shall be taken on the downwind side of the lead control area.
3. Lead-Based Paint Removal
- a. Manual or power sanding of interior and exterior surfaces is not permitted. Provide methodology for removing LBP in work plan. Remove paint within the areas designated on the drawings in order to completely expose the substrate. Take whatever precautions necessary to minimize damage to the underlying substrate.
 - b. Avoid flash rusting or deterioration of the substrate. Provide surface preparations for painting in accord with Division 07.
 - c. Provide methodology for removing LBP/LCP removal processes to minimize contamination of work areas outside the control area with lead-contaminated dust or other lead-contaminated debris/waste and to ensure that unprotected personnel are not exposed to hazardous concentrations of lead. Describe this LBP/LCP removal process in the LBP/LCPRP.



- d. Indoor Lead Paint Removal: Perform manual **OR** mechanical **OR** thermal **OR** chemical, **as directed**, paint removal in lead control areas using enclosures, barriers, or containments and powered locally exhausted paint removal tools. Collect residue and/or debris for disposal in accordance with federal, State, and local requirements.
 - e. Outdoor Lead Paint Removal: Perform outdoor removal as indicated in federal, State, and local regulations and in the LBP/CPRP. The worksite preparation (barriers or containments) shall be job dependent and presented in the LBP/LCPRP.
 - f. Sampling After Paint Removal: After the visual inspection, conduct soil sampling if bare soil is present during external removal operations and collect air samples inside and outside the lead control area to determine the airborne levels of lead inside and outside the work area. Collect wipe samples according to the HUD protocol contained in HUD Guidelines to determine the lead content of settled dust and dirt in micrograms per square foot (square meter) of surface area and parts per million (ppm) or micrograms per gram ($\mu\text{g/g}$) for soil.
4. Cleanup and Disposal
- a. Cleanup: Maintain surfaces of the lead control area free of accumulations of paint chips and dust. Restrict the spread of dust and debris; keep waste from being distributed over the work area. Do not dry sweep or use compressed air to clean up the area. At the end of each shift and when the paint removal operation has been completed, clean the area of visible lead paint contamination by vacuuming with a HEPA filtered vacuum cleaner, wet mopping the area and wet wiping the area as indicated by the CP. Reclean areas showing dust or residual paint chips or debris. After visible dust, chips and debris is removed, wet wipe and HEPA vacuum all surfaces in the work area. If adjacent areas become contaminated at any time during the work, clean, visually inspect, and then wipe sample all contaminated areas. The CP shall then certify in writing that the area has been cleaned of lead contamination before restarting work.
 - b. Clearance Certification
 - 1) The CP shall certify in writing that the final air samples collected inside and outside the lead control area are less than 30 micrograms per cubic meter of air; the respiratory protection used for the employees was adequate; the work procedures were performed in accordance with 29 CFR 1926.62 and 40 CFR 745; and that there were no visible accumulations of material and dust containing lead left in the work site. Do not remove the lead control area or roped off boundary and warning signs prior to the the Owner's acknowledgement of receipt of the CP certification.
 - 2) A third party consultant shall certify surface wipe sample results collected inside and outside the work area are less than 100 micrograms per square foot (0.1 square meter) on uncarpeted floors, less than 500 micrograms per square foot (0.1 square meter) on interior window sills and less than 800 micrograms per square foot (0.1 square meter) on window troughs **OR** not significantly greater than the initial surface loading determined prior to work, **as directed**.
 - 3) For exterior paint removal work, soil samples taken at the exterior of the work site shall be used to determine if soil lead levels had increased at a statistically significant level (significant at the 95 percent confidence limit) from the soil lead levels prior to the work. If soil lead levels do show a statistically significant increase above any applicable Federal or State standard for lead in soil, the soil shall be remediated back to the pre-work level.
 - c. Testing of Lead-Based Paint Residue and Used Abrasive: Test paint residue and used abrasive in accordance with 40 CFR 261 for hazardous waste.
 - d. Disposal
 - 1) Collect lead-contaminated waste, scrap, debris, bags, containers, equipment, and lead-contaminated clothing which may produce airborne concentrations of lead particles. Label the containers in accordance with 29 CFR 1926.62 and 40 CFR 261. Dispose of lead-contaminated waste material at an EPA or State approved hazardous waste treatment, storage, or disposal facility off Owner's property.



- 2) Store waste materials in U.S. Department of Transportation (49 CFR 178) approved 55 gallon (208 liter) drums. Properly label each drum to identify the type of waste (49 CFR 172) and the date the drum was filled. The the Owner or an authorized representative will assign an area for interim storage of waste-containing drums. Do not store hazardous waste drums in interim storage longer than 90 calendar days from the date affixed to each drum.
- 3) Handle, store, transport, and dispose lead or lead-contaminated waste in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, and 40 CFR 265. Comply with land disposal restriction notification requirements as required by 40 CFR 268.
- 4) All material, whether hazardous or non-hazardous shall be disposed in accordance with laws and provisions and Federal, State, or local regulations. Ensure waste is properly characterized. The result of each waste characterization (TCLP for RCRA materials) will dictate disposal requirements.
5. Disposal Documentation: Submit written evidence that the hazardous waste treatment, storage, or disposal facility (TSD) is approved for lead disposal by the EPA and State or local regulatory agencies. Submit one copy of the completed manifest, signed and dated by the initial transporter in accordance with 40 CFR 262.
6. Payment for Hazardous Waste: Payment for disposal of hazardous waste will not be made until a signed copy of the manifest from the treatment or disposal facility certifying the amount of lead-containing materials delivered is returned and a copy is furnished to the Owner.

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**SECTION 02 83 19 13a - LEAD PAINT RELATED ABATEMENT PROCEDURES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for lead paint related abatement procedures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. General Provisions

1. The site of this work will be occupied while work is being done. Perform the abatement work with the least inconvenience to the residents.
2. Take all necessary precautions to protect the property of the the Owner and its residents. Damaged property shall be repaired and restored to its original condition. If the damage is beyond repair, the Contractor shall replace it with new materials to match existing, at the Contractor's expense.
3. Hazardous waste generated during the abatement process (including lead-base paint) when carted away from the developments shall not be transferred from one vehicle to another except at a licensed transfer station.
4. Develop a work plan to be performed as requested by the the Owner. The detailed plan shall include sequencing of abatement work in a manner that will be least disruptive to the normal use of the non-work areas in the building. The plan should also include emergency procedures in case of fire.
5. The Contractor shall include all supplementary miscellaneous items not specified but implied or required in order to complete the work.
6. Workmanship required in the execution of the work herein specified shall be of good quality and subject to the approval of the the Owner.
7. Make in a timely fashion all applicable and necessary notifications to relevant Federal, State and Local authorities. The Contractor shall indemnify the the Owner and the the Owner's representative from, and pay all claims resulting from failure to adhere to these provisions.
8. the Owner may retain an independent Monitoring Contractor to monitor the abatement contract and conduct all wipe sampling and clearance tests.
9. Contractor performing lead-based paint abatement or renovation activities involving lead-based paint shall be a Certified Lead Abatement Contractor and shall ensure that supervisors and workers are trained and certified by U.S. EPA approved state program or equivalent, to perform lead paint removal operations.
10. Establish and implement a Chemical Hazard Communication Program as required by OSHA regulations 29 CFR 1926.59.
11. Provide workers with a comprehensive medical examination as required by OSHA regulations 29 CFR 1926.62 before exposure to lead contaminated dust. The medical examination shall be conducted to approve use of appropriate respirators and shall include biological monitoring. NIOSH/MSHA approved respirators shall be utilized.
12. For employees required to wear a negative pressure respirators: conduct a respirator fit test at the time of initial fitting and at least once every six (6) months thereafter as required by OSHA regulations 29 CFR 1926.62.
13. Determine if any worker will be exposed to lead at or above the action level in accordance with OSHA regulation 29 CFR 1926.62 and 29 CFR 1910.1025. Conduct an exposure assessment to identify the level of exposure a worker would be subjected to without respiratory protection. Assess the exposure level by obtaining personal monitoring samples representative of a full shift of at least an 8-hour TWA.
14. Furnish appropriate respirators approved by NIOSH/MSHA for use in atmospheres containing lead aerosols. Instruct workers in all aspects of respiratory protection. Maintain an adequate supply of HEPA filter elements and spare parts on site for all types of respirators in use.



15. For manual demolition, scraping, sanding, use of heat gun or power tool paint removal with HEPA collection systems, workers shall minimally use the half-mask negative pressure respirator with high efficiency filters (for airborne concentrations not in excess of 500 μ g/m³).
16. Ensure that work area preparation, work practices, and clean-up procedures comply with these specifications and applicable Federal, State and Local regulations.
17. Notify all applicable agencies five days prior to the date the abatement will begin and provide evidence of notifications to the the Owner at the pre-start meeting.

C. Submissions

1. Within ten (10) consecutive calendar days calculated from the date of the the Owner's Job Order, the Contractor shall tender all required submissions. Six (6) sets of each submission are required. Where physical samples are required two (2) physical samples shall be submitted for each item. In general, items shall include but not be restricted to the following:
 - a. Paint remover - corner cutter/Vac-Pac System by Pentek Inc; Decontamination Products Division 1026 Fourth Avenue, Corapolis, PA. 15108. Telephone No. (412) 262-0725 or approved equal.
 - b. Description of removal method to be used on each substrate condition including manufacturer's operating instructions and recommendation for equipment usage.
 - c. Copies of current training certificates of Staff to be assigned to the contract.
 - d. List of three previous lead abatement jobs performed successfully by Contractor and name, address, and telephone number of contact person for verification.
2. In the event that all or any portion of the submitted material is rejected by the the Owner, the Contractor shall tender new submissions. All submissions returned for corrections shall be resubmitted with the required corrections within ten(10) consecutive calendar days calculated from the date of rejection, until final submissions are obtained that require no further correction. In no event shall the Contractor be permitted to tender submissions hereunder beyond twenty (20) days from the the Owner's Job Order, unless duly extended in writing by the the Owner.
3. No work shall begin, nor shall the materials be ordered or delivered to the site until final approval of all submissions.

D. Applicable Regulations

1. 24 CFR Part 35
2. HUD "Guidelines For the Evaluation and Control of Lead-Based Paint Hazards in Housing"
3. Abatement work shall also be in accordance with applicable regulations of the Environmental Protection Agency (EPA), Occupational Safety & Health Agency (OSHA) and any State or Local LBP standards. Where there is a conflict between Federal, State or Local regulations, the more stringent requirement shall prevail.
4. OSHA Standards
 - a. 29 CFR 1926.20 General safety and health provisions;
 - b. 29 CFR 1926.21 Safety training and education;
 - c. 29 CFR 1925.25 Housekeeping;
 - d. 29 CFR 1926-28 Personal protective equipment;
 - e. 29 CFR 1926.51(f) Washing facilities;
 - f. 29 CFR 1926.55 Gases, vapors, fumes, dusts, and mists;
 - g. 29 CFR 1926.57 Ventilation
 - h. 29 CFR 1926.59 Hazardous Communication Standards;
 - i. 29 CFR 1926.103 Respiratory protection, and
 - j. 29 CFR 1926.62 Lead in Construction
5. The Contractor must comply with all applicable requirements of the Resource Conservation & Recovery Act (RCRA) of 1976 as amended in 1980 and 1984 by the Hazardous & Solid Waste Amendments (HSWA).
6. These Specifications refer to many requirements found in the preceding references but in no way is it intended to cite or reiterate all provisions therein or elsewhere. It is the Contractor's responsibility to obtain a copy, and know, understand and abide by all such regulations, guidelines and common practices.



1.2 PRODUCTS – (not used)

1.3 EXECUTION

A. Abatement

1. Have risk assessment or paint inspection performed by certified risk assessor or a certified inspector technician who is independent of the abatement contractor.
2. Develop a site specific lead hazard control plan, reviewed and signed by an asbestos consultant (LAC) who is licensed in the State in which the work is to be performed, and submit for review and approval to the the Owner.
3. Obtain any necessary building or waste permits, notify local authorities as required by applicable codes and laws.
4. Select specific building component replacement items, enclosure materials, paint removal equipment and/or chemicals, tools, and cleaning supplies. Consider waste management and historical preservation implications of selected treatment.
5. Develop project specific specifications.
6. Schedule other work so that leaded surfaces are not inadvertently disturbed and unprotected workers are not place at risk. Include time for clearance examinations and laboratory dust sample analysis in the scheduling process.
7. Select a certified abatement subcontractor.
8. Conduct a pre-construction conference to ensure that the subcontractor fully understands the work involved.
9. Notify residents of the dwelling and adjacent dwellings of the work and date it will begin. Coordinate this with the the Owner.
10. Correct any existing conditions that could impede the abatement work (i.e. trash removal, structural deficiencies).
11. Post warning signs and restrict entry to work area to authorized personnel. Implement worksite preparation procedures.
 - a. Place proper warning signs required by OSHA regulations at all entrances to the work area. Signage shall be minimum of 12" x 20" and shall state the following:

**WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING**

12. Coordinate test, pilot or sample portion approach to the project with the Owner.
13. Shut-down forced air heating, ventilation and air conditioning systems and cover all vents, diffusers, windows etc., with a single layer six-mil polyethylene sheet secured with duct tape. Exceptions shall be for minor disturbances of area less than 2 square feet and where if vents, diffusers, and windows are more than 5 feet away from surface being disturbed, they need not be covered.
14. Collect preabatement soil samples, which may not have to be analyzed until post abatement soil samples have been collected, analyzed, and compared to clearance standards. If postabatement soil levels are below applicable limits, the preabatement samples need not be analyzed.
15. Cover entrances to the work area with a single layer of 6 mil polyethylene sheets taped to the top and weighted at bottom.
16. Rig a containment non-flammable polyethylene sheet underneath the work area. This containment method should catch all stripped paint for proper disposal.
17. Execute abatement work.
18. Avoid spreading dust and debris outside the work area.
19. Store all waste in a secure area and make sure it is properly labeled with an accumulation start date.
20. Conduct daily and final cleanup.
21. Execute waste disposal procedures.



22. Maintain appropriate records.

B. Paint Removal

1. Do not use the following prohibited paint removal methods:
 - a. Dry scraping or sanding (except for limited areas)
 - b. Use of heat gun over 1,100°F
 - c. Open flame burning or torching
 - d. Machine sanding or grinding without HEPA vacuum exhaust tool
 - e. Abrasive blasting or sandblasting without HEPA vacuum exhaust tool
 - f. Uncontained hydro blasting or high-pressure wash
 - g. Use of chemical strippers containing Methylene chloride.
2. Select the appropriate worksite preparation level.
3. For heat gun work, provide fire extinguishers in the work area and ensure that adequate electrical power is available. Use for limited areas only. Train workers to avoid gouging or abrading the substrate.
4. For mechanical removal methods, use tools equipped with HEPA exhaust capability. Be sure workers keep the shroud against the surface being treated. Vacuum blasting and needle guns should not be used on wood, plaster, drywall, or other soft substrates. Observe all manufacturers directions for the amount of vacuum airflow required.
5. For wet scraping, use a spray bottle or wet sponge attached to the scraper to keep the surface wet while scraping. Apply enough water to moisten the surface completely, but not so much that large amounts of water run onto the ground or floor. Do not moisten areas near electrical circuits.
6. For chemical paint removers, determine if the building component can be removed and stripped offsite. Offsite stripping is generally preferred to onsite paint removal. Observe all manufacturers' directions for use of paint removers.
7. For offsite stripping, determine how to remove the component. Score the edges with a knife or razor blade to minimize the damage to adjacent surfaces. Punch or tag the building component, if similar building components are also being stripped offsite (i.e. doors). This will ensure that the individual component is reinstalled in the same location. Inform the offsite paint remover that the lead-based paint component is present for shipping. Wrap the component in plastic and send to the offsite stripping location. Clean all surfaces before reinstallation and remove any lead residue by HEPA vacuuming all surfaces, cleaning with other lead-specific cleaners, or phosphate detergents, and HEPA vacuuming again.
8. For onsite paint removal, first test the product on a small area to determine its effectiveness. Chemical paint removers may not be effective or desirable on exterior, deteriorated wood surfaces, aluminum, and glass. Provide neoprene, nitrile, rubber, or polyvinyl chloride (PVC) gloves (or other type of glove recommended by the manufacture); face shields; respirators with combination filter cartridges for lead dust and organic vapors(if appropriate); and chemically resistant clothing. Be sure to select the right type of organic vapor filter cartridge, gloves, and clothing for the specific chemical being used. Portable eyewash stations capable of providing a 15-minute flow must be on-site. Apply the chemical and wait the required period of time. Securely store chemical s overnight. For caustic chemical paint removers, neutralize the surface before repainting using glacial acetic acid (not vinegar). Repaint.
9. Make sure all debris is caught in the containment sheet for proper disposal.
10. Mark and legally dispose of waste in accordance with all applicable Federal, State and Local regulations. Most wastes from paint removal projects, such as paint chips and paint remover sludge, will need to be managed as hazardous waste.
11. Conduct clean-up
12. Have a certified risk assessor or inspector technician conduct a clearance examination and provide documentation and a Statement of Lead-Based Paint Compliance.

C. Building Component Replacement

1. Prepare work area by selecting proper worksite preparation level.
2. Prepare the hazardous material building component for removal. Turn off and disconnect any electrical circuits inside or near the building component to be removed.



3. Lightly mist the component to be removed (unless electrical circuits are located nearby).
4. Score all painted seams with a sharp knife.
5. Remove any screw, nails, or other fasteners.
6. Use flat pry instrument and hammer to pry component from the substrate.
7. Remove or bend back all nails.
8. Wrap and seal all bulk components in plastic and take them to a covered truck or secured waste storage area along a pathway covered in plastic. Shovel any debris. Dispose of properly.
9. HEPA vacuum any dust or chips in the area where the component was located.
10. Conduct cleaning and clearance activities.

D. Soil and Exterior Dust Abatement

1. Determine if soil lead hazard exists. For hazard to exist, a total of at least 9 square feet of soil in a single yard or area must be bare and soil concentrations must exceed 2,000 μ g/gram lead for the yard or building perimeter or 400 μ g/gram of lead for small, high-contact play areas (pending the development of an EPA soil standard). Bare soil above these levels shall be treated by either interim controls or abatement. Soil abatement is most appropriate when levels of lead are extraordinarily high (greater than 5,000 μ g/gram lead) and when use patterns indicate contact frequency and exposure will be high.
2. Collect Preabatement soil samples to determine baseline levels. These samples need not be analyzed if post abatement samples are below applicable clearance levels.
3. Determine the method of soil abatement (soil removal and replacement, soil cleaning, or paving). Soil cultivation (rototilling or turning over the soil) is not permitted.
4. If paving, use a high quality concrete or asphalt. Observe normal precautions associate with traffic load weight and thermal expansion and contraction. Obtain necessary permits. Keep soil cultivation to a minimum.
5. If removing and replacing soil.
 - a. Determine if waste soil will be placed in an offsite burial pit. Prepare vehicle operation and soil movement plan. Test new replacement soil (should not contain more than 200 μ g/gram lead).
 - b. Contact local utilities to determine location of underground utilities including water, gas, cable TV, electric, telephone, and sewer. Mark all locations to be avoided
 - c. Remove fencing, if necessary to allow equipment access and define set limits with temporary fencing, signs, or yellow caution tape.
 - d. Tie and protect existing trees, shrubs, and bushes.
 - e. Have enough tools to avoid handling clean soil with contaminated tools.
 - f. Remove soil.
 - g. Clean all walkways, driveways, and street areas near abatement area.
 - h. Replace soil at proper grade to allow drainage. Replacement soil should be at least 2 inches above existing grade to allow for settling.
 - i. Install new soil covering (grass or sod) and maintain it through the growing season.
 - j. Determine if soil waste is hazardous and manage it accordingly
 - k. Conduct clean-up and clearance.
 - l. Provide walk-off doormats.
 - m. Maintain proper documentation.

E. Encapsulation

1. Determine if the applicable regulations also encapsulates to be used. Do not encapsulate the following surfaces:
 - a. Friction surfaces, such as window jambs and door jambs.
 - b. Surfaces that fail patch tests.
 - c. Surfaces with substrates or existing coatings that have a high level of deterioration.
 - d. Surfaces in which there is a known incompatibility between two existing paint layers.
 - e. Surfaces that cannot support the additional weight stress of encapsulation due to existing paint thickness.
 - f. Metal surfaces that are prone to rust or corrosion.
2. Conduct field tests of surfaces to be encapsulated for paint film integrity.



3. Consider special use and environmental requirements (i.e. abrasion resistance and ability to span base substrate cracks).
4. Provide to the the Owner encapsulant test data provided by the manufacturer.
5. Conduct at least one test patch on each type of building component where the encapsulant will be used. Report the results to the the Owner.
6. For both nonreinforced and reinforced coatings, use a 6" x 6" test patch area. Prepare the surface in the manner selected to complete the job. Prepared surfaces for patch testing should be at least 2" larger in each direction than the patch area.
7. For fiber-reinforced wall coverings, use 3" x 3" patch. For rigid coatings that cannot be cut with a knife, use soundness test. For all encapsulants, carry out the appropriate adhesion tests.
8. For liquid coating encapsulants, allow coating to cure, then visually examine it for wrinkling, blistering, cracking, bubbling, or other chemical reaction with the underlying paint.
9. Record results of all patch tests and provide to the the Owner.
10. Implement proper work site preparation level.
11. Repair all building components and substrates as needed (i.e. caulk cracks and repair sources of water leaks).
12. Prepare surfaces. Remove all dirt, grease, chalking paint, mildew and other surface contaminants, remnants of cleaning solutions, and loose paint. All surfaces should be deglossed, as needed.
13. Ventilate the contaminated area whenever solvents or chemicals are used.
14. During encapsulant application or installation, monitor temperature and humidity. For liquid coatings monitor coating thickness to ensure that the encapsulant manufacturer's installation/application specifications are followed.
15. Conduct clean up and clearance.
16. Provide the the Owner information on how to care for the encapsulation system properly.
17. Maintain records on the exact detailed locations of encapsulant applications, patch test specifications and results, product name, subcontractor, date of application, a copy of the product label and material Data Safety sheet (MSDS) for the product and provide to the the Owner.

F. Enclosure

1. Stamp, label or stencil all lead-based painted surfaces that will be enclosed with a warning approximately every 2 feet both horizontally and vertically on all components. The Warning shall read "**Danger Lead-Based Paint**". Deteriorated paint should not be removed from the surface to be enclosed.
2. Select the proper worksite preparation level.
3. Attach a durable drawing to the utility room closet showing where lead-based paint has been enclosed in the dwelling.
4. An independent inspector or technician or risk assessor should evaluate the integrity of the enclosure.
5. Repair any unsound substrates and structural members that will support the enclosure, if necessary.
6. Utilize appropriate enclosure material (drywall or fiberboard, wood paneling, laminated products, ridged tile and brick veneers, vinyl, aluminum m, or plywood).
7. Install extension rings for all electrical switches and outlets that will penetrate the enclosure.
8. If enclosing floors, remove all dirt with a HEPA vacuum to avoid small lumps in the new flooring.
9. Seal and back-caulk all seams and joints. Back-caulk means applying caulk to the underside of the enclosure.
10. When installing enclosure directly to painted surfaces, use adhesive and then anchor with mechanical fasteners (screws or nails).
11. Conduct clean up and clearance activities.
12. Maintain proper records and submit a Statement of Lead-Based Paint Compliance.

G. Final Cleaning Procedures

1. Use the following step-by-step procedures



- a. Assign responsibilities to specific workers for cleaning and for maintaining the cleaning equipment.
 - b. Have sufficient cleaning equipment and supplies before beginning work.
 - c. If contamination is extensive, conduct precleaning of the dwelling unit.
 - d. Conduct ongoing cleaning during the job, including regular removal of large and small debris and dust. Decontamination of all tools, equipment and worker protection gear is required before it leaves contaminated areas. Electrical equipment should be wiped and high-efficiency particulate air (HEPA) vacuumed, not wetted down, to minimize electrocution hazards.
 - e. Schedule sufficient time (usually 30 minutes to an hour) for complete daily cleaning, starting at the same time near the end of every workday after lead hazard control activity has stopped.
 - f. For final cleaning, wait at least 1 hour after active lead hazard control activity has ceased to let dust particles settle.
 - g. Use a vacuum cleaner equipped with a HEPA exhaust filter. HEPA vacuum all surfaces in the room (ceilings, walls, trim, and floors). Start with the ceiling and work down, moving toward the entry door. Completely clean each room before moving on.
 - h. Wash all surfaces with lead-specific detergent, high-phosphate detergent, or other suitable cleaning agent to dislodge any ground-in contamination, then rinse. Change the cleaning solution after every room is cleaned.
 - i. Repeat step g above. To meet clearance standards consistently, a HEPA vacuum, wet wash, and HEPA vacuum cycle is recommended. For interim control projects involving dust removal only, the final HEPA vacuuming step is usually not needed. Other cleaning methods are acceptable, as long as clearance criteria are met and workers are not over exposed.
 - j. After final cleaning perform visual examination to ensure that all surfaces requiring lead hazard control have been addressed and all visible dust and debris have been removed. Record findings and correct any incomplete work.
 - k. If other construction work will disturb the lead-based paint surfaces, it should be completed at this point. If those surfaces are disturbed, repeat the final cleaning step after construction work has been completed.
 - l. Paint and otherwise seal treated surfaces and interior floors.
 - m. Conduct clearance examination.
 - n. If clearance is not achieved, repeat final cleaning.
 - o. Continue clearance testing and repeated cleanings until dwelling unit achieves compliance with all clearance standards. The cost of repeated cleaning, after failure to achieve clearance is to be borne by the contractor.
 - p. Do not allow residents to enter work area until final cleaning is completed and clearance is established.
 - q. Cleaning equipment list is as follows:
 - 1) HEPA Vacuums
 - 2) Detergent
 - 3) Waterproof gloves
 - 4) Rags
 - 5) Sponges
 - 6) Mops
 - 7) Buckets
 - 8) HEPA vacuum attachments (crevice tools, beater bar for cleaning rugs)
 - 9) 6-mil plastic bags
 - 10) Debris containers
 - 11) Waste water containers
 - 12) Shovels
 - 13) Rakes
 - 14) Water-misting sprayers
 - 15) 6-mil polyethylene sheeting (or equivalent)
2. Order of execution for final cleaning steps should be as follows:



- a. As the first stage in final cleaning, floor plastic shall be misted and swept.
- b. Upper level plastic, such as on cabinets and counters should be removed first, after it has been misted and cleaned. All plastic should be carefully folded from the corners/ends to the middle to trap any remaining dust. Next remove both layers of plastic from the floor.
- c. Plastic sheets used to isolate contaminated rooms from noncontaminated rooms should remain in place until after cleaning and removal of other plastic sheeting, these sheets may then be misted, cleaned and removed last.
- d. Removed plastic should be placed into double 4-mil or single 6-mil plastic bags, or plastic bags with equivalent (or better) performance characteristics, which are sealed and removed from the premises. As with daily cleanings, this plastic removal process usually requires workers to use protective clothing and respirators.
- e. After plastic has been removed from the contaminated area, the entire area should be cleaned using the HEPA/wet wash/HEPA cycle.

H. Waste Testing And Disposal

1. General: All materials, whether hazardous or non-hazardous shall be properly disposed of. the Owner may hire an independent Monitoring Consultant to perform TCLP test to determine which of the wastes are hazardous. Contractor shall cooperate in this test. If less than 100kg (200 lbs) or 1/2 of a 55 gallon drum of hazardous waste per month will be generated, it is considered "conditionally exempt" abatement waste, and may be managed as solid non-hazardous waste. The RCRA hazardous waste manifest is not required when shipping this waste to an offsite disposal facility.
2. Separate Abatement Waste into The Following Four Categories:
 - a. Category I. Low lead waste (typically non-hazardous) e.g. Filtered personal and commercial wash water.
 - b. Category II. Architectural components - (painted finish carpentry items) e.g. Doors, windows, window trim and sills, baseboards, railings, moldings. (May do a TCLP to determine if they are hazardous).
 - c. Category III. Concentrated lead waste e.g. sludge from stripping, lead-base paint chip and dust, HEPA vacuum debris and filter, unfiltered wash waste, any waste included in EPA's list of hazardous waste.
 - d. Category IV. Material that cannot be determined to be either hazardous or non-hazardous must be tested by TCLP.

If the hazardous waste generated is greater than 100kg per month, dispose according to the referenced guidelines and RCRA hazardous waste management requirements including those listed below.

3. Disposal Requirements: Contact the regional EPA, state, local and all other pertinent authorities to determine lead-based paint debris disposal requirements. Comply with requirements of the Resource Conservation and Recovery Act (RCRA) and with applicable federal, state, county, or local waste requirements.
4. EPA ID Numbers: Obtain a Generator RCRA Hazardous Material ID number and coordinate this action through the State and secure any additional number as required.
5. Storage Requirements: Keep all hazardous items in a secure area or lockable container that is inaccessible to all persons other than the Contractor's personnel. Label all hazardous waste "Hazardous Waste" with the date that the Contractor began to collect the waste in that container. Keep hazardous and non-hazardous waste in separate containers. Until TCLP testing is completed, considered all items hazardous and store in a secured area or lockable container.
6. Waste Transportation: Transport hazardous waste using a RCRA/DOT/EPA certified Hazardous Waste Transporter. Submit names and qualifications of certified transporter/hauler for the Owner approval. The Contractor shall be responsible for all actions of the waste hauler as pertaining to waste removal and disposal under these procedures and all EPA, DOT and other applicable regulations.
7. Disposal Facility: Supply documents that detail the site(s) to be used for ultimate disposal. Submit documents from these sites proving that they are licensed/permitted to accept such waste and shall accept the waste proposed by the Contractor for treatment or ultimate disposal.



8. Waste Containers: Comply with EPA and DOT regulations for waste containers. Contact the state and local authorities to determine their criteria for containers. In the case of any conflict in regulations, the more stringent shall apply.
 9. Emergencies: Contact local fire, police, hospitals or local emergency response teams and inform them of the type of hazardous waste activity and ask for assistance in the event of any accident. Additionally, the container shall provide the following:
 - a. Keep and properly maintain a suitable fire extinguisher(s) on site.
 - b. Have a immediate means of communication with the regulatory agency in the event of an emergency.
 - c. Keep a list of phone numbers of regulatory agencies on site.
 - d. Appoint an emergency coordinator and ensure the coordinator is on site to supervise emergency procedures to be carried out in the event of an emergency.
 - e. Keep and maintain a "right to know" manual that is in an easily accessible location and in an area that is known to all employees.
 10. Transporting Waste: Provide certifications that the transporter is registered with the U.S. Department of Transportation is required by 49 CFR Part 107(a) transport hazardous waste.
 - a. Provide certifications that each vehicle dedicated to haul hazardous waste has been assigned a "U.S. DOT Hazardous Material Registration Number" as required by 49 CFR Part 107.
 - b. Be responsible for all other applicable permits pertaining to hauling, transport, reduction, and disposal of hazardous waste as they may apply to this project.
 - c. Vehicle: Ensure that all non-hazardous waste is transported in covered vehicles to a landfill, or lined landfill, if required.
 - d. Container Handling: Carefully place the containers into the truck or dumpster used for disposal. At no time shall debris or containers be thrown or dropped.
 - e. Liquid Wastes: Contain and properly dispose of all liquid wastes, including lead-contaminated wash water.
 - f. Containers: HEPA vacuum the exterior of all waste containers prior to removing the waste containers from the work area. Wet wipe the containers to ensure that there is no residual contamination. Then move containers out of the work area into the designated storage area.
- I. Clearance
1. Clearance on all abatement projects must be done by an independent certified risk assessor or inspector technician. Follow all jurisdictional law with regard to licensure requirements for personnel conducting clearance activities.
 2. Clearance step-by-step procedures are as follows:
 - a. Finish the lead hazard control clean-up effort. Seal floors before clearance (if necessary).
 - b. Wait 1 hour to allow any airborne dust to settle. Do not enter work area during that hour.
 - c. Conduct visual examination
 - 1) Determine if all required work has been completed and all lead-based paint hazards have been controlled.
 - 2) Determine if there is visible settled dust, paint chips, or debris in the interior or around the exterior.
 - d. Complete the Visual Clearance Form required by the the Owner; if all work is not completed inform the the Owner and order completion of the work and repeat cleanup, if necessary.
 - e. Conduct clearance dust sampling of the floors, interior window sills, and window troughs using approved protocol.
 - f. Conduct soil sampling if bare soil is present that was not sampled previously, or if exterior paint work was completed as part of the lead hazard control effort. Whenever exterior work has been don, it may be necessary to take samples from the soil that is not bare to determine if contamination has occurred. If results are above 1,000 µg/g (or 400 µg/g in high contact play area), compare the results to baseline soil sampling results to determine what additional measures are needed.
 - g. Complete the Dust and Soil Sampling Clearance Form required by the the Owner.



- h. Submit samples to a U.S. Environmental Protection Agency (EPA) recognized laboratory participating in the National Lead Laboratory Accreditation program (NLLAP) for analysis.
- i. Interpret results by comparing them to Interim Clearance Standards as listed below:
 - 1) Floors 400 µg/ft²
 - 2) Window sills 250 µg/ft²
 - 3) Window Troughs 800 µg/ft²
 - 4) Soils (Play area with children under 6 years of age) 400 µg/gram
- j. If clearance is achieved go to step N.
- k. Order repeated cleanings or soil treatments if results are above applicable standards. Clean all surfaces the sample represents.
- l. Continue sampling and repeated cleanings until the dwelling achieves compliance with all applicable clearance standards.
- m. Complete any related construction work that does not disturb a surface with lead-based paint (all work that does disturb painted surfaces or that could generate lead dust should be completed as part of the lead hazard control effort).
- n. Issue any necessary statements of lead-based paint compliance or releases and maintain appropriate records.

J. Labels

- 1. Use the following labels on drums used for disposal.

HAZARDOUS WASTE

FEDERAL LAW PROHIBITS IMPROPER DISPOSAL.
IF FOUND, CONTACT THE NEAREST POLICE OR PUBLIC SAFETY
AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY.

GENERATOR INFORMATION:

NAME _____

ADDRESS _____ PHONE _____

CITY _____ STATE _____ ZIP _____

EPA- / MANIFEST
ID NO. / DOCUMENT NO. _____ / _____

ACCUMULATION START DATE _____ EPA WASTE NO. _____

HAZARDOUS WASTE, SOLID, N.O.S.

(_____)

NA3077

D.O.T. PROPER SHIPPING NAME AND UN OR NA NO. WITH PREFIX

HANDLE WITH CARE!

STYLE HMM12



WORKPLACE ACCUMULATION CONTAINER		
Proper D.O.T. Shipping Name: _____	HAZARDOUS WASTE	Workplace Accumulation Start Date: <input type="text"/>
UN or NA# _____		
Generator Information:	FEDERAL LAW PROHIBITS IMPROPER DISPOSAL. IF FOUND, CONTACT THE NEAREST POLICE OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY. HANDLE WITH CARE!	Waste Accumulation Area: <input type="text"/>
Name: _____		
Facility: _____		
Address: _____		
Phone: _____		
City: _____		
State: _____ Zip: _____		
EPA / Manifest ID No. / Document No. _____		
State Manifest Document No. _____		
EPA Waste No. _____		MANEJESE CON CUIDADO CONTIENE DESPERDICIOS TOXICOS



K. Disposal of lead-based paint waste.

1. Follow the RCRA and HUD recommended practices as defined in the table below:

Waste Management Practices	Category I:		Category II:	Category III:	Category IV:
	Low Waste	Lead Waste	Architectural Components	Concentrated Lead Waste	Other waste
RCRA Requirements	Manage as nonhazardous Waste		Depending upon knowledge or TCLP testing results, manage as solid hazardous or nonhazardous waste	If more than 100 kg/ month, manage as hazardous waste. If less than 100 kg/month manage as solid waste.	Use TCP to determine if waste is hazardous.
HUD Recommended Practices	Applicable		Applicable, if knowledge or TCLP testing indicates that it is nonhazardous.	Applicable if less than 100 kg/month otherwise subject to full RCRA regulations	Only applicable if TCLP testing shows waste is nonhazardous
Wrapped in plastic; seal all seams with tape (if acceptable to the disposal facility).	X		X	X	X
Stored in designated, secure area.	X		X	X	X
Covered During Transport	X		X	X	X
Prohibit cutting/breaking outside work area.	X		X	X	X
Cover ground with 6-mil plastic if handling outside.	X		X	X	X
Prohibit disposal in solid waste incinerators and reuse recycling for mulch	X		X	X	X
Recommended disposal in State licensed/permitted	X		X	If appropriate.	X



solid waste landfill.				
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L. Safety Requirements

1. To protect the health and safety of all persons involved, it is of the utmost importance that deleading is safely and correctly done in a timely manner. The following specific safety requirements are the responsibility of the Deleading Contractor.

K. General Safety:

1. General
 - a. NO ONE is to be allowed in the work area without an approved respirator except for methods that have been documented not requiring a respirator.
 - b. Each work area must be sealed from the remainder of the dwelling by taping plastic sheets (6 mil thick). Work areas must remain sealed off until both work and clean-up are completed.
 - c. Cover all floors, carpets, furniture and appliances with 6 mil plastic within the work area. Use automotive masking tape (2 inches wide) to seal all edges and seams.
 - d. Make certain all electrical connections are properly grounded.
 - e. At least three days prior to the start of any deleading work, post appropriate warning signs at all entrances and exits of work areas and leave in place until all clearance testing indicates that these areas are safe for re-occupancy. The signs must include the following phrase: "CAUTION LEAD HAZARD-KEEP OUT". Post bilingual signs when necessary.
2. Worker Safety: The Deleading Contractor shall take the following minimum precautions to protect the health of all individuals involved in the deleading process.
 - a. Pre-Abatement Medical Exam: Each employee shall undergo a medical examination to determine both respiratory fitness capability and also pre-existing/current blood lead level. Said results shall be provided to the employee and also to the Owner within 3 days of receipt of same, and in all cases, prior to employee's commencement to active abatement. Records of same are required to be kept by the Contractor for 40 years.
 - b. Medical Surveillance is the monitoring of worker blood levels. It is required that the Contractor have blood level monitoring of all active abatement and clean-up workmen and on-site supervisors performed and said results provided to the Owner.
 - 1) Before assignment to active abatement activity for each worker.
 - 2) 30 days after active abatement has begun.
 - 3) At least every two months during the first six months and every six months throughout the deleading job.
 - 4) At least every two months for each employee whose blood lead analysis indicated a blood lead level at or above 25 micrograms per deciliter. (20 micrograms per deciliter for women of child bearing age).
 - 5) At termination of employment.
 - 6) Contractor shall reassign any employee whose blood lead has reached 25 µg/dl (20 µg/dl for women of child bearing age) to a job function deemed safe from lead exposure. Said employee shall remain away from active abatement until such time as 2 consecutive months' blood tests indicate µg/dl below 20 µg/dl.
 - c. Respiratory Protection Programs must be established by the Contractor in accordance with OSHA regulations and qualitative respirator fit testing must be conducted daily by the on-site supervisor. Medical examinations must be performed by a physician prior to fit testing and at anytime when a worker demonstrates any difficulty breathing during the use of or the fit testing of respirators. The following are minimal acceptable respiratory protection program requirements as set up and administered by the Contractor:
 - 1) Written standard operating procedures which oversees the selection and use of respirators.
 - 2) Selection of respirators on the basis of hazards to which the worker is exposed.
 - 3) Worker training on the limitations and use of respirators (includes fit testing).
 - 4) Individual workers assigned respirators for their exclusive use only.



- 5) Daily cleaning and disinfecting of respirators.
 - 6) Proper storage of all respirators.
 - 7) Proper inspection of all respirators for wear and tear.
 - 8) Continual surveillance of work area conditions and level of worker exposure or stress.
 - 9) Use of approved respirators only, modified as needed by the weekly exposure monitoring results.
 - 10) Supply weekly report covering items 1-9 to the Owner or its Lead Consultant.
- d. Exposure Monitoring is the measured concentration of lead in the workers breathing zones. The Contractor shall perform personnel monitoring during active abatement using the NIOSH 7072 method and shall be responsible for:
- 1) Monitoring the level of worker protection needed during the abatement process;
 - 2) Evaluating, modifying and improving any engineering and work practice control(s) as needed;
 - 3) Evaluating each employee's personal quality of work and any need for additional worker training or safety instruction;
 - 4) Providing the Owner results of all personnel monitoring tests within 10 days of testing; and
 - 5) Providing half-face APR respirators with HEPA filters unless said monitoring test results dictate differently. OSHA guidelines shall be used to determine respirator PEL protection factors.
- e. Protective Clothing Equipment must be provided to all workers to help assure that lead dust is contained to the work areas. The following must be supplied/enforced by the Deleading Contractor:
- 1) Full body protective clothing and shoe covers of appropriate sizes on a daily basis or as needed.
 - 2) Clean changing areas separated from the dirty/contaminated clothes storage area.
 - 3) Water and wash facilities for washing of hands and face and shower facilities if deemed necessary by the Owner's Lead Advisor.
 - 4) Instructing worker on proper maintenance of clothing and equipment.
 - 5) Proper disposal of disposable clothing and proper permanent work clothes.
 - 6) Enforcing the removal of protective clothing at the end of each work day and before eating, drinking and smoking.
 - 7) Enforcement of the removal of protective shoe covers before leaving work area.
3. Contractor/Worker Daily Safe-Work Procedures
- a. Daily Start-Up:
 - 1) Workers to put on protective gear prior to entering work areas.
 - 2) All garment seams to be sealed with duct tape.
 - 3) All non-working garments must be stored in designated changing area.
 - 4) Respirators, as required, must be properly fitted before entering work area. Perform qualitative fit test.
 - b. Temporary depart:
 - 1) All protective clothing to be HEPA vacuumed while still being worn.
 - 2) All shoe covers to be removed and left in the work area (immediate departure upon removing).
 - 3) Remove all protective gear in designated "contaminated" changing area before eating, drinking, and smoking or before leaving work site.
 - 4) Wash hands and face.
 - 5) Clean respirators.
 - c. Daily Shut-Down:
 - 1) Dispose of protective clothing with abatement waste by sealing in a 6 mil poly bag.
 - 2) Laundered clothes must be placed in closed container.
 - 3) Wash hands and face.
 - 4) Shower if facilities allow and circumstances dictate.
 - 5) Clean all protective gear (respirators included).



4. Tenant's Safety: Temporary relocation of the tenants is necessary if the lead paint surface is broken. Temporary relocation of the tenants and their belongings is the responsibility of the Owner. However, the Contractor has the joint responsibility to administer and enforce the following safety practices on behalf of the occupants:
 - a. Adults
 - 1) NO OCCUPANT is allowed to enter the work area during paint removal and initial clean-up. A three day clean-up and settlement period may be imposed depending upon the abatement procedures used, at the discretion of the Owner or their Lead Consultant.
 - 2) the Owner shall notify all occupants in writing when they are allowed to return to their post-abated residence. Contractor shall abide by these notices.
 - 3) Every resident who has received prior notice of abatement is responsible for placing all personal items (clothing, dishes, linens, etc.) in closed, easy to handle containers; and move such items to the center of each room as requested.
 - 4) As long as visible dust remains, occupants may not occupy dwelling, and all surfaces within the dwelling must be re-washed with trisodium phosphate and HEPA vacuumed by deleading contractor.
 - 5) Persons reoccupying dwellings following abatement are required to report any visible dust or debris to the Owner immediately for additional Contractor clean-up.
 - b. Pregnant Women and Children
 - 1) Absolutely no pregnant women nor children under the age of twelve years of age may be allowed in the building while any part of the abatement process is going on.

END OF SECTION 02 83 19 13a



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SECTION 02 83 19 13b - XRF TESTING FOR LEAD-BASED PAINT**1.1 DESCRIPTION OF WORK**

- A. This specification covers the furnishing and installation of materials for XRF testing for lead-based paint. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 SUMMARY

- A. The Contractor shall perform work in accordance with the latest HUD Guidelines, in accordance with all applicable regulations of the Environmental Protection Agency (EPA), Occupational Safety & Health Agency (OSHA) and any applicable State or Local standards that may be more stringent than the Federal Standards except, as such guidelines are modified by the Owner in writing in this contract or any contract pursuant to this contract.
- B. Workmanship required in the execution of the work herein specified shall be of good quality and subject to the approval of the the Owner.

1.3 SUBMITTALS**A. Notification Before Start of Work**

- 1. The Contractor shall send notices to the Project Superintendent, Residents, and the Department of Planning and Development 48 hours before the scheduled start of work. The Contractor shall make three (3) attempts to gain entry to each apartment, with proper 48 hour notification to the resident each time.
- 2. The Contractor shall begin work no later than 48 hours after receiving a work proceed order.

B. Copies of the submissions listed below must be tendered with the bid:

- 1. Ability to perform XRF testing and paint chip sampling by submitting evidence of the successful completion of lead inspector training by all staff to be assigned to the job including inspector technicians. Training must be provided through a State approved EPA-Model program. All staff assigned to the Contract must also demonstrate training in the use of the XRF testing machines to be dedicated to this contract. The serial number of such XRF machine shall be provided to the Owner.
 - a. Contractor or Subcontractor performing the work must have at least 3 years of satisfactory experience (documented) in performing XRF testing for a City, State or Federal Agency.
- 2. Laboratory certification by the State Department of Health (or other responsible agency) and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP, and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided. Indicate if the laboratory is an independent entity from the Contractor.
- 3. If a subcontractor will be used for any of the laboratory work of this contract, evidence of certification stated above must also be provided for the subcontractor.

C. XRF Testing Report Format



- a. All XRF report must be made after a formal submittal and approval by the Owner.
- b. A faxed summary report must be provided to the the Owner within 48 hours after completion of testing for a work Authorization. For XRF testing requiring confirmation by laboratory analysis of paint chip samples, the faxed summary report must be provided within 48 hours after the the Owner gives approval for testing of the collected paint chip samples.
- c. A detailed report must be provided to the the Owner within 5 business days after completion of the testing.

1.4 QUALITY ASSURANCE

- A. The work shall consist of furnishing all labor, material, insurance and all other incidental items required to do the following:
 1. XRF Testing
 - a. Random or comprehensive testing of various components in single family housing units, multi-family housing units, common areas and exterior sites, using any of the approved X-ray Fluorescence ("XRF") machines, to determine if the lead-based paint concentration is within permissible limits.
Note: Testing may be for entire apartments or selected rooms or components within the apartment.
 - b. The permissible limit shall be defined as a final reading showing a lead concentration of less than 1.0 mg/cm².
 - c. Refer to the Manufacturer's manual, as well as the "XRF Performance Characteristic Sheet" when determining calibration check tolerance, and other instrument specific information. Use the adjusted "XRF Performance Characteristic Sheets" in this contract when determining the inconclusive range.
 - d. In addition to the manufacturer's recommended warm up and quality control procedures, a set of three nominal XRF calibration check readings must be taken before the inspection begins and after the inspection has been completed in a particular unit, or every 4 hours, whichever occurs first. All reference material values and calibration check readings must be included in the report provided to the Owner.
 - e. Do not use the XRF to test highly curved or ornate surfaces, or surfaces inaccessible to the XRF, due to poor reliability of results. For such surfaces, laboratory analysis of paint chips must be done.
 - f. Only one XRF reading is required per testing combination. A unique testing combination is characterized by the room equivalent, the component, the substrate and the visible color of the paint. However, testing combinations with different colors on the same component and substrate may be combined into a single component type.
 - g. All inconclusive results must be treated according to the inspection rules using multi-family inspection or single family inspection rules as appropriate.
 - h. XRF field data sheets shall be filled out as they appear on completed Form 7.1 ("Single-Family Housing LBP Testing Data Sheet") and 7.5 ("Multifamily Housing LBP Testing Data Sheet") in HUD Guidelines.
 - i. Room equivalents or sections thereof that are not accessible for testing (i.e. locked bedrooms) shall be noted in the final report to the Owner.
 2. Laboratory testing of paint chips.
 - a. Collection of paint chips from various painted components for laboratory analysis due to XRF substrate corrected inconclusive and/or positive readings as directed by the the Owner.



- b. Laboratory preparation and testing by Flame Atomic Absorption Spectrometry (FAAS) or Graphite Furnace Atomic Absorption Spectrometry (GFAAS) to determine if the lead paint concentration is within permissible limits.
 - c. The permissible limit shall be defined as a lead concentration less than 0.5% by weight.
 - d. Collect paint chips in accordance with ASTM ES28-94.
 - e. Prepare paint chips in the laboratory for testing in accordance with ASTM ES37-94.
 - f. Repair and repaint areas from which paint chips have been collected, to match adjacent areas, unless notified by the the Owner in writing to utilize a temporary covering for the tested surfaces. The Contractor shall provide water based latex paint for this purpose. Colors shall be limited to white and off-white; and other colors if provided by the tenant.
 - g. Only one paint chip is required per testing combination. A unique testing combination is characterized by the room equivalent, the component, the substrate, and the visible color of the paint. However, testing combinations with different colors on the same component and substrate may be combined into a single component type.
 - h. Field data sheets and signed chain of custodies must be attached to the final report to the Owner.
- B. Occupied Residences
1. Some of the work of this contract will be in occupied apartments. The Contractor shall perform all of the work of this contract with the least inconvenience to the tenants.
 2. The Contractor shall take all necessary precautions to protect the property of the the Owner, its residents and the public. The contractor must repair any damaged property, whether of the the Owner, its residents, or the public, and restore such property to its original condition. If the damage is beyond repair, the Contractor shall replace it with new, that in the judgement of the the Owner, match the existing materials and are of equal quality and workmanship. All such repairs shall be at the Contractor's expense.
- C. Applicable Regulations
1. ASTM Standards
 - a. ASTM E 1583 on evaluating laboratories used to determine lead levels;
 - b. ASTM E 1605 on terminology;
 - c. ASTM E 1613 on determining lead by atomic emission or atomic absorption spectroscopy;
 - d. ASTM E 1645 on laboratory preparation of paint-chip samples;
 - e. ASTM E 1775 on-site extraction and field portable stripping voltammetry analysis for lead;
 - f. ASTM PS 53 on identifying and managing lead in facilities;
 - g. ASTM PS 87 on ultrasonic extraction for later analysis for lead;
 - h. ASTM PS 88 on determining lead by portable electro analysis
 2. OSHA Standards (without limitation), include:
 - a. 29 CFR 1926.20 - General safety and health provisions;
 - b. 29 CFR 1926.21 - Safety training and education;
 - c. 29 CFR 1925.25 - Housekeeping;
 - d. 29 CFR 1926.28 - Personal protective equipment;
 - e. 29 CFR 1926.51(f) - Washing facilities;
 - f. 29 CFR 1926.55 - Gases, vapors, fumes, dusts, and mists;
 - g. 29 CFR 1926.57 - Ventilations;
 - h. 29 CFR 1926.59 - Hazardous Communication Standards;
 - i. 29 CFR 1926.10 - Respiratory protection; and
 - j. 29 CFR 1926.62 - Lead in Construction
 3. The Contractor must comply with all applicable requirements of the Resource Conservation & Recovery Act (RCRA) of 1976 as amended in 1980 and 1984 by the Hazardous & Solid Waste Amendments (HSWA).



4. The Contractor must follow the XRF Performance Characteristic Sheet (PCS) for all inspection activities. XRF PCSs are available from the National Lead Information Center Clearinghouse or through the HUD website at <http://www.hud.gov/offices/lead/lbp/hudguidelines/allpcs.pdf>.

1.5 PRODUCTS

- A. XRF Instruments and Testing Protocols
 1. The Contractor shall use XRF instruments that are approved by the Owner.
 2. XRFs must be used in accordance with the manufacturer's instructions and the XRF Performance Characteristic Sheet. If discrepancies exist between the XRF Performance Characteristic Sheet, the HUD Guidelines and the manufacturer's instructions, the most stringent guidelines should be followed.

1.6 EXECUTION

- A. Inspection and Testing
 1. **Single Family Testing Rules**
 - a. If the housing development has less
 - 1) than 10 units built between 1960-1970 or
 - 2) 20 units built before 1960 or
 - 3) the random testing rules in a multi-family development are not being used then single family testing rules must be followed.
 - b. List all testing combinations (see HUD Guidelines Table for an example) in all interior rooms, on all exterior building surfaces, and on surfaces in other exterior areas, such as fences, playground equipment, and garages. The "SingleFamily Housing LBP Testing Data Sheet" (see HUD Guidelines) or a comparable data collection instrument may be used for this purpose.
 - 1) Test all room equivalents inside and outside the dwelling unit. The final report must include a final determination of the presence or absence of lead-based paint on each testing combination in each room equivalent.
 - 2) Inspect each testing combination in each room equivalent, unless similar building component types with identical substrates (such as windows) are all found to contain lead-based paint in the first five interior room equivalents. In that case, testing of that component type in the remaining room equivalents may be discontinued, if and only if the Owner agrees beforehand to such a discontinuation. The inspector should then conclude that similar building component types in the rest of the dwelling unit also contain lead-based paint.
 - 3) Painted furniture that is physically attached to the unit (for example, a desk or dresser that is built-in) should be included in the inspection as a testing combination.
 - 4) Results of an inspection may be summarized by classifying component types across room equivalents if patterns or trends are supported by the data.
 - 5) All substrates across all room equivalents should be grouped into one of the six substrate categories (brick, concrete, drywall, metal, plaster, or wood).
 - c. Number and Location of XRF Readings
 - 1) XRF testing is required for at least one location per layers of paint should be included and the XRF probe testing combination, except for interior and exterior faceplate should be able to lie flat against the surface walls, where four readings should be taken, one on of the test location each wall.
 - 2) For interior and exterior walls: take at least four readings (one of ea. wall). If there are more than four walls test the four largest walls, calculate the average of the



- readings, round the result to same number of decimal places as the XRF instrument displays, and classify the remaining walls with the same painting history as the tested walls, based on this rounded average. When the remaining walls in a room equivalent clearly do not have the same painting history as that of the tested walls, test and classify the remaining walls individually.
- 3) Select areas of paint which are most likely to have old paint or coatings, where areas of paint appear thickest. Avoid testing where paint has worn away, chipped; or over pipes, electrical surfaces, nails, and any other possible interferences.
 - 4) A numbering system, floor plan, sketch or other system may be used to document which testing combinations were tested and sufficiently detailed enough for another individual to find them.
 - a) Side identification Identify perimeter wall sides with letters A, B, C, and D (or numbers or Roman numerals). Side A for single-family housing is the street side for the address. Side A in multi-family housing is the apartment entry door side. Side B, C, and D are identified clockwise from Side A as one faces the dwelling; thus Wall B is to the left, Wall C is across from Side A, and Side D is to the right of Side A. Each room equivalent's side identification follows the scheme for the whole housing unit. Because a room can have two or more entries, sides should not be allocated based on the entry point. For example, giving a closet a side allocation based on how the room is entered would make it difficult for another person to make an easy identification, especially if the room had two closets and two entryways.
 - b) Room Equivalent Identification Room equivalents should be identified by both a number and a use pattern (for example, Room 5-Kitchen). Room 1 can always be the first room, at the A-D junction at the entryway, or it can be the exterior. Rooms are consecutively numbered clockwise. If multiple closets exist, they are given the side allocation: for example, Room 3, Side C Closet. The exterior is always assigned a separate room equivalent identifier.
 - c) Sides in a Room Sides in an interior room equivalent follow the overall housing unit side allocation. Therefore, when standing in any four-sided room facing Side C, the room's Side A will always be to the rear, Side B will be to the left, and Side D will be to the right.
 - d) Building Component Identification Individual building components are first identified by their room number and side allocation (for example, the radiator in Room 1, Side B is easily identified). If multiple similar component types are in a room (for example, three windows), they are differentiated from each other by side allocation. If multiple components are on the same wall side, they are differentiated by being numbered left to right when facing the components. For example, three windows on Wall D are identified as windows D1, D2, and D3, left to right. If window D3 has the only old original sash, it is considered a separate testing combination from the other two windows. Codes or abbreviations for building components and/or locations may be used in order to shorten the time needed for data entry. If codes or abbreviations are used, the inspection records and the inspection report must include a table showing their meaning.
 - d. XRF Instrument Reading Time
 - 1) The recommended time to open an XRF instrument's shutter to obtain a single XRF result for a testing location depends on the specific XRF instrument model and the mode in which the instrument is operating. Follow manufacturer's instructions per HUD Guidelines.
 - e. XRF Calibration Check Readings
 - 1) Follow manufacturer's instructions per HUD Guidelines.

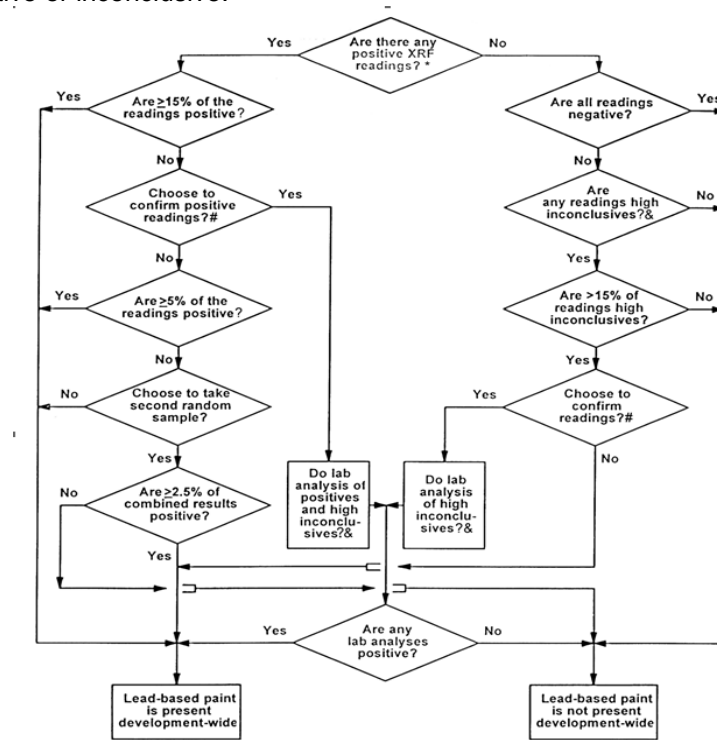


f. Substrate Correction

- 1) The XRF measurements, corrected for substrate contribution, if required by the Performance Characteristic Sheet ("PCS") for the particular type of instrument being used, should be sorted by the inspector by component type into the following categories:
 - a) Positive- A positive XRF reading in accordance with the XRF's Performance Characteristic Sheet.
 - b) Negative- A negative XRF reading in accordance with the XRF's Performance Characteristic Sheet.
 - c) High Inconclusive- An inconclusive XRF reading equal to or greater than the midpoint of the XRF's inconclusive range, in accordance with the XRF's Performance Characteristic Sheet.



- g. The following Decision analyses will be used to determine which components are positive, negative or inconclusive:



* "Positive," "negative," and "inconclusive" XRF readings are determined in accordance with the XRF instrument's Performance Characteristics Sheet as described in the HUD Guidelines for the Evaluation and Control of Lead Hazards in Housing, chapter 7.
 & A high inconclusive reading is an XRF reading at or above the midpoint of the inconclusive range. For example, if the inconclusive range is 0.41 to 1.39, its midpoint (average) is 0.90; a reading in the range from 0.90 to 1.39 would be a high inconclusive reading.
 # Any paint or coating may be assumed to be lead-based paint, even without XRF or laboratory analysis. Similarly, any XRF reading may be confirmed by laboratory analysis.

- 1)
- 2) All inconclusive results must be confirmed with laboratory analysis, or as an alternative must be classified as positive. the Owner may also wish to confirm positive XRF results with laboratory analysis. Therefore the Contractor must make a field determination of which XRF readings falls in the inconclusive or positive ranges and take paint chip samples during the XRF testing for possible laboratory analysis. If the majority of XRF readings are positive in the first few units, the inspector must consult with the Owner on whether to continue taking paint chip samples. Only the Owner may determine whether to submit collected paint chip samples for laboratory analysis or to classify the element as positive.

2. Multi-family Housing Testing Rules (Random Sampling)

- a. In order to use the Multi-family housing testing rules, there must multi-family housing is defined as any group of more than four units that are similar in construction from unit to unit
- b. Determine the number of randomly selected units to be tested in accordance with Table 7.3, below. Chapter 7 of the HUD Guidelines also describes how to select the units randomly. If a unit or units which were selected as part of the original random sample cannot be entered for a particular reason, a replacement unit(s) must be randomly selected in accordance with the HUD Guidelines.



Table 7.3 Number of Units to be Tested in Multi-family Building or Developments*

Number of Similar Units, Similar Common Areas, or Similar Exterior Sites	Pre-1960 or Unknown-Age Building or Development: Number of Units to Test *	1960-1977 Building or Development: Number of Units to Test *
1-10	All	All
11-13	All	10
14	All	11
15	All	12
16-17	All	13
18	All	14
19	All	15
20	All	16
21-26	20	16
27	21	17
28	22	18
29	23	18
30	23	19
31	24	19
32	25	19
33-34	26	19
35	27	19
36	28	19
37	29	19
38-39	30	20
40-48	31	21
49-50	31	22
51	32	22
52-53	33	22
54	34	22
55-56	35	22
57-58	36	22
59	37	23
60-69	38	23
70-73	38	24
74-75	39	24
76-77	40	24



Number of Similar Units, Similar Common Areas, or Similar Exterior Sites	Pre-1960 or Unknown-Age Building or Development: Number of Units to Test *	1960-1977 Building or Development: Number of Units to Test *
78-79	41	24
80-88	42	24
89-95	42	25
96-97	43	25
98-99	44	25
100-109	45	25
110-117	45	26
118-119	46	26
120-138	47	26
139-157	48	26
158-159	49	26
160-177	49	27
178-197	50	27
198-218	51	27
219-258	52	27
259-279	53	27
280-299	53	28
300-379	54	28
380-499	55	28
500-776	56	28
777-939	57	28
940-1004	57	29
1005-1022	58	29
1023-1032	59	29
1033-1039	59	30
1500	87	44
2000	116	58
2500	145	73
3000	174	87
3500	203	102
4000	232	116

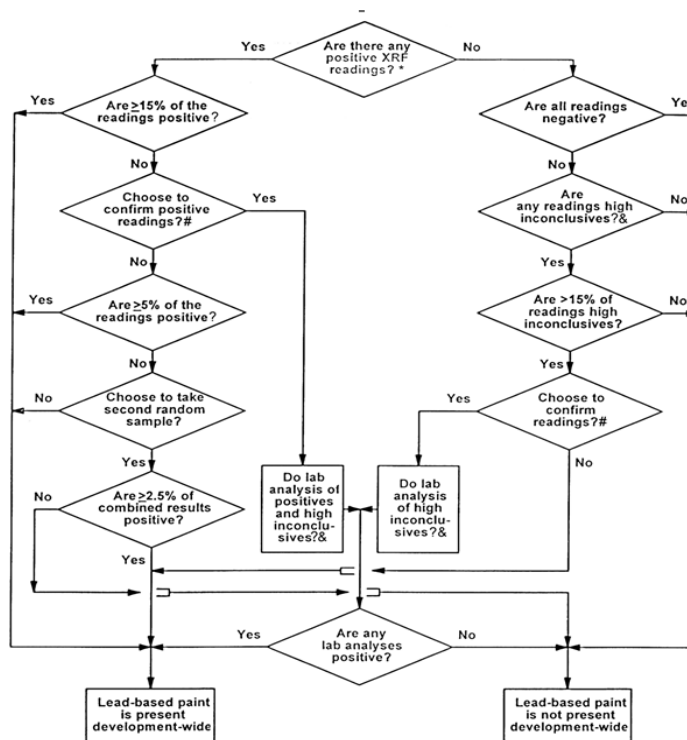
* For brevity, "Number of Units" and "Number of Units to Test" are used, but the number to test is the same for similar units, similar common areas, and similar exterior sites.



- c. An assessment on each tested component must note four attributes, also called a testing combination.
 - 1) The room equivalent (where the testing took place i.e. bedroom, bathroom, etc.)
 - 2) The component type (door, wall #1 - upper left, etc.)
 - 3) The substrate (brick, wood, concrete, drywall, plaster or metal).
 - 4) The color of the paint.
- d. These attributes must be included as part of the report.
- e. For each testing combination, the condition of the painted surfaces should be noted as either intact, fair or poor.
- f. One reading with the X-ray fluorescence (XRF) instrument on each testing combination is all that is required.
- g. At least 40 components of a given type must be tested to obtain the desired level of confidence in the results throughout the multi-family development. If less than 40 components of a given type exist in the buildings to be tested i.e. they are unique components, then the measurement should be taken using single family testing rules (described below). If less than 40 components of a given type exist in the units to be tested, additional components of this type can be identified in other units in the complex and tested to bring the total up to 40 so that multi-family testing rules can be used. The decision of which option the Contractor should use will be made by the the Owner.
- h. To increase the number of tested components of a given type, testing combinations with different colors on the same component and substrate may be combined into a single component type. For example, if "wood doors" is the component type, all wood doors tested for lead-based paint could belong to the same component type, regardless of color.
- i. A component type may be differentiated by color as long as there are 40 tested and there is a good reason for differentiation.
- j. The XRF measurements, corrected for substrate contribution, if required by the Performance Characteristic Sheet ("PCS") for the particular type of instrument being used, should be sorted by the inspector by component type into the following categories:
 - 1) Positive- A positive XRF reading in accordance with the XRF's Performance Characteristic Sheet.
 - 2) Negative- A negative XRF reading in accordance with the XRF's Performance Characteristic Sheet.
 - 3) High Inconclusive- An inconclusive XRF reading equal to or greater than the midpoint of the XRF's inconclusive range, in accordance with the XRF's Performance Characteristic Sheet.



- k. The following Decision analyses will be used to determine which components are positive, negative or inconclusive:



* "Positive," "negative," and "inconclusive" XRF readings are determined in accordance with the XRF instrument's Performance Characteristics Sheet as described in the HUD Guidelines for the Evaluation and Control of Lead Hazards in Housing, chapter 7.
& A high inconclusive reading is an XRF reading at or above the midpoint of the inconclusive range. For example, if the inconclusive range is 0.41 to 1.39, its midpoint (average) is 0.90; a reading in the range from 0.90 to 1.39 would be a high inconclusive reading.
Any paint or coating may be assumed to be lead-based paint, even without XRF or laboratory analysis. Similarly, any XRF reading may be confirmed by laboratory analysis.

- l. If there are readings on a component type(s) equal to or greater than 1.0 mg/cm² and paint chip samples are submitted to the laboratory, there are two possible results:
 - 1) If all lab samples on a component type are below 0.5% lead by weight, the component type can be classified as negative throughout the development.
 - 2) If one or more lab results are positive, (equal to or greater than 0.5% lead by weight for a component) the the Owner will take one of three options:
 - a) Treat the component type as positive throughout the development, or
 - b) Test the component type throughout the development, or
 - c) If 5% or less of the component type are positive, take a second random sample, just testing that component type.
 - 3) If option 2)c) above is selected by the Owner and the combined results of the first and second random sample are less than 2½% positive, the following additional options are available depending on the results.
 - a) If no positives are found in the second sample, no further testing is necessary. Those positives in the first random sample will be monitored/abated (not by this Agreement), but the rest of the component type can be classified as negative.



- b) If positives are found on a component type in the second sample, the the Owner has the option to classify the component type as positive throughout the development or comprehensively test it.
 - c) If the combined results of the two random samples are equal to or greater than 2½%, the the Owner also has the option to comprehensively test the remaining components of that type or classify them as positive.
 - m. **Paint Chip Sample Size:** The Paint chip samples should be taken from a 4 square inch (25 square centimeter) area that is representative of the paint on the testing combination, as close as possible to any XRF reading locations and, if possible, unobtrusive. This area may be a 2" x 2" (5 x 5 centimeters) square, or a 1" x 4" (2.5 x 10 centimeters) rectangle, or have any other dimensions that equal at least 4 square inches (25 square centimeters). Regardless of shape, the dimensions of the surface area must be accurately measured (to the nearest millimeter or 1/16th of an inch) so that the laboratory results can be reported in mg/cm². Results should be reported as percent by weight if the surface area cannot be measured accurately or if all paint within the sampled area cannot be removed. In these cases, lead should be reported in ppm or percent weight, not in mg/cm². Smaller surface area can be used if acceptable to the laboratory. (See ASTM E 1729). In all cases those who take the samples should consult with the NLAAP recognized laboratory selected regarding the requirements for the submission samples for lead-based paint analysis.
 - n. If the the Owner decides to test in search of these hard-to-find components coated with lead based paint, the inspector must use the single family testing rules described in the previous section.
- 3. Common Areas and Exterior Sites Testing Rules**
- a. Similar common areas and similar exterior sites must always be tested, but in some cases they can be sampled in much the same way that dwelling units are. Common areas and building exteriors typically have a similar painting history from one building to the next. In multifamily housing, each common area (such as building lobby, laundry room, or hallway) can be treated as a dwelling unit. If there are multiple similar common areas, they may be grouped for sampling purposes I exactly the same way as regular dwelling units. However, dwelling units, common areas and exterior sites cannot be all mixed together in a single group. All testing combinations within each common area or building exteriors selected for testing must be inspected. This includes playground equipment, benches and miscellaneous testing combinations located throughout the development. The specific common areas and building exteriors to test should be randomly selected, in much the same way as specific units are selected using random numbers. The number of common areas to be tested should be taken from table 7.3 (HUD Guidelines). In this instance, common areas and building exteriors can be treated in the same way as housing units (although they are not to be confused with true housing units).
- 4. Unit and Common Area Drawings**
- a. Mark-ups of as built drawings depicting room equivalents that are tested must be provided as part of the report.
 - b. The Contractor should test in a clockwise path starting from the door through the space and room equivalents so that the approximate location of each component tested can be easily established by referencing the room equivalent and sides.
 - c. Each space must have a reference point (side A, B, C, D or wall 1, 2, 3 or 4). The wall with the door should always be referenced as wall 1 or side A. If there is more than one door, wall 1 or side A should be used to refer to the wall with the door through which the room is first entered when moving in a clockwise fashion through the unit.

B. Evaluation of the Inspection by the the Owner



1. The Contractor will be required to carry out retesting at no additional cost to the the Owner, after completion of the Inspection at each the Owner's development as described in the HUD Guidelines, for single family housing, multi-family housing and common areas. The the Owner shall randomly select the testing combinations to be retested and the Contractor shall perform the retesting using the same XRF instrument(s) which was/were used to take the original readings. An the Owner's inspector shall be present to observe all retesting. The retesting shall be limited to ten (10) testing combinations, and if necessary to repeat the retest, the testing combinations randomly selected for repeating the retest shall also be limited to ten.
 2. If the retest tolerance limit computed from the information provided in the "XRF Performance Characteristics Sheet" (see HUD Guidelines) is exceeded, the retest will be repeated as described in the HUD Guidelines for single family, multi-family housing and common areas. If the retest tolerance limit is exceeded again, the the Owner may require the Contractor to retest the entire development at no additional cost to the the Owner, or the the Owner may withhold all payments and terminate its agreement with the Contractor.
- C. Option to do Laboratory Testing only
1. The the Owner may, for a specific testing assignment, request in writing that the Contractor, when utilizing the multi-family housing testing rules for random sampling, or the single family housing testing rules, do all testing through laboratory analysis of paint chips rather than through XRF Spectrum Analyzer testing with laboratory confirmation as needed. Please note that under the single family housing testing rules, only one paint chip must be taken and analyzed for each component type.
- D. Waste Disposal
1. All waste generated must be legally disposed in accordance with Federal, State and Local regulations.

END OF SECTION 02 83 19 13b



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SECTION 02 83 19 13c - LEAD DUST WIPE, AIR AND TCLP SAMPLING AND ANALYSIS**1.1 DESCRIPTION OF WORK**

- A. This specification covers the furnishing and installation of materials for lead dust wipe, air and TCLP sampling and analysis. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 GENERAL

- A. Definitions: Unless otherwise specified the following definitions shall apply:
1. **"Approved"**: shall mean approved by all public agencies having jurisdiction, and the Owner.
 2. **"The Owner"**: shall mean the Owner and its designated authorized representatives.
 3. **"Contractor"**: shall mean the firm that is awarded this contract and is responsible to ensure compliance with Federal, State and City regulations as well as these Contract documents.
 4. **"Development or Project"**: a group of buildings in one or more designated geographical locations, owned or operated by the Owner and referred to by a common name by the Owner.
 5. **"Dust Cleaning Firm"**: shall mean the contractor under a separate contract or the Owner responsible for cleaning of lead dust, as directed by the Owner, until the clearance levels are achieved, as defined in the "Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing, June 1995" or latest edition published by the United States Department of Housing and Urban Development (HUD).
 6. **"Equal or Approved Equal"**: shall mean equal in the opinion of the Owner.
 7. **"HUD"**: the United States Department of Housing and Urban Development.
 8. **"HUD Guidelines"**: shall mean Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing issued by HUD'S Office of Lead-Based Paint Abatement and Poisoning Prevention in June 1995 except as such guidelines are later modified by HUD and/or modified by the Owner in writing pursuant to this contract.
 9. **"Inspector"**: an individual who has completed training from an accredited program and been licensed or certified by the appropriate State or local agency to (1) perform inspections to determine and report the presence of lead-based paint on a surface-by-surface basis through on-site testing, (2) report the findings of such an inspection, (3) collect environmental samples for laboratory analysis, (4) perform clearance testing, and (5) document successful compliance with lead-based paint hazard control requirements or standards.
 10. **"Lead-Based Paint"**: any paint, varnish, shellac, or other coating that contains lead equal to or greater than 1.0 mg/cm² as measured by XRF or laboratory analysis, or 0.5 percent by weight (5,000 µg/g, 5,000 PPM, or 5,000 mg/kg) as measured by laboratory analysis.
 11. **"Lead-Based Paint Hazard"**: a condition in which exposure to lead from lead-contaminated dust, lead-contaminated soil or deteriorated lead-based paint would have an adverse effect on human health (as established by the EPA Administrator under Title IV of the Toxic Substance Control Act). Lead-based paint hazards include for example, deteriorated lead-based paint, leaded dust levels above applicable standards and bare leaded soil above applicable standards.
 12. **"Lead-Based Paint Hazard Control"**: activities to control or eliminate lead-based paint hazards, including interim controls and complete abatement.
 13. **"Lead-Contaminated Dust"**: surface dust in residences that contain an area or mass concentration of lead in excess of the standard established by the EPA Administrator, pursuant to Title IV of the Toxic Substance Control Act. Until the EPA standards are set, the HUD recommended clearance and risk assessment standards for leaded dust are 40 µg/ft² on floors, 250 µg/ft² on interior window sills, and 800 µg/ft² on window troughs.



14. **"Monitoring"**: shall refer to inspection to ensure compliance with all Federal, State and City Standards or guidelines, and contractual specifications.
15. **"Provide"**: shall mean furnish and install.
16. **"Risk Assessor"**: a certified individual who has completed training with an accredited training program and who has been certified to (1) perform risk assessments, (2) identify acceptable abatement and interim control strategies for reducing identified lead-based paint hazards, (3) perform clearance testing and reevaluations, and (4) document the successful completion of lead-based paint hazard control activities.

B. Applicable Regulations/References

1. The work conducted shall comply with all applicable Federal, State and City regulations. Applicable guidelines and standards listed in the scope of work include, but are not limited to:

<p>24 CFR Parts 35,36,37 Guidelines for the Evaluation and Control of Lead-Based Paint in Housing (HUD Guidelines June 1995) & 1997 Revisions</p> <p>29 CFR 1910 29 CFR 1910.1025 29 CFR 1910.134 29 CFR 1910.1200 29 CFR 1910.245 29 CFR 1926 29 CFR 1926.20 29 CFR 1926.21 29 CFR 1926.25 29 CFR 1926.28 29 CFR 1926.51 29 CFR 1926.55 29 CFR 1926.59 29 CFR 1926.62 29 CFR 1926.103 40 CFR 61 Subpart A 40 CFR 241</p> <p>40 CFR 257 40 CFR 261/262 American National Standards Institute (ANSI) Z87.1 ANSI Z88.2-80 American Society For Testing Materials (ASTM)</p>	<p>HUD Lead-Based Paint Regulations</p> <p>General Industry Standard Lead Standard for General Industry Respiratory Protection Hazard Communication Specification for Accident Prevention Construction Industry Standards General Safety & Health Provisions Safety Training & Education Housekeeping Personal Protective Equipment Washing Facilities Gases, Vapors, Fumes, Dusts & Mists Hazard Communication Standard Construction Industry Lead Standard Respiratory Protection General Provisions Guidelines for the Land Disposal of Solid Waste Criteria for the Land Disposal of Solid Waste Waste Disposal Facilities & Practices Eye Protection</p> <p>Practices for Respiratory Protection All Applicable Standards</p>
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2. The contractor shall ensure that any programs, certifications, licenses or other documentation in accordance with the above and/or any other applicable Federal, State, and Local Regulations/Guidelines are provided.

C. Scope Of Work

1. The work shall consist of furnishing labor, materials, insurance and all other incidental items required to perform the following:
 - a. Dust wipe sampling and analysis
 - 1) Collect dust wipe samples from various horizontal surfaces, such as floors, window sills, window troughs, etc., as directed by the Owner.
 - 2) Dust wipe samples shall be collected in accordance with ASTM ES30-94.



- 3) Analyze dust wipe sample in the laboratory using Flame Atomic Absorption Spectrometry ("FAAS") or Graphite Furnace Atomic Absorption Spectrometry("GFAAS").
 - 4) Provide result of analysis in micrograms per square foot.
 - 5) A faxed summary of results must be provided to the Owner within 24 hours after the Owner authorizes the Contractor to perform the laboratory analysis of the collected dust wipe sample. Contractor shall also have the ability to provide results in 4 hours for clearance, following lead-based paint abatement work, if requested by the Owner. The sampling result must be provided in a form approved by the Owner and must include for each dust wipe sample, the Project, the building address, the sample number, the room or room equivalent, the surface type, dimensions of sample areas, total micrograms, micrograms per square feet, and an indication of pass or fail.
 - 6) Turn-around time for results shall be counted from the time the Contractor performs collection of dust wipe samples to the time the results are actually presented to the Owner. This includes travel time from the site to the laboratory of the Contractor and back to the site.
 - 7) A detailed final report covering the results of all dust wipe samples taken and analyzed must be submitted within 5 days from the time the Owner authorizes the performance of the laboratory analysis. The sampling report must include for each dust wipe sample, the Project, the building address, the sample number, the room or room equivalent, the surface type, dimensions of sample areas, total micrograms, micrograms per square feet, and indicate pass or fail in a form approved by the Owner. Also include in the report the method of analysis, i.e. "FAAS" or "GFAAS", and the detection limits. The laboratory test results in the final report must be signed by the Laboratory Director.
 - 8) The sampling data report must contain all required data fields as specified by the Owner. The sampling data report shall be provided to the Owner on 3.5 inch high density diskettes in ASCII file form. The required data fields will be provided by the Owner to the Contractor.
 - 9) The laboratory used for the analysis of the dust wipe samples must be certified by the State Department of Health (or other responsible agency) and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP, and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided. Indicate if the laboratory is an independent entity from the Contractor.
- b. Dust Spiked Samples
- 1) Provide dust spiked samples to the Owner. Dust spiked samples shall be prepared in accordance with the HUD Guidelines.
NOTE: These samples are separate from the ones required by the Contractor for its own QA/QC
 - 2) Prepare dust spiked samples in a manner such that they are indistinguishable from the field samples.
 - 3) Prepare dust spiked samples using the same lot as that to be used in the field.
 - 4) Dust spiked samples shall be inserted into the sample stream, randomly, by the Owner Inspector.
 - 5) Blind analysis of dust spiked samples must fall within 80%-120% of the true value. If the laboratory fails to obtain readings within these limits, two more spiked samples shall be sent immediately to the lab for analysis.
 - 6) If the two additional spiked samples fail, the sample batch shall be considered invalid, and the Owner may, at its sole discretion, terminate this contract as well as withhold payment for services already rendered.
- c. Air Sampling and Analysis



- 1) Collect area air samples at various locations and various projects for personal exposure assessment as directed by the Owner.
 - 2) Air samples shall be collected in accordance with ASTM E1553-93.
 - 3) Prepare air samples for analysis in accordance with ASTM E33-94
 - 4) Analyze air samples using FAAS or GFAAS.
 - 5) All equipment required for personal air sampling, including pumps shall be provided by the Contractor at no extra cost to the Owner.
 - 6) Provide results of air samples in micrograms per cubic meter.
 - 7) A faxed summary of result must be provided to the Owner within 24 hours after the Owner authorizes the Contractor to perform the laboratory analysis of the collected air sample. The sampling result must include for each air sample taken the Project, the building address, the sample number, the room or room equivalent, and the reading.
 - 8) Turn-around time shall start after collection of the air samples, and includes travel time to and from the laboratory.
 - 9) A detailed final report covering the results of all air samples taken and analyzed must be submitted within 5 days from the time the Owner authorizes the performance of the laboratory analysis. The sampling report must include for each air sample, the Project, the building address, the sample number, the room or room equivalent, and the reading. The laboratory report contained in the final report must be signed by the Laboratory Director.
 - 10) The sampling data report must contain all required data fields as specified by the Owner. The sampling data report shall be provided to the Owner on 3.5 inch high density diskettes in ASCII file form. The required data fields will be provided by the Owner to the Contractor.
 - 11) The laboratory used for the analysis of the dust wipe samples must be certified by the State Department of Health (or other responsible agency) and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP, and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided. Indicate if the laboratory is an independent entity from the Contractor.
 - 12) Air sampling technician shall be present during the entire shift of the air sampling.
- d. TCLP Sampling and Analysis
- 1) Take core samples of construction waste as directed by the Owner and analyze by TCLP testing to determine if waste is hazardous.
 - 2) Waste shall be classified as hazardous if the concentration of lead is greater than 5 parts per million by TCLP testing.
 - 3) The laboratory used for the analysis of the TCLP samples must be certified by the State Department of Health (or other responsible agency) and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP, and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided. Indicate if the laboratory is an independent entity from the Contractor.
 - 4) A faxed summary of result must be provided to the Owner within 48 hours after the Owner authorizes the Contractor to perform the TCLP analysis of the waste. Provide results in parts per million (ppm).
 - 5) Final results provided to the Owner by the Contractor must include written sample preparation procedure and laboratory specific written procedures for performing TCLP, including quality control procedures used for performing the TCLP, and a table listing the sample numbers, description of the construction waste, and the



result of the TCLP. The laboratory report contained in the final report must be signed by the Laboratory Director.

- 6) Final report must also specify detection limits.
- 7) Final report must be provided within 5 days from the time the authorization to perform the TCLP is given by the Owner.

D. General Provisions

1. Some of the work of this contract may be in occupied apartments. The Contractor shall perform all of the work of this contract with the least inconvenience to the tenants.
2. The Contractor shall take all necessary precautions to protect the property of the Owner, its residents, and the public. The Contractor must repair any damaged property, whether of the Owner, its residents, or the public, and restore such property to its original condition. If the damage is beyond repair, the Contractor shall replace it with new, that in the judgment of the Owner, match the existing materials and/or of equal quality and workmanship. All such repairs shall be at the Contractor's expense.
3. The Contractor shall develop a work plan to be performed as requested by the Department of Planning and Development. The detailed plan shall include coordination of the monitoring and sampling work with the Contractor in a manner that will be least disruptive to the normal use of the non-work areas in the building. The plan should also include emergency procedures in case of fire.
4. The Contractor shall perform work in accordance with the latest HUD Guidelines, except as such Guidelines are modified by the Owner in writing in this Contract, or any Contract pursuant to this Contract, and in accordance with all applicable Federal, State and Local regulations.
5. The Contractor shall include in the bid price all supplementary miscellaneous items not specified but implied or required in order to complete the work.

E. Submissions

1. Six (6) copies of the submissions listed below must be submitted to the Owner by the Contractor or Subcontractor performing the Work:
 - a. Ability to perform lead dust wipe sampling by submitting evidence of the successful completion of lead inspector and/or risk assessor training by all staff to be assigned to the job including inspector technicians. As stated previously, training must be provided through an approved program.
 - b. Laboratory certification by the State Department of Health (or other responsible agency) through its ELAP program and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided.
 - c. If a subcontractor will be used for any of the laboratory work of this contract, evidence of certification stated in (2) above must also be provided for the subcontractor.

F. Waste Disposal

1. All waste generated must be legally disposed in accordance with the Federal, State and Local Regulations.

END OF SECTION 02 83 19 13c



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Task	Specification	Specification Description
02 83 19 13	02 82 33 00	Removal Of Friable Asbestos-Containing Materials
02 83 19 13	02 82 33 00a	Removal Of Nonfriable Asbestos-Containing Materials
02 83 33 13	02 83 19 13	Removal And Disposal Of Lead-Containing Paint
02 83 33 13	02 83 19 13a	Lead Paint Related Abatement Procedures
02 83 33 13	02 83 19 13b	XRF Testing For Lead-Based Paint
02 83 33 13	02 83 19 13c	Lead Dust Wipe, Air And Tcpl Sampling And Analysis



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SECTION 02 84 16 00 - REMOVAL OF FLUORESCENT LIGHT BALLASTS/CAPACITORS AND FLUORESCENT LIGHT TUBES**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for removal of fluorescent light ballasts/capacitors and fluorescent light tubes. Products shall be as follows or as directed by the the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Before Start of Work: Submit the following to the Owner's Representative for review. Do not start work until these submittals are returned with Owner's Representative's approval.
 - a. Copy of State or local license for hazardous waste hauler;
 - b. Certification of at least one on-site supervisor which has satisfactorily completed the OSHA 40 Hour Health and Safety Course for Handling Hazardous Materials;
 - c. Certificates of workers which have successfully completed at least the OSHA 40-Hour Health and Safety Course for Hazardous Materials;
 - d. List of employees scheduled to perform this work;
 - e. Schedule of start and finish times and dates for this work;
 - f. Name and address of landfill where these waste materials are to be deposited (include contact person and telephone numbers);
 - g. Material Safety Data Sheets for all materials requiring removal;
 - h. If contractor introduces any chemical into the work environmental, a MSDS for that chemical is required before use;
 - i. Transporter must have notified the EPA and/or the appropriate local government agency in advance of its intentions to transport PCB's, mercury and cadmium, and receive an identification number pursuant to the Toxic Substance Control Act (TSCA); and
 - j. Contingency Plan for handling emergency spills or leaks.

1.2 PRODUCTS**A. Materials**

1. Polyethylene Sheet: A single polyethylene film in the largest sheet size possible to minimize seams, 4.0 and 6.0 mil thick, clear, frosted, or black.
2. Duct Tape: Provide duct tape in 3" widths, with an adhesive which is formulated to stick aggressively to sheet polyethylene.
3. Spray Cement: Provide spray adhesive in aerosol cans which is specifically formulated to stick tenaciously to sheet polyethylene.
4. Disposal Bays: Provide 6 mil thick leak-tight polyethylene bags.
5. Labels: As required by the EPA and OSHA for handling, transportation, and disposal of hazardous waste.
6. **Drums:** Recovery or salvage drums acceptable for disposal of hazardous waste. Prior approval of drums is required. Drums or containers must meet the required OSHA EPA (40 CFR Parts 264-265 and 300), and DOT regulations (49 CFR Parts 171-178). Use of damaged drums will not be allowed.

1.3 EXECUTION**A. General**Removal of Fluorescent Light Ballasts/Capacitors and
Fluorescent Light Tubes



1. Where necessary, scaffolding shall be erected to fully access all applicable fluorescent light ballasts/capacitors and tubes. At no time will the ballasts/capacitors and tubes be allowed to drop onto the floor. Contractor must take care to protect from dropping the ballasts/capacitors and fluorescent tubes.
2. Prior to removing ballasts/capacitors and fluorescent tubes, contractor shall ensure that all electrical service to lights has been shut off, and locked out. Temporary lighting shall be erected to adequately illuminate work areas.
3. Depending on height of light fixtures, contractor shall utilize at least a 2-person per team system. The fluorescent light tubes shall be removed and passed to the appropriate number of workers required to lower the tubes to the floor without breaking them.
4. The worker on the floor shall lay the tubes in cardboard boxes large enough to hold a small quantity of tubes. Worker shall take care to not damage the tubes while they are lowered into the box. Once the box is full, it shall be wrapped with two layers of 6 mil thick polyethylene sheeting and sealed with duct tape.
5. Contractor may choose to either remove the fluorescent light ballasts/capacitors in-place or lower the lighting fixtures for easy access. The ballasts/capacitors shall be removed from the fixtures. Electrical wiring leading from the ballasts/capacitors shall be cut away. Ballasts/capacitors shall be placed in 55-gallon drums lined with at least two 6 mil thick polyethylene bags. Be careful not to overfill the drums so that they remain manageable. Once the drums have been filled to the acceptable level, seal the lid onto the top of the drum, and affix appropriate labels. Transport drums via hand dollies.

B. Worker Protection

1. As a minimum, while working with the ballasts/capacitors and light tubes, workers shall utilize impervious gloves adequate for the use with hazardous materials. If light ballasts/capacitors and/or light tubes are damaged, and/or exposure to these materials may reach the OSHA PEL or AGGIH threshold limit value (TLV), the contractor shall be required to provide impervious full body protection and respiratory protection. However, contractor is required to verify the type of protection required prior to working with these materials, and have written approval by Owner's Representative prior to beginning.
2. In addition, workers shall not smoke, drink or eat in these areas during work activities.

C. Storage Of Fluorescent Light Ballasts/Capacitors And Light Tubes

1. Once the containers holding the ballasts/capacitors and light tubes have been filled and sealed, they shall be stored in designated areas as agreed upon by the Owners Representative and Contractor. They shall not be allowed to be stored on-site in transportation vehicles until the time for them to be transported to the hazardous waste incinerators or landfill facility.

END OF SECTION 02 84 16 00

**SECTION 02 84 16 00a - INTERIOR LIGHTING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for interior lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Interior lighting fixtures, lamps, and ballasts.
 - b. Emergency lighting units.
 - c. Exit signs.
 - d. Lighting fixture supports.
 - e. Retrofit kits for fluorescent lighting fixtures.

C. Definitions

1. BF: Ballast factor.
2. CCT: Correlated color temperature.
3. CRI: Color-rendering index.
4. HID: High-intensity discharge.
5. LER: Luminaire efficacy rating.
6. Lumen: Measured output of lamp and luminaire, or both.
7. Luminaire: Complete lighting fixture, including ballast housing if provided.

D. Submittals

1. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - a. Physical description of lighting fixture including dimensions.
 - b. Emergency lighting units including battery and charger.
 - c. Ballast, including BF.
 - d. Energy-efficiency data.
 - e. Air and Thermal Performance Data: For air-handling lighting fixtures. Furnish data required in "Submittals" Article in Division 23 Section "Diffusers, Registers, And Grilles".
 - f. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 23 Section "Diffusers, Registers, And Grilles".
 - g. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
 - h. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - 1) Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
OR
Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
2. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.



- a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each Sample shall include the following:
 - a. Lamps and ballasts, installed.
 - b. Cords and plugs.
 - c. Pendant support system.
4. Installation instructions.
5. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Lighting fixtures.
 - b. Suspended ceiling components.
 - c. Partitions and millwork that penetrate the ceiling or extends to within 12 inches (305 mm) of the plane of the luminaires.
 - d. Ceiling-mounted projectors.
 - e. Structural members to which suspension systems for lighting fixtures will be attached.
 - f. Other items in finished ceiling including the following:
 - 1) Air outlets and inlets.
 - 2) Speakers.
 - 3) Sprinklers.
 - 4) Smoke and fire detectors.
 - 5) Occupancy sensors.
 - 6) Access panels.
 - g. Perimeter moldings.
6. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
7. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
8. Field quality-control reports.
9. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
 - a. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.
10. Warranty: Sample of special warranty.

E. Quality Assurance

1. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

OR

1. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with NFPA 70.
4. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. Coordination

1. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.



G. Warranty

1. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Final Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
 - b. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven years from date of Final Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.

1.2 PRODUCTS

A. General Requirements For Lighting Fixtures And Components

1. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
2. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
3. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
4. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
5. Metal Parts: Free of burrs and sharp corners and edges.
6. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
7. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
8. Diffusers and Globes:
 - a. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 1) Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
 - 2) UV stabilized.
 - b. Glass: Annealed crystal glass unless otherwise indicated.
9. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - a. Label shall include the following lamp and ballast characteristics:
 - 1) "USE ONLY" and include specific lamp type.
 - 2) Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
 - 3) Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
 - 4) Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
 - 5) ANSI ballast type (M98, M57, etc.) for HID luminaires.
 - 6) CCT and CRI for all luminaires.
10. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.
11. Air-Handling Fluorescent Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Division 15 Section "Diffusers, Registers, and Grilles."
 - a. Air-Supply Units: Slots in one or both side trims join with air-diffuser-boot assemblies.



- b. Heat-Removal Units: Air path leads through lamp cavity.
- c. Combination Heat-Removal and Air-Supply Unit: Heat is removed through lamp cavity at both ends of the fixture door with air supply same as for air-supply units.
- d. Dampers: Operable from outside fixture for control of return-air volume.
- e. Static Fixture: Air-supply slots are blanked off, and fixture appearance matches active units.

B. Ballasts For Linear Fluorescent Lamps

1. General Requirements for Electronic Ballasts:
 - a. Comply with UL 935 and with ANSI C82.11.
 - b. Designed for type and quantity of lamps served.
 - c. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
 - d. Sound Rating: Class A **OR** Class A except Class B for T8/HO and T12/Slimline lamp ballasts, **as directed**.
 - e. Total Harmonic Distortion Rating: Less than 10 **OR** 20, **as directed**, percent.
 - f. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 - g. Operating Frequency: 42 kHz or higher.
 - h. Lamp Current Crest Factor: 1.7 or less.
 - i. BF: 0.88 or higher.
 - j. Power Factor: 0.95 **OR** 0.98, **as directed**, or higher.
 - k. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
2. Luminaires controlled by occupancy sensors shall have programmed-start ballasts.
3. Electronic Programmed-Start Ballasts for T5 **OR** T8 **OR** T5HO **OR** T5 and T5HO, **as directed**, Lamps: Comply with ANSI C82.11 and the following:
 - a. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
 - b. Automatic lamp starting after lamp replacement.
4. Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
 - a. Ballast Manufacturer Certification: Indicated by label.
5. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
6. Ballasts for Low-Temperature Environments:
 - a. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic or electromagnetic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
 - b. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.
7. Ballasts for Residential Applications: Fixtures designated as "Residential" may use low-power-factor electronic ballasts having a Class B sound rating and total harmonic distortion of approximately 30 percent.
8. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.
9. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
 - a. Dimming Range: 100 to 5 percent of rated lamp lumens.
 - b. Ballast Input Watts: Can be reduced to 20 percent of normal.
 - c. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
 - d. Control: Coordinate wiring from ballast to control device to ensure that the ballast, controller, and connecting wiring are compatible.
10. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.



- a. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - 1) High-Level Operation: 100 percent of rated lamp lumens.
 - 2) Low-Level Operation: 30 percent of rated lamp lumens.
 - b. Ballast shall provide equal current to each lamp in each operating mode.
 - c. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.
11. Ballasts for Tri-Level Controlled Lighting Fixtures: Electronic type.
- a. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - 1) High-Level Operation: 100 percent of rated lamp lumens.
 - 2) Low-Level Operation: 30 and 50 **OR** 30 and 60, **as directed**, percent of rated lamp lumens.
 - b. Ballast shall provide equal current to each lamp in each operating mode.
 - c. Compatibility: Certified by manufacturer for use with specific tri-level control system and lamp type indicated.
- C. Ballasts For Compact Fluorescent Lamps
1. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
 - a. Lamp end-of-life detection and shutdown circuit.
 - b. Automatic lamp starting after lamp replacement.
 - c. Sound Rating: Class A.
 - d. Total Harmonic Distortion Rating: Less than 20 percent.
 - e. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 - f. Operating Frequency: 20 kHz or higher.
 - g. Lamp Current Crest Factor: 1.7 or less.
 - h. BF: 0.95 or higher unless otherwise indicated.
 - i. Power Factor: 0.95 **OR** 0.98, **as directed**, except fixtures designated as "Residential" may use low-power-factor electronic ballasts, **as directed**, or higher.
 - j. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
- D. Emergency Fluorescent Power Unit
1. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
 - a. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
 - b. Nightlight Connection: Operate one fluorescent lamp continuously.
 - c. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
 - 1) Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - 2) Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - d. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - e. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
 - f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.



- g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
- 2. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from lighting fixture. Comply with UL 924.
 - a. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
 - b. Nightlight Connection: Operate one fluorescent lamp in a remote fixture continuously.
 - c. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - d. Charger: Fully automatic, solid-state, constant-current type.
 - e. Housing: NEMA 250, Type 1 enclosure.
 - f. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - g. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - h. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - i. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

E. Ballasts For HID Lamps

- 1. Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features unless otherwise indicated:
 - a. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 - b. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
 - c. Rated Ambient Operating Temperature: 104 deg F (40 deg C).
 - d. Open-circuit operation that will not reduce average life.
 - e. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
- 2. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
 - a. Minimum Starting Temperature: Minus 20 deg F (Minus 29 deg C) for single-lamp ballasts.
 - b. Rated Ambient Operating Temperature: 130 deg F (54 deg C).
 - c. Lamp end-of-life detection and shutdown circuit.
 - d. Sound Rating: Class A.
 - e. Total Harmonic Distortion Rating: Less than 20 percent.
 - f. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 - g. Lamp Current Crest Factor: 1.5 or less.
 - h. Power Factor: 0.90 or higher.
 - i. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
 - j. Protection: Class P thermal cutout.
 - k. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
 - 1) High-Level Operation: 100 percent of rated lamp lumens.
 - 2) Low-Level Operation: 35 **OR** 50, **as directed**, percent of rated lamp lumens.
 - 3) Compatibility: Certified by ballast manufacturer for use with specific bi-level control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.
 - l. Continuous Dimming Ballast: Dimming range shall be from 100 to 35 percent of rated lamp lumens without flicker.



- 1) Ballast Input Watts: Reduced to a maximum of 50 percent of normal at lowest dimming setting.
 3. High-Pressure Sodium Ballasts: Electromagnetic type, with solid-state igniter/starter. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.
 - a. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
 - b. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).
- F. Quartz Lamp Lighting Controller
1. General Requirements for Controllers: Factory installed by lighting fixture manufacturer. Comply with UL 1598.
 2. Standby (Quartz Restrike): Automatically switches quartz lamp on when a HID lamp in the fixture is initially energized and during the HID lamp restrike period after brief power outages.
 3. Connections: Designed for a single branch -circuit connection.
 4. Switching Off: Automatically switches quartz lamp off when HID lamp strikes.
- OR**
- Switching Off: Automatically switches quartz lamp off when HID lamp reaches approximately 60 percent light output.
- G. Exit Signs
1. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
 2. Internally Lighted Signs:
 - a. Lamps for AC Operation: Fluorescent, two for each fixture, 20,000 hours of rated lamp life.

OR

Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
 - b. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - 1) Battery: Sealed, maintenance-free, nickel-cadmium type.
 - 2) Charger: Fully automatic, solid-state type with sealed transfer relay.
 - 3) Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - 4) Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - 5) LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - 6) Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - 7) Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
 - c. Master/Remote Sign Configurations:
 - 1) Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply **OR** ballast **OR** battery, **as directed**, for power connection to remote unit.
 - 2) Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.



3. Self-Luminous Signs: Powered by tritium gas, with universal bracket for flush-ceiling, wall, or end mounting. Signs shall be guaranteed by manufacturer to maintain the minimum brightness requirements in UL 924 for 10 **OR** 15 **OR** 20, **as directed**, years.

OR

Self-Luminous Signs: Using strontium oxide aluminate compound to store ambient light and release the stored energy when the light is removed. Provide with universal bracket for flush-ceiling, wall, or end mounting.

H. Emergency Lighting Units

1. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
 - a. Battery: Sealed, maintenance-free, lead-acid type.
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - c. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - f. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
 - g. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
 - h. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - i. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

I. Fluorescent Lamps

1. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 20,000 hours unless otherwise indicated.
2. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours unless otherwise indicated.
3. T5 rapid-start lamps, rated 28 W maximum, nominal length of 45.2 inches (1150 mm), 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3000 K, and average rated life of 20,000 hours unless otherwise indicated.
4. T5HO rapid-start, high-output lamps, rated 54 W maximum, nominal length of 45.2 inches (1150 mm), 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life of 20,000 hours unless otherwise indicated.
5. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at three hours operation per start, and suitable for use with dimming ballasts, **as directed**.

J. HID Lamps

1. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), color temperature 1900 K, and average rated life of 24,000 hours, minimum.



- a. Dual-Arc Tube Lamps: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.
 2. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 65, and color temperature 4000 K.
 3. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000 K.
 4. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000 K.
 5. Low-Pressure Sodium Lamps: ANSI 78.41, CRI 0, and color temperature 1800 K.
- K. Lighting Fixture Support Components
1. Comply with Division 26 Section "Hangers And Supports For Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
 2. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
 3. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
 4. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
 5. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).
 6. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
 7. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- L. Retrofit Kits For Fluorescent Lighting Fixtures
1. Reflector Kit: UL 1598, Type I. Suitable for two- to four-lamp, surface-mounted or recessed lighting fixtures by improving reflectivity of fixture surfaces.
 2. Ballast and Lamp Change Kit: UL 1598, Type II. Suitable for changing existing ballast, lamps, and sockets.

1.3 EXECUTION

- A. Installation
1. Lighting fixtures:
 - a. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
 - b. Install lamps in each luminaire.
 2. Temporary Lighting: If it is necessary, and approved by the Owner, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.
 3. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.
 4. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
 - a. Install ceiling support system rods or wires, independent of the ceiling suspension devices, **as directed**, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
 - b. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 - c. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
 - d. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
 5. Suspended Lighting Fixture Support:
 - a. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.



- b. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 - c. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
 - d. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.
6. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.
 7. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

B. Identification

1. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".

C. Field Quality Control

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
2. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.
3. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

D. Startup Service

1. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by the Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

E. Adjusting

1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 - a. Adjust aimable luminaires in the presence of the Owner.

END OF SECTION 02 84 16 00a



SECTION 02 84 16 00b - EXTERIOR LIGHTING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for exterior lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Exterior luminaires with lamps and ballasts.
 - b. Luminaire-mounted photoelectric relays.
 - c. Poles and accessories.
 - d. Luminaire lowering devices.

C. Definitions

1. CCT: Correlated color temperature.
2. CRI: Color-rendering index.
3. HID: High-intensity discharge.
4. LER: Luminaire efficacy rating.
5. Luminaire: Complete lighting fixture, including ballast housing if provided.
6. Pole: Luminaire support structure, including tower used for large area illumination.
7. Standard: Same definition as "Pole" above.

D. Structural Analysis Criteria For Pole Selection

1. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.
2. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4-M.
3. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied as stated in AASHTO LTS-4-M Ice Load Map.
4. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.
 - a. Basic wind speed for calculating wind load for poles exceeding 49.2 feet (15 m) in height is 100 mph (45 m/s) **OR** 90 mph (40 m/s), **as directed**.
 - 1) Wind Importance Factor: 1.0.
 - 2) Minimum Design Life: 50 years.
 - 3) Velocity Conversion Factors: 1.0.
 - b. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 100 mph (45 m/s) **OR** 90 mph (40 m/s).
 - 1) Wind Importance Factor: 1.0.
 - 2) Minimum Design Life: 25 years.
 - 3) Velocity Conversion Factors: 1.0.

E. Submittals

1. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
 - a. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
 - b. Details of attaching luminaires and accessories.
 - c. Details of installation and construction.
 - d. Luminaire materials.
 - e. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.



- 1) Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

OR

Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

- f. Photoelectric relays.
- g. Ballasts, including energy-efficiency data.
- h. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
- i. Materials, dimensions, and finishes of poles.
- j. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
- k. Anchor bolts for poles.
- l. Manufactured pole foundations.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
 - c. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
 - d. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.
4. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.
5. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
6. Field quality-control reports.
7. Operation and Maintenance Data: For luminaires and poles **OR** luminaire lowering devices, **as directed**, to include in emergency, operation, and maintenance manuals.
8. Warranty: Sample of special warranty.

F. Quality Assurance

1. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

OR

Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with IEEE C2, "National Electrical Safety Code."
4. Comply with NFPA 70.

G. Delivery, Storage, And Handling

1. Package aluminum poles for shipping according to ASTM B 660.
2. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
3. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.



4. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
5. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - a. Warranty Period for Luminaires: Five years from date of Final Completion.
 - b. Warranty Period for Metal Corrosion: Five years from date of Final Completion.
 - c. Warranty Period for Color Retention: Five years from date of Final Completion.
 - d. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Final Completion.

1.2 PRODUCTS

A. General Requirements For Luminaires

1. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
 - a. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
 - b. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
 - c. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.
2. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
3. Metal Parts: Free of burrs and sharp corners and edges.
4. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.
5. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
6. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
7. Exposed Hardware Material: Stainless steel.
8. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
9. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
10. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - a. White Surfaces: 85 percent.
 - b. Specular Surfaces: 83 percent.
 - c. Diffusing Specular Surfaces: 75 percent.
11. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
12. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
13. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.



- a. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
 - b. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - 1) Color: As selected from manufacturer's standard catalog of colors **OR** As selected from manufacturer's full range, **as directed**.
14. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- a. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - b. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 - c. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - d. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - 1) Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black, **as directed**.
15. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
- a. Label shall include the following lamp and ballast characteristics:
 - 1) "USES ONLY" and include specific lamp type.
 - 2) Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
 - 3) Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
 - 4) Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
 - 5) ANSI ballast type (M98, M57, etc.) for HID luminaires.
 - 6) CCT and CRI for all luminaires.
- B. Luminaire-Mounted Photoelectric Relays
1. Comply with UL 773 or UL 773A.
 2. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff, **as directed**.
 - a. Relay with locking-type receptacle shall comply with ANSI C136.10.
 - b. Adjustable window slide for adjusting on-off set points.
- C. Fluorescent Ballasts And Lamps
1. Ballasts for Low-Temperature Environments:
 - a. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic or electromagnetic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
 - b. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.
 2. Ballast Characteristics:
 - a. Power Factor: 90 percent, minimum.



- b. Sound Rating: Class A **OR** Class A except Class B for T8/HO ballasts, **as directed**.
 - c. Total Harmonic Distortion Rating: Less than 10 **OR** 20, **as directed**, percent.
 - d. Electromagnetic Ballasts: Comply with ANSI C82.1, energy-saving, high power factor, Class P, automatic-reset thermal protection.
 - e. Case Temperature for Compact Lamp Ballasts: 65 deg C, maximum.
 - f. Transient-Voltage Protection: Comply with IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
3. Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures 0 deg F (minus 18 deg C) **OR** minus 20 deg F (minus 29 deg C), **as directed**, and higher.
- D. Ballasts For HID Lamps
1. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:
 - a. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 - b. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C).
 - c. Normal Ambient Operating Temperature: 104 deg F (40 deg C).
 - d. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.
 2. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output.
 3. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.
 - a. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
 - 1) Restrike Range: 105- to 130-V ac.
 - 2) Maximum Voltage: 250-V peak or 150-V ac rms.
 - b. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).
- E. HID Lamps
1. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), CCT color temperature 1900 K, and average rated life of 24,000 hours, minimum.
 - a. Dual-Arc Tube Lamp: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.
 2. Low-Pressure Sodium Lamps: ANSI C78.43.
 3. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 65, and CCT color temperature 4000 K.
 4. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and CCT color temperature 4000 K.
 5. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and CCT color temperature 4000 K.
- F. General Requirements For Poles And Support Components
1. Structural Characteristics: Comply with AASHTO LTS-4-M.
 - a. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
 - b. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
 2. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.
 3. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.



- a. Materials: Shall not cause galvanic action at contact points.
- b. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
- c. Anchor-Bolt Template: Plywood or steel.
4. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws. Provide on all, except wood poles.
5. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete."
6. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
7. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

G. Steel Poles

1. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
 - a. Shape: Round, tapered **OR** Round, straight **OR** Square, tapered **OR** Square, straight, **as directed**.
 - b. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
2. Steel Mast Arms: Single-arm **OR** Truss **OR** Davit, **as directed**, type, continuously welded to pole attachment plate. Material and finish same as pole.
3. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 - a. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with stainless **OR** galvanized, **as directed**, -steel bolts.
 - b. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
 - c. Match pole material and finish.
4. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
5. Steps: Fixed steel, with nonslip treads, positioned for 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet (3 m) above finished grade.
6. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.
7. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems", listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
8. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
9. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.
10. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
11. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.
12. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - a. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."



- b. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
 - c. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - 1) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
- H. Aluminum Poles
- 1. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.
 - 2. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
 - a. Shape: Round, tapered **OR** Round, straight **OR** Square, tapered **OR** Square, straight, **as directed**.
 - b. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
 - 3. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
 - 4. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems", listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
 - 5. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
 - a. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
 - b. Finish: Same as pole **OR** luminaire, **as directed**.
 - 6. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
 - 7. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - a. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - b. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 - c. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - d. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - 1) Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from manufacturer's full range, **as directed**.
- I. Fiberglass Poles
- 1. Poles: Designed specifically for supporting luminaires, with factory-formed cable entrance and handhole. Not less than 65 percent fiberglass, with resin and pigment making up the remainder.
 - a. Resin Color: Dark bronze; provide uniform coloration throughout entire wall thickness.
 - b. Surface Finish: Pigmented polyurethane, with a minimum dry film thickness of 1.5 mils (0.04 mm). Polyurethane may be omitted if the surface layer of pole is inherently UV inhibited.
- J. Decorative Poles
- 1. Pole Material:
 - a. Cast ductile iron.
 - b. Cast gray iron, according to ASTM A 48/A 48M, Class 30.
 - c. Cast aluminum.
 - d. Cast concrete.



- e. Spun concrete.
- f. Steel tube, covered with closed-cell polyurethane foam, with a polyethylene exterior.
- 2. Mounting Provisions:
 - a. Bolted to concrete foundation.
 - b. Embedded.
- 3. Fixture Brackets:
 - a. Cast ductile iron.
 - b. Cast gray iron.
 - c. Cast aluminum.
- 4. Pole Finish: <Insert finish>.

K. Laminated Wood Poles

1. Species and Grades for Structural Glulam Timber: Engineer and fabricate structural laminated wood poles, complying with ANSI A190.1. Use southern pine **OR** Douglas fir **OR** Alaska cedar **OR** any species listed in AITC 117, **as directed**, to withstand indicated structural loads without exceeding allowable design working stresses according to AITC 117.
2. Features: Include wood bracket **OR** wood crossarm **OR** pole-top adapter, **as directed**, for mounting luminaire(s), metal pole cap, **as directed**, and concealed raceway path connected to access handhole.
3. Mounting Provisions: Embedded.
4. Appearance Grade: Architectural appearance grade complying with AITC 110.
5. Preservative Treatment: Pressure treat lumber before gluing according to AWWA C28 for waterborne preservatives. After dressing and end-cutting each member to final size and shape, apply a field-treatment preservative to comply with AWWA M4 to surfaces cut to a depth of more than 1/16 inch (1.6 mm).
6. Adhesive: Wet-use type complying with ASTM D 2559.
7. End Sealer: Manufacturer's standard, transparent, colorless wood sealer that is effective in retarding the transmission of moisture at cross-grain cuts and is compatible with indicated finish.
8. Penetrating Sealer: Manufacturer's standard, transparent, penetrating wood sealer that is compatible with indicated finish.
9. Finish: Natural, unstained wood **OR** Semitransparent stain applied after erection **OR** Semitransparent stain applied at factory, **as directed**, color as selected.

L. Wood Poles

1. Poles: Douglas fir **OR** Southern yellow pine, **as directed**, machine trimmed by turning, **as directed**, complying with ANSI O5.1 and with AWWA C4 for wood species used; and bored, roofed, and galled before treatment.
 - a. Mounting Provisions: Embedded.
2. Preservative Treatment: Pressure treat poles with creosote **OR** pentachlorophenol **OR** ammoniacal copper arsenate, **as directed**, according to AWWA C1 and AWWA C4.
3. Luminaire Brackets: Comply with ANSI C136.13.

M. Prestressed Concrete Poles

1. Poles: Manufactured by centrifugal spin-casting process **OR** of cast concrete, **as directed**.
 - a. Shape: Round, tapered **OR** Round, straight **OR** Square, tapered **OR** Square, straight, **as directed**.
 - b. Mounting Provisions: Steel butt flange for bolted mounting to foundation or breakaway support **OR** Embedded, **as directed**.
 - c. Finishing: Capped at top and plugged at bottom. Seat each steel reinforcing strand with epoxy adhesive.
 - d. Grounding: Continuous copper ground wire cast into pole. Terminate at top of pole and attach to 24-inch (610-mm) lightning rod, **as directed**.
2. Cure with wet steam and age for a minimum of 15 days before installation.
3. Fabricate poles with a hard, nonporous surface that is resistant to water, frost, and road and soil chemicals and that has a maximum water-absorption rate of 3 percent.



4. Cast aluminum nameplate into pole wall at approximately 5 feet (1.5 m) above ground line, listing name of manufacturer, Project identifier, overall height, and approximate weight.
5. Pole Brackets: Comply with ANSI C136.13.
6. Finish Color: Provided by color material complying with ASTM C 979, uniformly impregnated throughout the pole concrete. Color material shall provide a uniform, stable, permanent color and be as follows:
 - a. Inert, and carbon free.
 - b. Unaffected by environmental conditions and contaminants including, but not limited to, UV solar radiation, salts, and alkalis.
7. Finish Texture: Standard form **OR** Polished exposed aggregate **OR** Etched exposed aggregate, **as directed**.
 - a. Exposed aggregate shall be of **<Insert aggregate type selected from manufacturers' lists>** type.

N. Pole Accessories

1. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 16 Section "Wiring Devices" for ground-fault circuit-interrupter type.
 - a. Surface mounted **OR** Recessed, **as directed**, 12 inches (300 mm) above finished grade.
 - b. Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, that when mounted results in NEMA 250, Type 3R **OR** Type 4X, **as directed**, enclosure.
 - c. With cord opening.
 - d. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
2. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
3. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
4. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept ballast(s) **OR** indicated accessories, **as directed**.
5. Decorative accessories, supplied by decorative pole manufacturer, include the following:
 - a. Banner Arms: **<Insert material>**.
 - b. Flag Holders: **<Insert material>**.
 - c. Ladder Rests: **<Insert material>**.

O. Lowering System For Luminaires

1. Arrange system to lower luminaire **OR** luminaire assembly, **as directed**, to a servicing position within 36 inches (900 mm) of finished grade in winds up to 30 mph (49 km/h) and to provide for manual plug connection to electrical power in the lowered position for testing.
2. Coordinate with luminaire and pole manufacturers for assembly details, wind-load and vibration analysis, and compatibility of materials for electrolysis-free attachment and connection for luminaire mounting assembly, lowering device, lowering cable, and portable winch.
3. Structural and Mechanical Design: Use a minimum safety factor of 5.0 for static and dynamic loads of load-bearing components, including cable.
4. Luminaire Mounting and Disconnect Arrangement: Multiple ring **OR** carriage, **as directed**, -mounted luminaires, arranged for lowering and rising as a group.
 - a. Electrical cable for normal operating power to luminaires manually disconnects inside pole base, using weatherproof multipin connector, and shall be arranged to move within the pole during lowering and rising of luminaire assembly.
OR
Electrical cable for normal operating power to luminaires automatically disconnects at a weatherproof multipin connector within the pole-top lowering head at the beginning of the lowering cycle and reconnects when luminaire or luminaire assembly is raised to the operating position.
5. Lowering Device: Weatherproof, cast-aluminum housing and multiple mechanical latches. Moving parts of latching assembly shall be located in the portion of the unit that is lowered to the servicing position. Positive latching in the operating position shall be indicated to the operator at the base of the pole by a clear visual signal, or by other means acceptable to the Owner or authorities having jurisdiction.



6. Lowering Cable: Zinc-electroplated- or stainless-steel aircraft cable.
7. Portable Winch: Manual **OR** 120-V electric, **as directed**, type. One required.
 - a. Winch Power Connection: Cord and plug.
 - b. Winch Raise-Lower Control: Remote-control station with 15 feet (5 m) of cable.
8. Winch Transformer: Portable, totally enclosed, encapsulated, single-phase, dry type. Primary rated at lighting-circuit voltage; secondary rated at 120 V. Permanent, primary and secondary, twist-locking plug connectors on pigtails shall match pole-base power outlet and winch plug.

1.3 EXECUTION

A. Luminaire Installation

1. Install lamps in each luminaire.
2. Fasten luminaire to indicated structural supports.
 - a. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
3. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation, **as directed**.

B. Pole Installation

1. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
2. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
 - a. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
 - b. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).
 - c. Trees: 15 feet (5 m) from tree trunk.
3. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 - a. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - b. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - c. Install base covers unless otherwise indicated.
 - d. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
5. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 - a. Dig holes large enough to permit use of tampers in the full depth of hole.
 - b. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
6. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 - a. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
 - b. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days, and finish in a dome above finished grade.
 - c. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
 - d. Cure concrete a minimum of 72 hours before performing work on pole.
7. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent



- concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
8. Raise and set poles using web fabric slings (not chain or cable).
- C. Bollard Luminaire Installation
1. Align units for optimum directional alignment of light distribution.
 2. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-place Concrete".
- D. Installation Of Individual Ground-Mounting Luminaires
1. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-place Concrete".
- E. Corrosion Prevention
1. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
 2. Steel Conduits: Comply with Division 26 Section "Raceway And Boxes For Electrical Systems". In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.
- F. Grounding
1. Ground metal poles and support structures according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 - a. Install grounding electrode for each pole unless otherwise indicated.
 - b. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
 2. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 - a. Install grounding electrode for each pole.
 - b. Install grounding conductor and conductor protector.
 - c. Ground metallic components of pole accessories and foundations.
- G. Field Quality Control
1. Inspect each installed fixture for damage. Replace damaged fixtures and components.
 2. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
 - a. Verify operation of photoelectric controls.
 3. Illumination Tests:
 - a. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
 - 1) IESNA LM-5, "Photometric Measurements of Area and Sports Lighting Installations."
 - 2) IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
 - 3) IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
 - 4) IESNA LM-64, "Photometric Measurements of Parking Areas."
 - 5) IESNA LM-72, "Directional Positioning of Photometric Data."
 4. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.
- H. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices.



END OF SECTION 02 84 16 00b



SECTION 02 84 33 00 - OVERHEAD ELECTRICAL DISTRIBUTION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for overhead electrical distribution. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Conductors, connectors, and splices.
 - b. Poles and crossarms.
 - c. Hardware and accessories.
 - d. Surge arresters.
 - e. Cutouts, switches, and fuses.
 - f. Pole-mounted distribution transformers.
 - g. Primary metering equipment.

C. Definitions

1. BIL: Basic impulse level, stated in kilovolts.
2. RUS: Department of Agriculture, Rural Utilities Service.
3. Sag: The distance measured vertically from a conductor to the straight line joining its two points of support, measured at the midpoint of the span, unless otherwise indicated.
 - a. Final Sag: The sag of a conductor under specified conditions of loading and temperature applied after it has been subjected, for an appreciable period, to the loading prescribed for the loading district in which it is situated, or equivalent loading, and the loading removed. Final sag includes the effect of inelastic deformation (creep).
 - b. Initial Unloaded Sag: The sag of a conductor before the application of an external load.
4. Secondary: Conductors and components for circuits operating at the utilization voltage of 600 V or less.
5. Service: Set of insulated conductors extending from a pole to the metering point or service entrance connection at the location of utilization of electricity.

D. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Qualification Data: For qualified manufacturer **OR** testing agency, **as directed**.
3. Material Certificates: For the following items, from manufacturers:
 - a. Wood poles.
 - b. Concrete poles.
 - c. Wood crossarms.
4. Listing Documentation: Indicate that products comply with RUS listing requirements specified in "Quality Assurance" Article.
 - a. Time-Current Coordination Curves: Illustrate optimum coordination of protective devices involved in the Work of this Section.
 - b. Source quality-control test reports.
5. Field quality-control reports.
6. Operation and Maintenance Data: For switches **OR** transformers, **as directed**, to include in emergency, operation, and maintenance manuals.
7. Survey records for locations of pole, anchors, and other features for inclusion in Project Record Documents.



E. Quality Assurance

1. Concrete Pole Manufacturer Qualifications: Certified by PCI as a qualified manufacturer of concrete utility poles of type and size indicated for this Project.
2. Inspection Agency Qualifications for Pole and Crossarm Inspection: An independent agency, acceptable to authorities having jurisdiction, qualified to conduct inspections indicated.
3. Testing Agency Qualifications: Member company of NETA or an NRTL.
4. Testing Agency's Field Supervisor: Currently certified by NETA or an NRTL.
5. Treatment Technician Qualifications for Field Treatment of Wood Poles and Crossarms: Certified by authorities having jurisdiction over environmental protection at the location of Project for field application of chemicals required.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
7. Overhead-Line Components, Devices, and Accessories: Currently listed in RUS Informational Publication 202-1 without restriction for the intended application.
8. Comply with IEEE C2 **OR** CPUC General Order 95, **as directed**, except where stricter requirements are indicated or where local requirements that are stricter apply.
9. Strength of Line and Line Components Selected by Contractor: Provide grades of construction and strength required by IEEE C2 for conditions encountered at Project site for heavy **OR** medium **OR** light, **as directed**, line loading unless otherwise indicated.

F. Delivery, Storage, And Handling

1. Wood Pole Storage and Handling: Comply with ATIS O5.1. Do not use pointed handling tools capable of producing indentations greater than 1 inch (25 mm).

G. Project Conditions

1. Interruption of Existing Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - a. Notify Owner no fewer than two days in advance of proposed interruption of service.
 - b. Do not proceed with interruption of service without Owner's written permission.

H. Coordination

1. Coordinate with utility supplying electricity to lines specified in this Section, and make final connections **OR** arrangements for final connections by utility, **as directed**.
2. Coordinate with those responsible for voice **OR** data **OR** video, **as directed**, systems that will have cables supported by poles installed according to this Section.

1.2 PRODUCTS

A. Conductors, Connectors, And Splices

1. Conductor Type AAC: Bare **OR** Bare and covered, **as directed**, all-aluminum, Alloy 1350-H19, complying with ASTM B 230/B 230M and ASTM B 231/B 231M.
OR
Conductor Type AAAC: Bare **OR** Bare and covered, **as directed**, all-aluminum-alloy, Alloy 6201-T81, complying with ASTM B 398/B 398M and ASTM B 399/B 399M.
OR
Conductor Type ACSR: Bare **OR** Bare and covered, **as directed**, aluminum conductor, steel reinforced, complying with ASTM B 232/B 232M.
OR
Conductor Type CU: Bare **OR** Bare and covered, **as directed**, hard-drawn copper, complying with ASTM B 1 and ASTM B 8.
2. Conductor Covering: UV resistant, complying with ICEA-S-70-547. HDPE **OR** XLP, **as directed**, 150 mils (3.81 mm) thick.



3. Self-Supported, Multiconductor, Insulated Medium-Voltage Wiring: Factory-assembled, messenger-supported type, listed under UL 1072 as sunlight-resistant Type MV cable for cable tray use.
 - a. Conductors: Aluminum, Alloy 1350, complying with ASTM B 230/B 230M and ASTM B 231/B 231M **OR** Hard-drawn copper, complying with ASTM B 1 and ASTM B 8, **as directed**; stranded for No. 2 AWG and larger.
 - b. Conductor Insulation: XLP, complying with NEMA WC 70/ICEA S-95-658 **OR** EPR, complying with NEMA WC 70/ICEA S-95-658, **as directed**.
 - c. Insulation Level: 100 **OR** 133, **as directed**, percent of rated circuit line-to-line voltage.
 - d. Conductor Shield: Extruded, nonconducting, thermoset material, complying with NEMA WC 70/ICEA S-95-658; 18-mil (0.046-mm) minimum thickness.
 - e. Insulation Shield: Include the following two components:
 - 1) Nonmetallic conducting, material complying with NEMA WC 70/ICEA S-95-658 and UL 1072, extruded over, and free stripping from the insulation.
 - 2) Metallic Tape Shield: Bare copper, 5-mil (0.127-mm) minimum thickness, helically applied with a 15 percent minimum overlap.
 - f. Conductor Jacket: Extruded, chlorosulfonated-polyethylene-based material, complying with NEMA WC 70/ICEA S-95-658.
 - g. Messenger: Copper **OR** Composite copper and copper, **as directed**, -clad steel.
 - h. Conductor Support Strap: Copper strap, wound around conductors and messenger the full length of the cable.
4. Secondary-Voltage Line Conductors: Aluminum conductor, steel **reinforced**, complying with ASTM B 232/B 232M **OR** Covered aluminum conductor, steel reinforced, complying with ICEA S-70-547, with HDPE or XLP covering, **as directed**, 60 mils (1.52 mm) thick.

OR

Secondary-Voltage Line Conductors: Bare hard-drawn copper, complying with ASTM B 1 and ASTM B 8 **OR** Covered hard-drawn copper, complying with ICEA S-70-547, with HDPE or XLP covering, **as directed**, 60 mils (1.52 mm) thick. Neutral-supported, secondary service-drop cable, **as directed**.

OR

Racked Secondary Conductors, 600 V and Less: Copper, insulated with XLP, complying with NEMA WC 70/ICEA S-95-658, **as directed**.
5. Neutral-Supported, Secondary Service-Drop Cable, 600 V and Less: Insulated conductors with bare neutral, complying with ICEA S-76-474, and using the following combination of materials:
 - a. Conductors and Neutral: Copper with copper-clad-steel neutral **OR** Aluminum with bare Alloy 1350 aluminum neutral **OR** Aluminum with ACSR neutral, **as directed**.
 - b. Insulation: XLP, complying with NEMA WC 70/ICEA S-95-658 **OR** High-modular-weight, low-density polyethylene **OR** Weather-resistant polyolefin, complying with ICEA S-70-547, **as directed**.
6. Connectors, Splices, and Conductor Securing and Protecting Components: Items include wire clamps, ties, conductor armor, fittings, connectors, and terminals. Listed for the specific applications and conductor types and combinations of materials used. Descriptions as follows for various applications:
 - a. Copper to Copper: Copper alloy, complying with UL 486A-486B.
 - b. Aluminum Composition to Aluminum Composition: Aluminum alloy, complying with UL 486A-486B.
 - c. Copper to Aluminum Composition: Type suitable for this purpose, complying with UL 486A-486B.
 - d. Connectors and Splices for Secondary Conductors: Listed and labeled for the conditions and materials involved in each application.
 - e. Taps for Medium-Voltage Line Conductors: Hot-line clamps, screw type, with concealed threads and bare, hard-drawn copper stirrups. Listed for the combination of materials being connected.
 - f. Splices under Tension: Compression type with strength exceeding the conductors spliced.



- g. Splices and Terminations for Covered Conductors: As recommended by conductor manufacturer for conductor and covering combination and for specific materials and physical arrangement of each splice.
 - h. Splices and Terminations for Insulated Medium-Voltage Conductors: Comply with requirements in Division 26 Section "Medium-voltage Cables".
- B. Wood Poles
- 1. Comply with ATIS O5.1 and RUS Bulletin 1728F-700, for wood poles pressure treated with creosote **OR** pentachlorophenol, **as directed**, **OR** ammoniacal copper arsenate, **OR** ammoniacal copper zinc arsenate **OR** chromated copper arsenate, **as directed**.
 - 2. Wood Species: Douglas fir **OR** Lodgepole pine **OR** Western larch **OR** Southern yellow pine, **as directed**.
 - 3. Pole Marking:
 - a. Manufacturer's Mark: Comply with ATIS O5.1; locate 10 feet (3 m) from the pole butt for poles 50 feet (15 m) long or less.
 - b. Pole Number: Machine-embossed aluminum, alphanumeric characters not less than 2-1/2 inches (65 mm) high, with aluminum nails.
 - 4. Factory Operations: Machine trim poles by turning smooth, full length. Roof, gain, and bore poles before pressure treatment.
- C. Concrete Poles
- 1. Description: Spun-cast prestressed concrete, complying with requirements of ASTM C 1089.
 - a. Comply with requirements of RUS Bulletin 1724E-216.
 - 2. Design: Base design on calculation of strength required by IEEE C2 or indicated on Drawings, whichever is greater. Design shall be suitable for installation at a location where annual temperature range is between minus 4 deg F and plus 100 deg F (minus 20 deg C and plus 38 deg C). Include pole design for embedded attachments matching fittings, brackets, and other items installed in the field.
 - 3. Shaft: Hollow, for poles at overhead-to-underground connections. Provide 3-1/2-inch- (89-mm-) minimum cable raceway capacity, with conduit elbow **OR** cable entry port, **as directed**, at base.
 - 4. Water Absorption: Not more than 3 percent.
 - 5. Surface: Smooth, hard, nonporous, and resistant to soil acids **OR** road salts **OR** frost and freezing damage, **as directed**.
 - 6. Pole Marking:
 - a. Manufacturer's Mark: Comply with ATIS O5.1; locate 10 feet (3 m) from the pole butt for poles 50 feet (15 m) long or less.
 - b. Pole Number: Machine-embossed aluminum, alphanumeric characters not less than 2-1/2 inches (65 mm) high.
- D. Crossarms
- 1. Description: Solid-wood distribution type, complying with RUS Bulletin 1728H-701 for specified construction grade **OR** Galvanized, steel angles, **as directed**, and complying with IEEE C2 for required climbing space and wire clearances.
 - 2. Braces: Galvanized, flat, ferrous-metal units; 1/4 inch (6 mm) thick by 1-1/4 inches (30 mm) wide, minimum, with length to suit crossarm dimensions.
- E. Guys And Anchors
- 1. Guy Strand Assemblies: Cable and attachment assemblies shall have uniform minimum breaking strength of the cable.
 - 2. Cable: Seven strands. Zinc-coated steel, complying with ASTM A 475 **OR** Aluminum-clad steel, complying with ASTM B 416 **OR** Copper-clad steel, complying with ASTM B 228, **as directed**. Breaking strength shall be not less than 10,000 lb (45 kN).
 - 3. Cable Termination:
 - 1) Thimble eye.

OR



- 2) Hooks and guy strain plates, complying with IEEE C135.1.
 - 2) Preformed galvanized-steel guy grips, matching material, galvanizing, and strength of the guy strand assembly.
 4. Anchor and Anchor-Rod Assemblies: Hot-dip galvanized steel.
 - a. Power-installed screw-type anchors.
 - 1) 15-inch (380-mm) screw; with rod 96 inches (2400 mm) long by 1-1/2 inches (38 mm) in diameter. Rated at 10,000 lb (45 kN) when installed.
 - 2) Guy anchors shall have strength and holding area as required for anchor load and soil conditions at location of that anchor.
 5. Strain Insulators: Epoxy-bonded fiberglass of length to meet clearance requirements specified in "Guy Installation" Article.
 6. Guy Markers: Round, of vinyl or PVC material, white **OR** yellow, **as directed**, color, 96 inches (2440 mm) long. Shatter resistant at temperatures below 0 deg F (minus 18 deg C).
- F. Hardware And Accessories
1. Description: Ferrous-metal items include, but are not limited to, bolts, nuts, washers, crossarm gains and braces, insulator pins, anchor rods, anchors, eyebolts, staples, and transformer brackets.
 - a. Comply with IEEE C135.1, IEEE C135.2, ANSI C135.4, ANSI C135.22, and RUS Informational Publication 202-1 listings with the exception that base material shall be malleable iron or ductile iron, and finish shall be hot-dip galvanized, **as directed**.
 2. Insulator Brackets: Hot-dip galvanized steel, style as indicated, designed to hold vertical-post-type or pin-type insulators, with one **OR** two, **as directed**, -bolt attachment to pole.
 3. Secondary Insulator Racks: Hot-dip galvanized steel, style as indicated, with smooth, rounded 12-gage struts designed to support two **OR** three **OR** four, **as directed**, spool insulators for attachment of secondary drop conductors. Spool spacing of 4 inches (100 mm) **OR** 8 inches (200 mm) **OR** 12 inches (300 mm), **as directed**.
 4. Pole Riser Shields: Galvanized steel with boot **OR** backplate **OR** vent, **as directed**.
 5. Padlocks: ASTM F 883.
 - a. Class: PO1 **OR** PO2, **as directed**.
 - b. Grade: 1 **OR** 2 **OR** 3 **OR** 4 **OR** 5 **OR** 6, **as directed**.
 - c. Option: A **OR** B **OR** C **OR** D **OR** E **OR** F **OR** G, **as directed**.
 6. Insulators: Units rated 6 kV and above shall be free from radio interference.
 - a. Porcelain insulators shall be wet-process type, complying with the following:
 - 1) Pin: ANSI C29.5.
 - 2) Line Post: ANSI C29.7. Include mounting stud of length suitable for each mounting arrangement used.
 - 3) Suspension: ANSI C29.2.
 - 4) Guy Strain: ANSI C29.4.
 - 5) Secondary Spool: ANSI C29.3, Class 53-2.
 - b. Polymer-composite, fiberglass-reinforced insulators shall comply with the following:
 - 1) Line Post: CEA LWIWG-02.
 - 2) Dead End/Suspension: CEA LWIWG-01.
 - 3) Guy Strain: Fiberglass reinforced, epoxy finished. Designed specifically for use in guy assemblies.
 7. Grounding Materials: Comply with Division 26 Section "Grounding And Bonding For Electrical Systems", using materials listed by RUS for the intended purpose without restriction.
 - a. Conductors: No. 4 AWG, minimum; bare, solid, annealed copper, complying with ASTM B 8 unless otherwise indicated.
 - b. Ground Conductor Protectors: PVC or half-round wood molding, fir, pressure treated according to AWPAC 25 **OR** cypress **OR** cedar, **as directed**.
- G. Surge Arresters
1. Distribution-Class Surge Arresters: Porcelain **OR** Polymer, **as directed**, -enclosed, gapless, metal-oxide type with automatic-indicating type, ground-lead disconnection feature, **as directed**, complying with IEEE C62.11 and NEMA LA 1.



2. Intermediate-Class Surge Arresters: Porcelain **OR** Polymer, **as directed**, -enclosed, gapless, metal-oxide type, complying with IEEE C62.11 and NEMA LA 1.
 - a. Voltage Rating: 3 **OR** 6 **OR** 9 **OR** 10 **OR** 12 **OR** 15 **OR** 27 **OR** 30 **OR** 36, **as directed**, kV, at the altitude of Project, unless otherwise indicated.

H. Cutouts, Switches, And Fuses

1. Description: Medium-voltage disconnect, protective, and bypass, **as directed**, units shall be rated for the line-to-line voltage of the systems in which installed, unless higher ratings are indicated. BIL ratings are 45 **OR** 60 **OR** 75 **OR** 95 **OR** 150 **OR** 200, **as directed**, kV.
 - a. Momentary Current Rating of Switching Devices: 20 **OR** 40, **as directed**, kA, asymmetrical at nominal system operating voltage.
 - b. Fuse Characteristics: Time-current characteristics for each set of fuses selected according to written recommendations of manufacturer of component protected by the fuses and coordinated with upstream and downstream protective devices. Prepare time-current coordination curves according to IEEE 242 that illustrate optimum coordination of devices in this Project.
 - c. Interrupting Rating of Fuses: **<Insert value>** symmetrical A at nominal system operating voltage.
2. Fuse Cutouts: Open **OR** enclosed, **as directed**, type, rated 100 **OR** 200, **as directed**, A, continuous, complying with ANSI C37.42.
 - a. Fuses: Enclosed link, Type K **OR** Type T, **as directed**, complying with ANSI C37.42.
 - b. Fuse Current Rating: 150 percent of the transformer full-load current unless otherwise indicated.
 - c. Switching Application: Include switch link instead of fuse.
 - d. Switch Current Interrupting Rating: Transformer magnetizing current.
3. Fused Switches: Single-pole, manual units.
 - a. Switch Rating: 400 **OR** 600, **as directed**, -A rms continuous and load-current interrupting.
 - b. Fuses: Dropout-type power fuses.
4. Nonfused Switches: Single-pole, manual units, rated 100 **OR** 200 **OR** 400 **OR** 600, **as directed**, -A rms continuous.
5. Group-Operated, Load-Interrupter Switches: Fused **OR** Nonfused, **as directed**, three-pole, single-throw units, manually operated by handle through insulated mechanical linkage.
 - a. High-pressure contact type, complying with ANSI C37.32.
 - b. Factory assembled to suit specific configuration and mounting conditions for this Project.
 - c. Operating Handle: Padlock equipped.
 - d. Current Interrupting Rating: Equal to continuous current rating of switch.
 - e. Fuses: Nondropout power type.
6. Group-Operated, Air-Break (Nonloadbreak) Switches: Three-pole, single-throw units, manually operated by handle through insulated mechanical linkage.
 - a. Comply with ANSI C37.32.
 - b. Factory assembled to suit specific configuration and mounting conditions for this Project.
 - c. Operating Handle: Padlock equipped.
 - d. Suitable for field conversion to load-interrupter switch by adding interrupter modules.

I. Distribution Transformers

1. Description: Single-phase, two-winding, single **OR** two, **as directed**, -bushing, liquid-filled, self-cooled, pole-mounting distribution type, suitable for external fuse and surge suppressor protection; complying with IEEE C 57.12.00, and tested according to IEEE C 57.12.90 and with the following additional requirements, **as directed**:
 - a. Cooling Class: OA.
 - b. Temperature Rise: 65 deg C.
 - c. Insulating Liquid: Mineral oil, ASTM D 3487, Type II.
OR
Insulating Liquid: High molecular weight, mineral oil based, and UL listed as less-flammable type.

**OR**

Insulating Liquid: Biodegradable insulating and cooling liquid, UL listed as less flammable type.

- d. Identification: Label the transformer as "non-PCB" and place manufacturer's name and type of fluid on the nameplate.
 2. BIL: 95 **OR** 75 **OR** 60, **as directed**, kV.
 3. Taps: Two, 2.5 percent above and below **OR** Four, 2.5 percent below, **as directed**, high-voltage and full-load rated. Tap changer shall have an external operating handle, **as directed**.
 4. Mounting Brackets: Single **OR** Double, **as directed**, integral; suitable for pole mounting, individually or in cluster, or on crossarm.
 5. Minimum Efficiency: Class 1, as defined by NEMA TP 1, based on test results that comply with requirements of NEMA TP 2.
 6. Bushings: Creepage distance shall exceed nominal value standard for unit rating by at least 75 percent.
 7. Hardware: Stainless steel.
 8. Tank and Cover: Stainless steel, complying with ASTM A 167, Type 304 or 304L, with paint coating exterior finish system complying with IEEE C57.12.28, including manufacturer's standard color finish coat.
 9. Show transformer kiloampere capacity using 2-1/2-inch (65-mm) numerals placed near the low-voltage bushings.
- J. Primary Metering Equipment
1. Metering Transformers: Outdoor current and potential transformers, designed for crossarm mounting, complying with IEEE C57.13, and having the following features:
 - a. BIL: 45 **OR** 60 **OR** 75 **OR** 95 **OR** 150 **OR** 200, **as directed**, kV.
 - b. Secondary connection box arranged for conduit connection.
 - c. Potential-Transformer Voltage Rating: 2.4 **OR** 4.16 **OR** 7.2 **OR** 12.0 **OR** 12.47, **as directed**, kV to 120-V ac, 60 Hz.
 - d. Potential-Transformer Accuracy Class: Minimum 0.3 at 75-VA burden.
 - e. Voltage Rating: 2.4 **OR** 4.16 **OR** 7.2 **OR** 12.0 **OR** 12.47, **as directed**, kV.
 - f. Current Rating: **<Insert value>** to 5 A.
 - g. Accuracy Class: Minimum 0.2 at 50-VA burden.
 2. Watt-Hour Meter: Outdoor solid-state unit, with demand register, **OR** arranged for pulse initiation, **as directed**, complying with ANSI C12.10, and including the following ratings and features:
 - a. Form: 8S **OR** 9S, **as directed**.
 - b. Element: 2 **OR** 2-1/2 **OR** 3, **as directed**.
 - c. Voltage: 120 V.
 - d. Current: 2-1/2 A.
 - e. Frequency: 60 Hz.
 - f. Kilowatt-Hour Register: Five-digit type.
 - g. Demand-Register Multiplier: A quantity in even hundreds, indicated on meter face.
 - h. Demand-Register Interval: 15 **OR** 30, **as directed**, minutes.
 - i. Mounting: On matching socket, complying with ANSI C12.7, and complete with automatic current short-circuiting device.
 - j. Meter Test Block: Matched to meter, and furnished and equipped with open knife switches designed to isolate each metering component for test.
 - k. Meter Cabinet: Galvanized steel; weatherproof enclosure with pole-mounting bracket and the following features:
 - 1) Hinged Door: Arranged for padlocking in closed position.
 - 2) Size: Adequate to house meter and other equipment indicated, but not less than 20 by 30 by 11 inches (510 by 760 by 280 mm) deep.
- K. Source Quality Control
1. Factory Tests: Conduct routine tests of transformers **OR** medium-voltage switches **OR** metering equipment, **as directed**, according to referenced standards.



2. Testing Agency: Engage a qualified testing agency to inspect poles and crossarms before and after preservative treatment for compliance of wood poles and crossarms with requirements indicated. RUS quality mark "WQC" on each item is acceptable in place of inspection as evidence of compliance.
3. Poles and crossarms will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

1.3 EXECUTION

A. Right-Of-Way Clearance And Tree Trimming

1. Clear right of way according to Division 01 Section(s) "Temporary Tree And Plant Protection" AND Division 31 Section(s) "Site Clearing".
2. Clear right of way to maintain minimum clearances required by IEEE C2, unless Drawings indicate greater clearances or greater clearances are required by state or local codes or regulations. If no minimum requirements are mandated, maintain a minimum of 15 feet (4.5 m) on both sides horizontally and below medium-voltage conductors and 60 inches (1500 mm) on both sides horizontally and below secondary-voltage conductors. Remove overhanging branches.

B. General Installation Requirements

1. Install underground power and metering circuits and those circuits indicated to be in raceways according to Division 26 Section "Underground Ducts And Raceways For Electrical Systems" and Division 26 Section "Medium-voltage Cables", and make splices and terminations for those circuits according to the applicable Sections.
2. Engage the services of a licensed surveyor to verify dimensions by field measurement, to identify locations of poles, anchors, and other features, and to verify all clearances. The survey document shall also identify locations of connections to new and existing supply lines and to primary and secondary services. Notify the Owner of discrepancies and field conditions that are not indicated and that will affect installation.
3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
4. Apply warning signs and equipment labels according to Division 26 Section "Identification For Electrical Systems".

C. Conductor Installation, General

1. Handle and string conductors to prevent cuts, gouges, scratches, kinks, flattening, or deformation. Remove damaged sections and splice conductors.
 - a. String new conductors to "initial" sag values recommended by manufacturer for type and size of conductor except as otherwise indicated.
 - b. Conductors Reinstalled or Resagged: String to "final" sag values recommended by manufacturer for type and size of conductor except as otherwise indicated.
2. Connections, Splices, and Terminations: Use kits listed for the specific type of connection and combination of materials in the connection or recommended for the specific use by manufacturer of material on which applied.
 - a. Splice Location: Do not install within 10 feet (3 m) of a support.
 - b. Line Conductors and Service Drops: Install so strength exceeds ultimate rated strength of conductor.
 - c. Splices and Terminations of Covered Conductors: Comply with manufacturer's written instructions.
 - d. Splices and Terminations of Insulated Conductors of Self-Supported, Medium-Voltage Cable: Comply with manufacturer's written instructions.

D. Medium-Voltage Line Conductor Installation

1. Application: Install bare conductors unless otherwise indicated.



2. Armor Rod: Install to protect conductors if line conductors are supported by insulators.
 3. Flat Aluminum Armor Wire: Install to protect conductors if they are supported by, or attached to, galvanized or coated iron or steel clamps or fittings.
 4. Support line conductors and taps as follows:
 - a. Use wire ties for conductor attachment to pin and vertical post insulators unless otherwise indicated.
 - b. Install wire ties tight against conductor and insulator, and turn ends back and flat against conductor, to eliminate exposed wire ends.
 - c. Use wire clamps on horizontal post, dead end, and suspension insulators unless otherwise indicated.
- E. Pole And Crossarm Installation
1. Pole Orientation: Align curve of curved wood poles with straight-line runs of three or more poles. Align gained surfaces perpendicular to runs.
 2. Elevation of Line above Grade: Install poles with top at same elevation, unless grade changes dictate elevation change in poles, and according to the following:
 - a. On level ground, set poles so tops of consecutive poles vary not more than 60 inches (1500 mm) in elevation.
 - b. Shorten wood poles by cutting off the top and make cuts to shed water. Apply preservative to cuts.
 3. Set poles according to the following:
 - a. Make pole holes vertical, uniform in diameter, and large enough to permit effective use of tamping bars all around. Bore or excavate holes with an average diameter at grade less than twice the diameter of the pole at the same grade.
 - b. Use minimum depths indicated, except at locations where hole is partly or entirely in rock and if hole is not vertical or has a diameter at grade more than two times the pole diameter at the same level; in these conditions, increase the depth of the hole by the following increments before setting the pole:
 - 1) Poles up to 35 Feet (10.6 m) Long: 24 inches (600 mm).
 - 2) Poles 36 to 60 Feet (11 to 18.3 m) Long: 30 inches (760 mm).
 - 3) Poles 61 to 75 Feet (18.6 to 22.9 m) Long: 36 inches (900 mm).
 - c. For poles on slopes, indicated hole depth is from finished grade at lowest side of hole.
 - d. Set poles in alignment and plumb except at dead ends, angles, and points of extra strain; rake poles against conductor strain 1 inch (25 mm) minimum, 2 inches (51 mm) maximum, (after conductors are installed at required tension) for each 10 feet (3 m) of pole length. Rake poles so they will not lean or bend in direction of strain when loaded.
 - e. Backfill holes in 6-inch (150-mm) maximum lifts, and thoroughly tamp each layer before starting the next.
 - f. Place surplus earth around pole in a conical shape, and tamp thoroughly to provide drainage away from pole.
 - g. Set poles so alternate crossarm gains face in alternate directions, except at terminals and dead ends; place gains on last two poles on side facing terminal or dead end.
 - h. Poles Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
 4. Field treat factory-treated poles and crossarms as follows:
 - a. Poles Treated More Than One Year before Installation: Treat portion from 24 inches (600 mm) above ground line to butt.
 - b. Field-Bored Holes and Field-Cut Gains and Pole Tops: Treat cut portions.
 - c. Unused Holes: Treat and plug with treated-wood-dowel drive pins.
 - d. Engage the services of a technician certified according to "Quality Assurance" Article to apply treatment. Comply with requirements in AWPA standards that govern original factory treatment for field-applied treatment and application of chemicals.
 5. Crossarm Installation: Set line crossarms at right angle to line for straight runs and for angles 45 degrees and more. Bisect angles less than 45 degrees.
 - a. Buck Arms: Install at corners and junction poles unless otherwise indicated.



- b. Double Crossarms: Install at dead ends, corners, angles, and line crossings.
 - c. Equipment Arms: Locate below lines and set parallel or at right angles to them, whichever provides best climbing space.
 - d. Gains: Install factory-cut or metal-pole gains only. Do not cut gains in field without specific written approval.
6. Locate pole numbers to provide maximum visibility from the road or patrol route.
- F. Guy Installation
1. Install guys to resist unbalanced loads, including those developed at angles, corners, and dead ends. Install two or more guys if a single guy will not provide adequate strength. Install separate guys if unbalanced loads are separated by 36 inches (900 mm) or more. Comply with IEEE C2.
 - a. Unless a thimble eye is used, at the pole end, install a minimum of two guy hooks and two guy strain plates.
 - b. At the anchor end, attach guy strand assembly with preformed grips.
 2. Protect guy strands from damage. Replace damaged guy strands. Install guy insulators where required to comply with IEEE C2 clearance requirements.
 3. Install guys with a lead-to-height ratio of 1 to 1 unless otherwise indicated. The minimum lead-to-height ratio shall be 1/2 to 1. When less than 1 to 1, increase guy strength by the ratio of the sine of the lead angle indicated to the sine of the lead angle provided.
 4. Install screw-type guy anchors aligned in soil with guy. Set with anchor rod pointing at guy attachment on pole and rod projecting 6 to 9 inches (150 to 230 mm) from ground.
 5. Install strain insulators to provide a minimum of 12 inches (300 mm) of clearance between the nearest energized surface and the strain insulator fitting farthest from the pole. When loaded to the tension indicated, fiberglass strain insulators shall be loaded to not more than two-thirds of manufacturer's published rating.
 6. Guy Markers: Install at anchor end of guys to visually mark the guy wire at all accessible locations. Clamp to guy strand or anchor at top and bottom of marker.
- G. Hardware And Accessories Installation
1. Install washers against wood and under nuts, including eyenuts and locknuts.
 2. Install nuts and locknuts wrench-tight on threaded connections.
- H. Insulator Installation
1. Medium-Voltage Line Application: Install pin **OR** post, **as directed**, type, except install suspension type at corners, angles, dead ends, and other locations where horizontal forces exceed rated values for pin or line-post-type units.
 - a. Install suspension insulators and hardware that have mechanical strength exceeding rated breaking strength of attached conductors.
 - b. Install horizontal line-post insulators for armless construction.
 2. Post-Insulator Conductor Support: Where installed horizontally and for line angles more than 15 degrees, install clamp-top conductor clamps.
 3. Install spool-type insulators for secondary lines mounted on clevis attachments or secondary racks.
 4. Guy Strain Type: Install porcelain **OR** fiberglass-reinforced, **as directed**, units.
- I. Surge Arresters
1. Install surge arresters to protect distribution **OR** metering equipment **OR** reclosers, **as directed**, group-operated, load-interrupter switches, **as directed**, aerial-to-underground transitions, **as directed**, and other items indicated.
 - a. Units Installed 6000 Feet (1800 m) or More above Sea Level: Use arresters specifically rated for this service.
- J. Cutout, Switch, And Fuse Installation
1. Hook-Stick-Operated Switches: Install to maximize safe operating access.



2. Group-Operated, Load-Interrupter Switches and Air-Break Switches: Install operating handle 42 inches (1067 mm) above finished grade.
 - a. Locking Provisions: Install padlock at hasp.
- K. Metering Component Installation
 1. Current and Voltage Transformers: Install secondary conductors between transformers and cabinet in sleeves made of galvanized rigid steel **OR** intermediate metal **OR** PVC, **as directed**, conduit. Install to prevent collection of moisture in raceway and cabinet system.
 2. Meter Cabinet: Mount on pole, 72 inches (1825 mm) above finished grade to center of cabinet.
 - a. Make conduit connections with raintight hubs.
 - b. Install metering transformer secondary leads without splices. Train leads at sides and bottom of enclosure, and secure with wire ties.
 - c. Install meter and meter test block within cabinet.
 - d. Install identical phase sequence, and color-code for both potential and current leads.
 - e. Identify leads using designations consistent with marking on transformer terminals.
- L. Field Quality Control
 1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 2. Perform tests and inspections.
 3. Tests and Inspections:
 - a. Furnish instruments and equipment required for tests that comply with NETA Acceptance Testing Specification.
 - b. Guy Anchors: Test one of each type and capacity installed, plus additional units specifically indicated for testing, **as directed**. Apply rated pull-out force in the same pull direction applied by the guy at the test location.
 - 1) Acceptable Test Results: Denoted by movement of less than 3/8 inch (10 mm) by the holding component of the anchor in the earth or other medium in which it is installed.
 - 2) Replace or reinstall, at the Owner 's option, all anchors of same type and capacity as anchor type that fails this test.
 - c. Ground Resistance: Comply with Division 26 Section "Grounding And Bonding For Electrical Systems". Measure resistance of each separate grounding electrode, including pole grounds. Also measure resistance of separate grounding electrode systems before bonding together.
 - 1) Perform tests and obtain acceptable results before energizing any portion of overhead electrical distribution system.
 - 2) Results and Follow-up: If ground resistance for a single ground electrode or pole ground, tested individually, exceeds 25 ohms, add a ground electrode not less than 10 feet (3 m) away and interconnect with No. 2 AWG, minimum, bare conductor buried at least 12 inches (300 mm) below furnished grade.
 - d. Aerial Conductor Sag and Tension: Observe procedures used by Contractor to verify that initial stringing sags and tensions comply with IEEE C2 and conductor manufacturer's product data and written recommendations.
 - e. Self-Supported, Medium-Voltage Cable: After installation, while cable is isolated, and after terminations are installed and before connecting or energizing, apply dc voltage between each phase conductor and grounding connections of sheath or metallic shield. Comply with NEMA WC 70/ICEA S-95-658 for method, voltage, duration, pass-fail performance, and other test criteria. Perform other field inspections and tests recommended by manufacturer.
 - f. Neutral-Supported, Secondary Service-Drop Cable: Test for insulation resistance while cable is isolated, before connecting or energizing. Minimum acceptable resistance is 100 megohms.
 - g. Existing Surge Arresters: Disconnect and measure resistance between line and ground terminals with a megger test rated 600 V or more. Acceptable resistance values are 300 megohms and more.



- h. New Surge Arresters, Cutouts, and Switches: Inspect after installation and connection to wiring. Verify that ratings and characteristics match approved submittals and comply with system requirements. Verify that installation complies with requirements and that clearances of units and connecting wiring comply with IEEE C2 requirements.
 - 1) Verify proper grounding of metallic equipment parts.
 - 2) Fuses and Disconnect Links: Verify that ratings and characteristics match submittals and comply with system requirements.
 - 3) Switches:
 - a) Manually operate each cutout and switch at least three times, to verify proper operation.
 - b) Verify correct contact alignment, blade penetration, travel stops, and arc interrupter operation.
 - 4) Group-Operated, Load-Interrupter Switches and Air-Break Switches:
 - a) Perform mechanical operator tests according to manufacturer's written instructions.
 - b) Test resistance to ground of parts to be energized. Acceptable value is 200,000 megohms.
 - c) Perform contact-resistance test across all switch blade contacts. Refer to manufacturer's data for acceptable contact resistance.
 - 5) Verify that clearances of energized parts and connecting wires comply with IEEE C2 requirements.
 - i. Distribution Transformers: Inspect after installation and connection to wiring and verify that ratings and characteristics match approved submittals and comply with system requirements. Verify the integrity and good condition of unit.
 - 1) Inspect for physical damage, cracked insulators, leaks, tightness of connections, and overall mechanical and electrical integrity.
 - 2) Perform preenergizing inspections and tests recommended by manufacturer.
 - 3) Verify proper equipment grounding.
 - 4) Verify that clearances of terminals and connecting wires comply with IEEE C2.
 - j. Metering Transformers: Inspect after installation and connection to wires, and verify that ratings and characteristics match approved submittals and comply with system requirements. Verify the integrity and good condition of unit.
 - 1) Verify proper connections, tightness of bolted connections, and integrity of mounting provisions.
 - 2) Verify that required grounding and shorting connections provide good contact.
 - 3) Verify that clearances of terminals and connecting wires comply with IEEE C2.
 - 4) Perform electrical tests according to manufacturer's written instructions, including insulation-resistance tests, polarity tests, and turns-ratio and ratio-verification tests.
 - k. Meters: Inspect after installation and connection to wiring and verify that ratings and characteristics match approved submittals and comply with system requirements. Verify the integrity and good condition of unit.
 - 1) Verify tightness of electrical connections.
 - 2) Verify accuracy at 25, 50, 75, and 100 percent of full-rated load and verify all instrument multipliers according to manufacturer's written instructions.
4. Prepare test and inspection reports.
- M. Adjusting
1. Distribution Transformers: Set voltage taps as directed by the Owner.
- N. Cleaning
1. After completing equipment installation, inspect equipment. Remove spots, dirt, and debris. Repair damaged finish to match original finish. For distribution transformer, use tank touchup paint provided by manufacturer.
 - a. Clean enclosures internally, on completion of installation, according to manufacturer's written instructions.



- O. Demonstration
 - 1. Train Owner's maintenance personnel to adjust, operate, and maintain overhead electrical distribution.

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SECTION 02 87 13 33 - MOLD REMEDIATION**1.1 GENERAL****A. Description Of Work**

1. This specification covers the removal and disposal of mold. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. List of all personnel to be involved in the work with their training and certifications.
2. List of all products and procedures proposed for use in performance of the work.
3. Test reports.
4. Certificates.

C. References

1. U.S. EPA "Mold Remediation in Schools and Commercial Buildings"
2. U.S. EPA "A Brief Guide to Mold, Moisture, and Your Home"

D. Quality Assurance

1. Conform to all Federal, State, and Local regulations which govern the handling and disposal of mold materials.

1.2 PRODUCT - (Not Used)**1.3 EXECUTION**

- A. Environmental Assessment:** The presence of mold, water damage, or musty odors shall be addressed immediately. In all instances, any source(s) of water must be stopped and the extent of water damaged determined. Water damaged materials shall be dried and repaired. Mold damaged materials shall be remediated in accordance with this document.

1. **Visual Inspection:** A visual inspection is the most important initial step in identifying a possible contamination problem. The extent of any water damage and mold growth shall be visually assessed. This assessment is important in determining remedial strategies. Ventilation systems shall also be visually checked, particularly for damp filters but also for damp conditions elsewhere in the system and overall cleanliness. Ceiling tiles, gypsum wallboard (sheetrock), cardboard, paper, and other cellulosic surfaces shall be given careful attention during a visual inspection. The use of equipment such as a boroscope, to view spaces in ductwork or behind walls, or a moisture meter, to detect moisture in building materials, may be helpful in identifying hidden sources of fungal growth and the extent of water damage.
2. **Bulk/Surface Sampling**
 - a. Bulk or surface sampling is not required to undertake a remediation. Remediation of visually identified fungal contamination shall proceed without further evaluation.
 - b. Bulk or surface samples may need to be collected to identify specific fungal contaminants as part of a medical evaluation if occupants are experiencing symptoms which may be related to fungal exposure or to identify the presence or absence of mold if a visual inspection is equivocal (e.g., discoloration, and staining).
 - c. An individual trained in appropriate sampling methodology shall perform bulk or surface sampling. Bulk samples shall be collected from visibly moldy surfaces by scraping or cutting materials with a clean tool into a clean plastic bag. Surface samples shall be collected by wiping a measured area with a sterile swab or by stripping the suspect surface



with clear tape. Surface sampling is less destructive than bulk sampling. Other sampling methods may also be available. A laboratory specializing in mycology shall be consulted for specific sampling and delivery instructions.

3. Air Monitoring
 - a. Air sampling for fungi shall not be part of a routine assessment. This is because decisions about appropriate remediation strategies can usually be made on the basis of a visual inspection. In addition, air-sampling methods for some fungi are prone to false negative results and therefore cannot be used to definitively rule out contamination.
 - b. Air monitoring may be necessary if an individual(s) has been diagnosed with a disease that is or may be associated with a fungal exposure (e.g., pulmonary hemorrhage/hemosiderosis, and aspergillosis).
 - c. Air monitoring may be necessary if there is evidence from a visual inspection or bulk sampling that ventilation systems may be contaminated. The purpose of such air monitoring is to assess the extent of contamination throughout a building. It is preferable to conduct sampling while ventilation systems are operating.
 - d. Air monitoring may be necessary if the presence of mold is suspected (e.g., musty odors) but cannot be identified by a visual inspection or bulk sampling (e.g., mold growth behind walls). The purpose of such air monitoring is to determine the location and/or extent of contamination.
 - e. If air monitoring is performed, for comparative purposes, outdoor air samples shall be collected concurrently at an air intake, if possible, and at a location representative of outdoor air. For additional information on air sampling, refer to the American Conference of Governmental Industrial Hygienists' document, "Bioaerosols: Assessment and Control."
 - f. Personnel conducting the sampling shall be trained in proper air sampling methods for microbial contaminants. A laboratory specializing in mycology shall be consulted for specific sampling and shipping instructions.
4. Analysis of Environmental Samples
 - a. Microscopic identification of the spores/colonies requires considerable expertise. These services are not routinely available from commercial laboratories. Documented quality control in the laboratories used for analysis of the bulk/surface and air samples is necessary. The American Industrial Hygiene Association (AIHA) offers accreditation to microbial laboratories (Environmental Microbiology Laboratory Accreditation Program (EMLAP)). Accredited laboratories must participate in quarterly proficiency testing (Environmental Microbiology Proficiency Analytical Testing Program (EMPAT)).
5. Evaluation of bulk/surface and air sampling data shall be performed by an experienced health professional. The presence of few or trace amounts of fungal spores in bulk/surface sampling shall be considered background. Amounts greater than this or the presence of fungal fragments (e.g., hyphae, and conidiophores) may suggest fungal colonization, growth, and/or accumulation at or near the sampled location. Air samples shall be evaluated by means of comparison (i.e., indoors to outdoors) and by fungal type (e.g., genera, and species). In general, the levels and types of fungi found should be similar indoors (in non-problem buildings) as compared to the outdoor air. Differences in the levels or types of fungi found in air samples may indicate that moisture sources and resultant fungal growth may be problematic.

B. Remediation

1. General
 - a. **In all situations, the underlying cause of water accumulation must be rectified or fungal growth will recur.** Any initial water infiltration shall be stopped and cleaned immediately. An immediate response (within 24 to 48 hours) and thorough clean up, drying, and/or removal of water damaged materials will prevent or limit mold growth. If the source of water is elevated humidity, relative humidity shall be maintained at levels below 60% to inhibit mold growth. Emphasis shall be on ensuring proper repairs of the building infrastructure, so that water damage and moisture buildup does not recur.
 - b. Five different levels of abatement are described below. The size of the area impacted by fungal contamination primarily determines the type of remediation. The sizing levels below



are based on professional judgment and practicality; currently there is not adequate data to relate the extent of contamination to frequency or severity of health effects. **The goal of remediation is to remove or clean contaminated materials in a way that prevents the emission of fungi and dust contaminated with fungi from leaving a work area and entering an occupied or non-abatement area, while protecting the health of workers performing the abatement.** The listed remediation methods were designed to achieve this goal, however, due to the general nature of these methods it is the responsibility of the people conducting remediation to ensure the methods enacted are adequate. The listed remediation methods are not meant to exclude other similarly effective methods. Any changes to the remediation methods listed in these guidelines, however, shall be carefully considered prior to implementation.

- c. Non-porous (e.g., metals, glass, and hard plastics) and semi-porous (e.g., wood, and concrete) materials that are structurally sound and are visibly moldy can be cleaned and reused. Cleaning shall be done using a detergent solution. Porous materials such as ceiling tiles and insulation, and wallboards with more than a small area of contamination shall be removed and discarded. Porous materials (e.g., wallboard, and fabrics) that can be cleaned, can be reused, but should be discarded if possible. A professional restoration consultant shall be contacted when restoring porous materials with more than a small area of fungal contamination. All materials to be reused shall be dry and visibly free from mold. Routine inspections shall be conducted to confirm the effectiveness of remediation work.
 - d. The use of gaseous, vapor-phase, or aerosolized biocides for remedial purposes is **not** recommended. The use of biocides in this manner can pose health concerns for people in occupied spaces of the building and for people returning to the treated space if used improperly. Furthermore, the effectiveness of these treatments is unproven and does not address the possible health concerns from the presence of the remaining non-viable mold. For additional information on the use of biocides for remedial purposes, refer to the American Conference of Governmental Industrial Hygienists' document, "Bioaerosols: Assessment and Control."
2. **Level I: Small Isolated Areas** (10 sq. ft or less) - e.g., ceiling tiles, small areas on walls
 - a. Remediation can be conducted by regular building maintenance staff. Such persons shall receive training on proper clean up methods, personal protection, and potential health hazards. This training can be performed as part of a program to comply with the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200).
 - b. Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection shall be worn.
 - c. The work area shall be unoccupied. Vacating people from spaces adjacent to the work area is not necessary but is recommended in the presence of infants (less than 12 months old), persons recovering from recent surgery, immune suppressed people, or people with chronic inflammatory lung diseases (e.g., asthma, hypersensitivity, pneumonitis, and severe allergies).
 - d. Containment of the work area is not necessary. Dust suppression methods, such as misting (not soaking) surfaces prior to remediation, are recommended.
 - e. Contaminated materials that cannot be cleaned shall be removed from the building in a sealed plastic bag. There are no special requirements for the disposal of moldy materials.
 - f. The work area and areas used by remedial workers for egress shall be cleaned with a damp cloth and/or mop and a detergent solution.
 - g. All areas shall be left dry and visibly free from contamination and debris.
 3. **Level II: Mid-Sized Isolated Areas** (10 - 30 sq. ft.) - e.g., individual wallboard panels.
 - a. Remediation can be conducted by regular building maintenance staff. Such persons shall receive training on proper clean up methods, personal protection, and potential health hazards. This training can be performed as part of a program to comply with the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200).
 - b. Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection shall be worn.



- c. The work area shall be unoccupied. Vacating people from spaces adjacent to the work area is not necessary but is recommended in the presence of infants (less than 12 months old), persons having undergone recent surgery, immune suppressed people, or people with chronic inflammatory lung diseases (e.g., asthma, hypersensitivity, pneumonitis, and severe allergies).
 - d. The work area shall be covered with a plastic sheet(s) and sealed with tape before remediation, to contain dust/debris.
 - e. Dust suppression methods, such as misting (not soaking) surfaces prior to remediation, are recommended.
 - f. Contaminated materials that cannot be cleaned shall be removed from the building in sealed plastic bags. There are no special requirements for the disposal of moldy materials.
 - g. The work area and areas used by remedial workers for egress shall be HEPA vacuumed (a vacuum equipped with a High-Efficiency Particulate Air filter) and cleaned with a damp cloth and/or mop and a detergent solution.
 - h. All areas shall be left dry and visibly free from contamination and debris.
4. **Level III: Large Isolated Areas** (30 - 100 square feet) - e.g., several wallboard panels.
- a. A health and safety professional with experience performing microbial investigations shall be consulted prior to remediation activities to provide oversight for the project.
 - b. The following procedures *at a minimum* are recommended:
 - 1) Personnel trained in the handling of hazardous materials and equipped with respiratory protection, (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection shall be worn.
 - 2) The work area and areas directly adjacent shall be covered with a plastic sheet(s) and taped before remediation, to contain dust/debris.
 - 3) Seal ventilation ducts/grills in the work area and areas directly adjacent with plastic sheeting.
 - 4) The work area and areas directly adjacent shall be unoccupied. Further vacating of people from spaces near the work area is recommended in the presence of infants (less than 12 months old), persons having undergone recent surgery, immune suppressed people, or people with chronic inflammatory lung diseases (e.g., asthma, hypersensitivity, pneumonitis, and severe allergies).
 - 5) Dust suppression methods, such as misting (not soaking) surfaces prior to remediation, are recommended.
 - 6) Contaminated materials that cannot be cleaned shall be removed from the building in sealed plastic bags. There are no special requirements for the disposal of moldy materials.
 - 7) The work area and surrounding areas shall be HEPA vacuumed and cleaned with a damp cloth and/or mop and a detergent solution.
 - 8) All areas shall be left dry and visibly free from contamination and debris.
 - c. If abatement procedures are expected to generate a lot of dust (e.g., abrasive cleaning of contaminated surfaces, demolition of plaster walls) or the visible concentration of the fungi is heavy (blanket coverage as opposed to patchy), then it is recommended that the remediation procedures for Level IV are followed.
5. **Level IV: Extensive Contamination** (greater than 100 contiguous square feet in an area)
- a. A health and safety professional with experience performing microbial investigations shall be consulted prior to remediation activities to provide oversight for the project. The following procedures are recommended:
 - 1) Personnel trained in the handling of hazardous materials equipped with:
 - a) Full-face respirators with high efficiency particulate air (HEPA) cartridges
 - b) Disposable protective clothing covering both head and shoes
 - c) Gloves
 - 2) Containment of the affected area:



- a) Complete isolation of work area from occupied spaces using plastic sheeting sealed with duct tape (including ventilation ducts/grills, fixtures, and any other openings)
 - b) The use of an exhaust fan with a HEPA filter to generate negative pressurization
 - c) Airlocks and decontamination room
- 3) Vacating people from spaces adjacent to the work area is not necessary but is recommended in the presence of infants (less than 12 months old), persons having undergone recent surgery, immune suppressed people, or people with chronic inflammatory lung diseases (e.g., asthma, hypersensitivity, pneumonitis, and severe allergies).
 - 4) Contaminated materials that cannot be cleaned shall be removed from the building in sealed plastic bags. The outside of the bags shall be cleaned with a damp cloth and a detergent solution or HEPA vacuumed in the decontamination chamber prior to their transport to uncontaminated areas of the building. There are no special requirements for the disposal of moldy materials.
 - 5) The contained area and decontamination room shall be HEPA vacuumed and cleaned with a damp cloth and/or mop with a detergent solution and be visibly clean prior to the removal of isolation barriers.
 - 6) Air monitoring shall be conducted prior to occupancy to determine if the area is fit to reoccupy.
6. **Level V: Remediation of HVAC Systems**
- a. A Small Isolated Area of Contamination (<10 square feet) in the HVAC System
 - 1) Remediation can be conducted by regular building maintenance staff. Such persons shall receive training on proper clean up methods, personal protection, and potential health hazards. This training can be performed as part of a program to comply with the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200).
 - 2) Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection shall be worn.
 - 3) The HVAC system shall be shut down prior to any remedial activities.
 - 4) The work area shall be covered with a plastic sheet(s) and sealed with tape before remediation, to contain dust/debris.
 - 5) Dust suppression methods, such as misting (not soaking) surfaces prior to remediation, are recommended.
 - 6) Growth supporting materials that are contaminated, such as the paper on the insulation of interior lined ducts and filters, shall be removed. Other contaminated materials that cannot be cleaned shall be removed in sealed plastic bags. There are no special requirements for the disposal of moldy materials.
 - 7) The work area and areas immediately surrounding the work area shall be HEPA vacuumed and cleaned with a damp cloth and/or mop and a detergent solution.
 - 8) All areas shall be left dry and visibly free from contamination and debris.
 - 9) A variety of biocides are recommended by HVAC manufacturers for use with HVAC components, such as, cooling coils and condensation pans. HVAC manufacturers shall be consulted for the products they recommend for use in their systems.
 - b. Areas of Contamination (>10 square feet) in the HVAC System: A health and safety professional with experience performing microbial investigations shall be consulted prior to remediation activities to provide oversight for remediation projects involving more than a small isolated area in an HVAC system. The following procedures are recommended:
 - 1) Personnel trained in the handling of hazardous materials equipped with:
 - a) Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended.
 - b) Gloves and eye protection



- c) Full-face respirators with HEPA cartridges and disposable protective clothing covering both head and shoes shall be worn if contamination is greater than 30 square feet.
 - 2) The HVAC system shall be shut down prior to any remedial activities.
 - 3) Containment of the affected area:
 - a) Complete isolation of work area from the other areas of the HVAC system using plastic sheeting sealed with duct tape.
 - b) The use of an exhaust fan with a HEPA filter to generate negative pressurization.
 - c) Airlocks and decontamination room if contamination is greater than 30 square feet.
 - 4) Growth supporting materials that are contaminated, such as the paper on the insulation of interior lined ducts and filters, shall be removed. Other contaminated materials that cannot be cleaned should be removed in sealed plastic bags. When a decontamination chamber is present, the outside of the bags shall be cleaned with a damp cloth and a detergent solution or HEPA vacuumed prior to their transport to uncontaminated areas of the building. There are no special requirements for the disposal of moldy materials.
 - 5) The contained area and decontamination room shall be HEPA vacuumed and cleaned with a damp cloth and/or mop and a detergent solution prior to the removal of isolation barriers.
 - 6) All areas shall be left dry and visibly free from contamination and debris.
 - 7) Air monitoring shall be conducted prior to re-occupancy with the HVAC system in operation to determine if the area(s) served by the system are fit to reoccupy.
 - 8) A variety of biocides are recommended by HVAC manufacturers for use with HVAC components, such as, cooling coils and condensation pans. HVAC manufacturers shall be consulted for the products they recommend for use in their systems.
7. Hazard Communication: When fungal growth requiring large-scale remediation is found, the building owner, management, and/or employer shall notify occupants in the affected area(s) of its presence. Notification shall include a description of the remedial measures to be taken and a timetable for completion. Group meetings held before and after remediation with full disclosure of plans and results can be an effective communication mechanism. Individuals with persistent health problems that appear to be related to bioaerosol exposure should see their physicians for a referral to practitioners who are trained in occupational/environmental medicine or related specialties and are knowledgeable about these types of exposures. Individuals seeking medical attention shall be provided with a copy of all inspection results and interpretation to give to their medical practitioners.

END OF SECTION 02 87 13 33



SECTION 02 87 16 13 - BIRD AND BIRD WASTE ABATEMENT**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for bird and bird waste abatement. Products shall be as follows or as directed by the the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary Of Work

1. Work Included - Conventional Enclosure for Removal of Birds and Bird Waste
 - a. Seal off penetrations on perimeter walls into the work area (critical barriers) and establish a decontamination facility for workers.
 - b. Coordinate activities with the demolition and well capping activities.
2. Work Included - Removal and disposal of birds and bird waste.
 - a. Establish work area by installing construction barrier tape around removal area.
 - b. Remove and properly dispose of bulk contamination debris.
 - c. Mist bird waste and contaminated material with Biocide or the equivalent (i.e. Sanogene, Oxine, or Envirocon).
 - d. Remove and properly dispose of contaminated waste material from all building components.
 - e. Utilize low pressure washers or scrub brushes to clean all wall surfaces of bird waste.

C. Quality Criteria

1. Qualifications for Performance of Work
 - a. Contractor (or subcontractor engaged to perform the Work of this Section) shall:
 - 1) Be a licensed bird waste abatement contractor in accordance with the Statutes of the State in which the work is to be performed. Submit notarized documentation confirming current licensure.
 - 2) Have a record of not less than five years successful experience in bird waste removal or asbestos removal.
2. Reference Standards
 - a. Acknowledge, by the executing of the Contract, awareness and familiarity with the contents and requirements of the following regulations, codes, and standards, and assume responsibility for the performance of the Work in strict compliance therewith and for every instance of failure to comply therewith.
 - b. Where conflict among requirements or with the Contract Documents exists, the more stringent requirements shall apply.
 - 1) USEPA Regional National Emissions Standards for Hazardous Air Pollutants (NESHAPS)
 - 2) U.S. Occupational and Safety and Health Administration (OSHA)
 - 3) U.S. EPA Office of Pesticide and Toxic Substances Guidance Document
 - 4) U.S. Department of Transportation, Hazardous Substances: Final Rule (49 CFR 171 and 172), Federal Register November 21, 1986 and corrected February 17, 1987.
 - 5) Statutes of the State in which the Work is to be Performed: Licensure for Asbestos Consultants and Contractors.
 - 6) All state, county, and city codes and ordinances as applicable. Make available for review at the site one copy of EPA, OSHA, and applicable State, County, and City Regulations governing the Work.
3. Patent/Copyright Compliance: Contractor shall determine the applicability of any process patents that may be employed and shall be responsible for the payment of all fees, royalties and licenses that may be required for the use of any patented or licensed process. Contractor shall hold the Owner, Engineer and Testing Laboratory harmless for failure to obtain any licenses and to pay any applicable fees and royalties.



- D. Product Handling
1. Deliver all materials in the original packages, containers, or bundles bearing the name of the manufacturer and the brand name.
 2. Store all materials subject to damage off the ground, away from wet or damp surfaces, and under cover sufficient to prevent damage or contamination.
 3. Remove from the premises all damaged or deteriorating materials. Dispose of materials that become contaminated with waste in accordance with applicable regulatory standards.
- E. Worksite Conditions
1. Worker and Visitor Procedures: The Contractor is hereby advised that the birds and bird wastes have been determined to cause diseases by inhalation and Contractor shall provide workers and qualified visitors with respirators that, as a minimum, shall meet the requirements of current applicable OSHA regulations, and protective clothing during preparation of system of enclosures, prior to commencing, during actual removal, and until final clean-up is completed. Also all personnel assigned to work on this project shall attend a training/awareness class for the purpose of explaining the hazards of improperly handling these materials and proper control measures to take in order to protect themselves.
- F. Personnel Protection
1. General
 - a. Provide respiratory protection in accordance with OSHA regulations 29 CFR 1910-134 and in accordance with the following paragraphs.
 - 1) Prior to commencement of work, all workers shall be instructed by the Contractor and shall be knowledgeable in the appropriate procedures of personnel protection and waste removal.
 - 2) Where respirators with disposable filters are used, provide sufficient filters for replacement as necessary by the workers, or as required by applicable regulations.
 - 3) Permit no visitors, except for governmental inspectors having jurisdiction, or as authorized by Engineer or the Owner, in the work areas after commencement of waste disturbance or removal. Provide authorized visitors with suitable respirators.
 - 4) Provide workers with sufficient sets of protective disposable clothing, consisting of full-body coveralls, head covers, gloves, and foot covers, of sizes to properly fit individual workers.
 - 5) Provide authorized visitors with a set of suitable protective disposable clothing, headgear, eye protection, and/or footwear of sizes to properly fit visitors whenever they are required to enter the work area, to a maximum of six sets per day.
 - 6) Provide, in addition to respirators and protective clothing provided for authorized visitors, protective clothing and respirators for use by Testing Laboratory's representative. Furnish protective clothing in as many sets as required for full-time monitoring by Testing Laboratory.
 - 7) Provide and post the decontamination and work procedures to be followed by workers.
 2. Respiratory Protection Program
 - a. Maintain a respiratory protection program that contains all the elements of the OSHA regulations. Provide a copy to the Engineer for approval.
 - b. Appoint a respiratory protection program administrator, who shall be responsible for the program, maintaining all documentation, instructing workers and providing fit tests. Respiratory protection administrator is to be qualified under OSHA requirements and to have attended and passed, as a minimum, OSHA training institute 2-week course on respiratory protection or NIOSH course "Occupational Respiratory Protection." Respiratory protection program administrator is to be on-site daily during abatement activities. All written programs and directions are to be in English and/or the language of the abatement workers if they are not fluent in English.
 - c. The Contractor is advised that the minimum respiratory requirements as called for in this section and on any drawings/sketches shall be applied unless reported measures indicate



that a lower form of respiratory protection is acceptable according to the appropriate OSHA regulations and the more strict sections of the specification.

3. Respiratory Protection Requirements
 - a. Workers shall be provided with respiratory protection equipment. The respirators are to be sanitized and maintained in accordance with the manufacturer's specification. Appropriate respirator selection will be dependent upon the work to be performed and the level of exposure, as given below.
 - b. For the clean-up, as a minimum, the use of full-faced air-purifying respirators is required for all preparation, removal and cleaning work.
 - c. This specification requires that workers shall wear suitable respiratory protection at all times whenever a potential for exposure to bird and bird waste exists.

1.2 PRODUCTS

A. Materials

1. Polyethylene/Plastic sheeting shall be of the thicknesses specified, in sizes to minimize the frequency of joints. Utilize reinforced plastic sheeting in specified thicknesses on floors.
2. Tape shall be glass fiber or other type capable of sealing joints of adjacent sheets of plastic and for attachment of plastic sheet to finished or unfinished surfaces of dissimilar materials under both dry and wet conditions.
3. Sodium Hypochlorite ("bleach")
4. Impermeable Containers shall be suitable to receive and retain contaminated materials until disposal at an approved site and shall be labeled in accordance with U.S. DOT 49 CFR 171 and 172, and containers shall be both air- and water-tight. Use a minimum of two types of impermeable containers: 1) six millimeter-thick (mil) plastic bags sized to fit within the drum; and 2) metal or fiber drums with tightly fitting lids.
5. Other Materials: Provide all other materials, such as lumber, nails, and hardware, that may be required to construct and dismantle the decontamination area and the barriers that isolate the work area(s).
6. Caulking shall be non-shrinking caulk to be used where insulated pipes continue through areas such as walls and ceilings. Contractor shall determine and submit proof that caulk proposed for use is compatible with the temperature conditions of the surfaces to which it is to be applied.
 - a. Tools And Equipment
 - 1) Water Sprayer - utilize airless or other low pressure sprayer for amended water application.
 - 2) Air Purifying Equipment (for internal recirculation in the work area) shall be HEPA Filtration Systems or Electronic Precipitators. Ensure that no internal air movement system or purification equipment exhausts contaminated air from the work area(s) outside the work area.
 - 3) Diminished Air Pressure Equipment shall comply with ANSI 29.2-7, local exhaust ventilation.
 - 4) Scaffolding shall be as required to accomplish the specified work and shall meet all applicable safety regulations.
 - 5) Transportation - as required for loading, temporary storage, transit, and unloading of contaminated waste without exposure to persons or property.

1.3 EXECUTION

A. Procedures

1. All personnel assigned to perform the work shall attend a training/awareness class for the purpose of explaining the hazards of improperly handling the waste and the proper control measures to take in order to protect themselves. These work procedures shall be discussed with each individual followed by the individual acknowledging receipt of this training by completing the pertinent information on a Hazardous Awareness Training Form



2. The majority of diseases related to bird waste is related to the inhalation of the airborne dust released by the waste. All personnel performing removal/decontamination waste shall therefore wear Powered Air Purifying Respirators (PAPR) equipped with combination Organic Vapor and High Efficiency Particulate Air (HEPA) filters while handling the waste.
3. Workers shall wear non-porous gloves and boots during all preparatory and removal operations.
4. When entering the building, the removal/decontamination personnel shall mist all surfaces having visible remnants of waste, using a diluted sodium hypochlorite ("bleach") and water solution. This solution shall be diluted at a ratio of 10 parts water to 1 part bleach for a 10 to 1 ration (10:1). The waste shall be continuously misted during occupancy in order to keep airborne dust emissions from the waste to a minimum.
5. Remove all birds from the building and seal all openings into the building. The main purpose of this is to eliminate the availability for future bird access into the building. The openings may be temporarily sealed or closed up in many ways, including boarding up windows/doors, polyethylene sheeting, or other convenient and cost effective means. It is not the intention of this task to complete seal the building airtight.
6. Designate an area of the facility for the purpose of storing the waste prior to loading for transportation to the appropriate landfill. The area designated shall have easy access to the door which will be utilized as the waste load-out.

END OF SECTION 02 87 16 13



Task	Specification	Specification Description
02 89 00 00	01 22 16 00	No Specification Required
02 89 00 00	02 83 19 13	Removal And Disposal Of Lead-Containing Paint
02 89 00 00	02 83 19 13a	Lead Paint Related Abatement Procedures
02 89 00 00	02 83 19 13b	XRF Testing For Lead-Based Paint
02 89 00 00	02 83 19 13c	Lead Dust Wipe, Air And Tcpl Sampling And Analysis



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Task	Specification	Specification Description
05 05 19 00	01 22 16 00	No Specification Required
05 05 19 00	05 50 00 00	Metal Fabrications



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SECTION 05 05 23 00 - STRUCTURAL STEEL

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for structural steel. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Structural steel.
 - b. Prefabricated building columns.
 - c. Grout.

C. Definitions

1. Structural Steel: Elements of structural-steel frame, as classified by AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."
2. Seismic-Load-Resisting System: Elements of structural-steel frame designated as "SLRS" or along grid lines designated as "SLRS" on Drawings, including columns, beams, and braces and their connections.
3. Heavy Sections: Rolled and built-up sections as follows:
 - a. Shapes included in ASTM A 6/A 6M with flanges thicker than 1-1/2 inches (38 mm).
 - b. Welded built-up members with plates thicker than 2 inches (50 mm).
 - c. Column base plates thicker than 2 inches (50 mm).
4. Protected Zone: Structural members or portions of structural members indicated as "Protected Zone" on Drawings. Connections of structural and nonstructural elements to protected zones are limited.
5. Demand Critical Welds: Those welds, the failure of which would result in significant degradation of the strength and stiffness of the Seismic-Load-Resisting System and which are indicated as "Demand Critical" or "Seismic Critical" on Drawings.

D. Performance Requirements

1. Connections: Provide details of connections **OR** simple shear connections, **as directed**, required by the Contract Documents to be selected or completed by structural-steel fabricator, including comprehensive engineering design by a qualified professional engineer, **as directed**, to withstand loads indicated and comply with other information and restrictions indicated.
 - a. Select and complete connections using schematic details indicated and AISC 360.
 - b. Use LRFD; data are given at factored-load level **OR** ASD; data are given at service-load level, **as directed**.
2. Moment Connections: Type PR, partially **OR** FR, fully, **as directed**, restrained.
3. Construction: Moment frame **OR** Braced frame **OR** Shear wall system **OR** Combined system of moment frame and braced frame **OR** Combined system of moment frame and shear walls **OR** Combined system of braced frame and shear walls **OR** Combined system of moment frame, braced frame, and shear walls, **as directed**.

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.



3. Shop Drawings: Show fabrication of structural-steel components.
 - a. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
 - b. Include embedment drawings.
 - c. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
 - d. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical high-strength bolted connections.
 - e. Identify members and connections of the seismic-load-resisting system.
 - f. Indicate locations and dimensions of protected zones.
 - g. Identify demand critical welds.
 - h. For structural-steel connections indicated to comply with design loads, include structural design data signed and sealed by the qualified professional engineer responsible for their preparation, **as directed**.
 4. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs): Provide according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for each welded joint whether prequalified or qualified by testing **OR** qualified by testing, **as directed**, including the following:
 - a. Power source (constant current or constant voltage).
 - b. Electrode manufacturer and trade name, for demand critical welds.
 5. Qualification Data: For qualified Installer **OR** fabricator **OR** professional engineer **OR** testing agency, **as directed**.
 6. Welding certificates.
 7. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.
 8. Mill test reports for structural steel, including chemical and physical properties.
 9. Product Test Reports: For the following:
 - a. Bolts, nuts, and washers including mechanical properties and chemical analysis.
 - b. Direct-tension indicators.
 - c. Tension-control, high-strength bolt-nut-washer assemblies.
 - d. Shear stud connectors.
 - e. Shop primers.
 - f. Nonshrink grout.
 10. Source quality-control reports.
- F. Quality Assurance
1. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category STD.
 2. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category ACSE **OR** CSE, **as directed**.
 3. Shop-Painting Applicators: Qualified according to AISC's Sophisticated Paint Endorsement P1 **OR** P2 **OR** P3, **as directed**, or SSPC-QP 3, "Standard Procedure for Evaluating Qualifications of Shop Painting Applicators."
 4. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - a. Welders and welding operators performing work on bottom-flange, demand-critical welds shall pass the supplemental welder qualification testing, as required by AWS D1.8. FCAW-S and FCAW-G shall be considered separate processes for welding personnel qualification.
 5. Comply with applicable provisions of the following specifications and documents:
 - a. AISC 303.
 - b. AISC 341 and AISC 341s1.
 - c. AISC 360.
 - d. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
 6. Preinstallation Conference: Conduct conference at Project site.



- G. Delivery, Storage, And Handling
1. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
 - a. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
 2. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
 - a. Fasteners may be repackaged provided the Owner's testing and inspecting agency observes repackaging and seals containers.
 - b. Clean and relubricate bolts and nuts that become dry or rusty before use.
 - c. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.
- H. Coordination
1. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' recommendations to ensure that shop primers and topcoats are compatible with one another.
 2. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

1.2 PRODUCTS

- A. Structural-Steel Materials
1. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 **OR** 50, **as directed**, percent.
OR
Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than the following:
 - a. W-Shapes: 60 percent.
 - b. Channels, Angles, M **OR** S, **as directed**, -Shapes: 60 percent.
 - c. Plate and Bar: 25 percent.
 - d. Cold-Formed Hollow Structural Sections: 25 percent.
 - e. Steel Pipe: 25 percent.
 - f. All Other Steel Materials: 25 percent.
 2. W-Shapes: ASTM A 992/A 992M **OR** ASTM A 572/A 572M, Grade 50 (345) **OR** ASTM A 529/A 529M, Grade 50 (345) **OR** ASTM A 913/A 913M, Grade 50 (345), **as directed**.
 3. Channels, Angles, M **OR** S, **as directed**, -Shapes: ASTM A 36/A 36M **OR** ASTM A 572/A 572M, Grade 50 (345) **OR** ASTM A 529/A 529M, Grade 50 (345) **OR** ASTM A 913/A 913M, Grade 50 (345), **as directed**.
 4. Plate and Bar: ASTM A 36/A 36M **OR** ASTM A 572/A 572M, Grade 50 (345) **OR** ASTM A 529/A 529M, Grade 50 (345), **as directed**.
 5. Corrosion-Resisting Structural-Steel Shapes, Plates, and Bars: ASTM A 588/A 588M, Grade 50 (345).
 6. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B **OR** C, **as directed**, structural tubing.
 7. Corrosion-Resisting Cold-Formed Hollow Structural Sections: ASTM A 847/A 847M, structural tubing.
 8. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B.
 - a. Weight Class: Standard **OR** Extra strong **OR** Double-extra strong, **as directed**.
 - b. Finish: Black **OR** Galvanized **OR** Black except where indicated to be galvanized, **as directed**.



9. Steel Castings: ASTM A 216/A 216M, Grade WCB with supplementary requirement S11.
10. Steel Forgings: ASTM A 668/A 668M.
11. Welding Electrodes: Comply with AWS requirements.

B. Bolts, Connectors, And Anchors

1. High-Strength Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C, (ASTM A 563M, Class 8S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers; all with plain finish.
 - a. Direct-Tension Indicators: ASTM F 959, Type 325 (ASTM F 959M, Type 8.8), compressible-washer type with plain finish.
2. High-Strength Bolts, Nuts, and Washers: ASTM A 490 (ASTM A 490M), Type 1, heavy-hex steel structural bolts or tension-control, bolt-nut-washer assemblies with splined ends, **as directed**; ASTM A 563, Grade DH, (ASTM A 563M, Class 10S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers with plain finish.
 - a. Direct-Tension Indicators: ASTM F 959, Type 490 (ASTM F 959M, Type 10.9), compressible-washer type with plain finish.
3. Zinc-Coated High-Strength Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade DH (ASTM A 563M, Class 10S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers.
 - a. Finish: Hot-dip zinc coating **OR** Mechanically deposited zinc coating, **as directed**.
 - b. Direct-Tension Indicators: ASTM F 959, Type 325 (ASTM F 959M, Type 8.8), compressible-washer type with mechanically deposited zinc coating **OR** mechanically deposited zinc coating, baked epoxy-coated, **as directed**, finish.
4. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, heavy-hex **OR** round, **as directed**, head assemblies consisting of steel structural bolts with splined ends, heavy-hex carbon-steel nuts, and hardened carbon-steel washers.
 - a. Finish: Plain **OR** Mechanically deposited zinc coating, **as directed**.
5. Shear Connectors: ASTM A 108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.
6. Unheaded Anchor Rods: ASTM F 1554, Grade 36 **OR** ASTM F 1554, Grade 55, weldable **OR** ASTM A 354 **OR** ASTM A 449 **OR** ASTM A 572/A 572M, Grade 50 (345) **OR** ASTM A 36/A 36M, **as directed**.
 - a. Configuration: Straight **OR** Hooked, **as directed**.
 - b. Nuts: ASTM A 563 (ASTM A 563M) hex **OR** heavy-hex, **as directed**, carbon steel.
 - c. Plate Washers: ASTM A 36/A 36M carbon steel.
 - d. Washers: ASTM F 436 (ASTM F 436M), Type 1, hardened carbon steel.
 - e. Finish: Plain **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
7. Headed Anchor Rods: ASTM F 1554, Grade 36 **OR** ASTM F 1554, Grade 55, weldable **OR** ASTM A 354 **OR** ASTM A 449, **as directed**, straight.
 - a. Nuts: ASTM A 563 (ASTM A 563M) hex **OR** heavy-hex, **as directed**, carbon steel.
 - b. Plate Washers: ASTM A 36/A 36M carbon steel.
 - c. Washers: ASTM F 436 (ASTM F 436M), Type 1, hardened carbon steel.
 - d. Finish: Plain **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
8. Threaded Rods: ASTM A 36/A 36M **OR** ASTM A 193/A 193M, Grade B7 **OR** ASTM A 354, Grade BD **OR** ASTM A 449 **OR** ASTM A 572/A 572M, Grade 50 (345), **as directed**.
 - a. Nuts: ASTM A 563 (ASTM A 563M) hex **OR** heavy-hex, **as directed**, carbon steel.
 - b. Washers: ASTM F 436 (ASTM F 436M), Type 1, hardened **OR** ASTM A 36/A 36M, **as directed**, carbon steel.
 - c. Finish: Plain **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
9. Clevises and Turnbuckles: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1035.
10. Eye Bolts and Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1030.



11. Sleeve Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1018.
 12. Structural Slide Bearings: Low-friction assemblies, of configuration indicated, that provide vertical transfer of loads and allow horizontal movement perpendicular to plane of expansion joint while resisting movement within plane of expansion joint.
 - a. Mating Surfaces: PTFE and PTFE **OR** PTFE and mirror-finished stainless steel, **as directed**.
 - b. Coefficient of Friction: Not more than 0.03 **OR** 0.04 **OR** 0.05 **OR** 0.06 **OR** 0.10 **OR** 0.12, **as directed**.
 - c. Design Load: Not less than 2,000 psi (13.7 MPa) **OR** 5,000 psi (34 MPa) **OR** 6,000 psi (41 MPa), **as directed**.
 - d. Total Movement Capability: 2 inches (50 mm).
- C. Primer
1. Primer: Comply with Division 07 **OR** Division 09 Section(s) "High-performance Coatings" **OR** Division 07 AND Division 09 Section(s) "High-performance Coatings", **as directed**.
OR
Primer: SSPC-Paint 25, Type I **OR** Type II, **as directed**, zinc oxide, alkyd, linseed oil primer.
OR
Primer: SSPC-Paint 25 BCS, Type I **OR** Type II, **as directed**, zinc oxide, alkyd, linseed oil primer.
OR
Primer: SSPC-Paint 23, latex primer.
OR
Primer: Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat, **as directed**.
 2. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20 **OR** ASTM A 780, **as directed**.
- D. Grout
1. Metallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, metallic aggregate grout, mixed with water to consistency suitable for application and a 30-minute working time.
 2. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.
- E. Fabrication
1. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC's "Code of Standard Practice for Steel Buildings and Bridges" and AISC 360.
 - a. Camber structural-steel members where indicated.
 - b. Fabricate beams with rolling camber up.
 - c. Identify high-strength structural steel according to ASTM A 6/A 6M and maintain markings until structural steel has been erected.
 - d. Mark and match-mark materials for field assembly.
 - e. If shop priming is required, complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
 2. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
 - a. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.
 3. Bolt Holes: Cut, drill, mechanically thermal cut, **as directed**, or punch standard bolt holes perpendicular to metal surfaces.
 4. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
 5. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 1, "Solvent Cleaning" **OR** SSPC-SP 2, "Hand Tool Cleaning" **OR** SSPC-SP 3, "Power Tool Cleaning", **as directed**.
 6. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.



7. Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural steel. Straighten as required to provide uniform, square, and true members in completed wall framing.
 8. Welded Door Frames: Build up welded door frames attached to structural steel. Weld exposed joints continuously and grind smooth. Plug-weld fixed steel bar stops to frames. Secure removable stops to frames with countersunk machine screws, uniformly spaced not more than 10 inches (250 mm) o.c. unless otherwise indicated.
 9. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel framing members.
 - a. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning, **unless directed otherwise**.
 - b. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
 - c. Weld threaded nuts to framing and other specialty items indicated to receive other work.
- F. Shop Connections
1. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
 - a. Joint Type: Snug tightened **OR** Pretensioned **OR** Slip critical, **as directed**.
 2. Weld Connections: Comply with AWS D1.1/D1.1M and AWS D1.8/D1.8M, **as directed**, for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 - a. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.
- G. Prefabricated Building Columns
1. Prefabricated building columns consisting of load-bearing structural-steel members protected by concrete fireproofing encased in an outer non-load-bearing steel shell.
 2. Fire-Resistance Ratings: Provide prefabricated building column listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction for ratings indicated, based on testing according to ASTM E 119.
 - a. Fire-Resistance Rating: 4 hours **OR** 3 hours **OR** 2 hours **OR** As indicated, **as directed**.
- H. Shop Priming
1. If shop priming is required, shop prime steel surfaces except the following:
 - a. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches (50 mm).
 - b. Surfaces to be field welded.
 - c. Surfaces to be high-strength bolted with slip-critical connections.
 - d. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
 - e. Galvanized surfaces.
 2. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
 - a. SSPC-SP 2, "Hand Tool Cleaning."
 - b. SSPC-SP 3, "Power Tool Cleaning."
 - c. SSPC-SP 7/NACE No. 4, "Brush-Off Blast Cleaning."
 - d. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."
 - e. SSPC-SP 14/NACE No. 8, "Industrial Blast Cleaning."
 - f. SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - g. SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
 - h. SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning."
 - i. SSPC-SP 8, "Pickling."
 3. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5



mils (0.038 mm). Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

- a. Stripe paint corners, crevices, bolts, welds, and sharp edges.
 - b. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.
4. Painting: Prepare steel and apply a one-coat, nonasphaltic primer complying with SSPC-PS Guide 7.00, "Painting System Guide 7.00: Guide for Selecting One-Coat Shop Painting Systems," to provide a dry film thickness of not less than 1.5 mils (0.038 mm).
- I. Galvanizing
1. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123/A 123M.
 - a. Fill vent and drain holes that will be exposed in the finished Work unless they will function as weep holes, by plugging with zinc solder and filing off smooth.
 - b. Galvanize lintels, shelf angles, and welded door frames attached to structural-steel frame and located in exterior walls.
- J. Source Quality Control
1. Testing Agency: Engage an independent testing and inspecting agency to perform shop tests and inspections and prepare test reports.
 - a. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.
 2. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
 3. Bolted Connections: Shop-bolted connections will be inspected **OR** tested and inspected, **as directed**, according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
 4. Welded Connections: In addition to visual inspection, shop-welded connections will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - a. Liquid Penetrant Inspection: ASTM E 165.
 - b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - c. Ultrasonic Inspection: ASTM E 164.
 - d. Radiographic Inspection: ASTM E 94.
 5. In addition to visual inspection, shop-welded shear connectors will be tested and inspected according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
 - a. Bend tests will be performed if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
 - b. Tests will be conducted on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1/D1.1M.

1.3 EXECUTION

A. Examination

1. Verify, with steel Erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
 - a. Prepare a certified survey of bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in



intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

- a. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

C. Erection

1. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.
2. Base Bearing and Leveling Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
 - a. Set plates for structural members on wedges, shims, or setting nuts as required.
 - b. Weld plate washers to top of baseplate.
 - c. Snug-tighten **OR** Pretension, **as directed**, anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 - d. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts, **as directed**.
3. Maintain erection tolerances of structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."
4. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
 - a. Level and plumb individual members of structure.
 - b. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.
5. Splice members only where indicated.
6. Do not use thermal cutting during erection unless approved by the Owner. Finish thermally cut sections within smoothness limits in AWS D1.1/D1.1M.
7. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.
8. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.

D. Field Connections

1. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
 - a. Joint Type: Snug tightened **OR** Pretensioned **OR** Slip critical, **as directed**.
2. Weld Connections: Comply with AWS D1.1/D1.1M and AWS D1.8/D1.8M, **as directed**, for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 - a. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
 - b. Remove backing bars or runoff tabs where indicated, back gouge, and grind steel smooth.
 - c. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC's "Code of Standard Practice for Steel Buildings and Bridges" for mill material.

E. Prefabricated Building Columns

1. Install prefabricated building columns to comply with AISC 360, manufacturer's written recommendations, and requirements of testing and inspecting agency that apply to the fire-resistance rating indicated.



F. Field Quality Control

1. Testing Agency: Engage a qualified independent testing and inspecting agency to inspect field welds and high-strength bolted connections.
2. Bolted Connections: Bolted connections will be inspected **OR** tested and inspected, **as directed**, according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
3. Welded Connections: Field welds will be visually inspected according to AWS D1.1/D1.1M.
 - a. In addition to visual inspection, field welds will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - 1) Liquid Penetrant Inspection: ASTM E 165.
 - 2) Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - 3) Ultrasonic Inspection: ASTM E 164.
 - 4) Radiographic Inspection: ASTM E 94.
4. In addition to visual inspection, test and inspect field-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
 - a. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
 - b. Conduct tests on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1/D1.1M.
5. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

G. Repairs And Protection

1. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair galvanizing to comply with ASTM A 780.
2. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

OR

Touchup Painting: Cleaning and touchup painting are specified in Division 07.

END OF SECTION 05 05 23 00



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Task	Specification	Specification Description
05 05 23 00	01 22 16 00	No Specification Required
05 05 23 00	05 50 00 00	Metal Fabrications



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SECTION 05 12 23 00 - COLD-FORMED METAL FRAMING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for cold-formed metal framing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Exterior load-bearing wall framing.
 - b. Interior load-bearing wall framing.
 - c. Exterior non-load-bearing wall framing.
 - d. Floor joist framing.
 - e. Roof trusses.
 - f. Roof rafter framing.
 - g. Ceiling joist framing.

C. Performance Requirements

1. Structural Performance: Provide cold-formed metal framing capable of withstanding design loads within limits and under conditions indicated.
 - a. Design Loads: **As directed.**
 - b. Deflection Limits: Design framing systems to withstand design loads without deflections greater than the following:
 - 1) Exterior Load-Bearing Wall Framing: Horizontal deflection of 1/240 **OR** 1/360 **OR** 1/600 **OR** 1/720, **as directed**, of the wall height.
 - 2) Interior Load-Bearing Wall Framing: Horizontal deflection of 1/240 **OR** 1/360, **as directed**, of the wall height under a horizontal load of 5 lbf/sq. ft. (239 Pa).
 - 3) Exterior Non-Load-Bearing Framing: Horizontal deflection of 1/240 **OR** 1/360 **OR** 1/600 **OR** 1/720, **as directed**, of the wall height.
 - 4) Floor Joist Framing: Vertical deflection of 1/480 for live loads and 1/360 for total loads of the span.
 - 5) Roof Trusses: Vertical deflection of 1/240 **OR** 1/360, **as directed**, of the span.
 - 6) Scissor Roof Trusses: Horizontal deflection of 1-1/4 inches (32 mm) <Insert dimension> at reactions.
 - 7) Roof Rafter Framing: Horizontal deflection of 1/240 **OR** 1/360, **as directed**, of the horizontally projected span.
 - 8) Ceiling Joist Framing: Vertical deflection of 1/240 **OR** 1/360, **as directed**, of the span.
 - c. Design framing systems to provide for movement of framing members without damage or overstressing, sheathing failure, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change of 120 deg F (67 deg C).
 - d. Design framing system to maintain clearances at openings, to allow for construction tolerances, and to accommodate live load deflection of primary building structure as follows:
 - 1) Upward and downward movement of 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed.**
2. Cold-Formed Steel Framing, General: Design according to AISI's "Standard for Cold-Formed Steel Framing - General Provisions."
 - a. Headers: Design according to AISI's "Standard for Cold-Formed Steel Framing - Header Design."



- b. Design exterior non-load-bearing wall framing to accommodate horizontal deflection without regard for contribution of sheathing materials.
- c. Roof Trusses: Design according to AISI's "Standard for Cold-Formed Steel Framing - Truss Design."

D. Submittals

1. Product Data: For each type of product and accessory indicated.
2. LEED Submittal:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Show layout, spacings, sizes, thicknesses, and types of cold-formed metal framing; fabrication; and fastening and anchorage details, including mechanical fasteners.
 - a. For cold-formed metal framing indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. Welding certificates.
5. Qualification data.
6. Product test reports.
7. Research/evaluation reports.

E. Quality Assurance

1. Engineering Responsibility: Preparation of Shop Drawings, design calculations, and other structural data by a qualified professional engineer.
2. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of cold-formed metal framing that are similar to those indicated for this Project in material, design, and extent.
3. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM E 329 to conduct the testing indicated.
4. Product Tests: Mill certificates or data from a qualified independent testing agency, or in-house testing with calibrated test equipment, **as directed**, indicating steel sheet complies with requirements, including base-metal thickness, yield strength, tensile strength, total elongation, chemical requirements, ductility, and metallic-coating thickness.
5. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," and AWS D1.3, "Structural Welding Code--Sheet Steel."
6. Fire-Test-Response Characteristics: Where indicated, provide cold-formed metal framing identical to that of assemblies tested for fire resistance per ASTM E 119 by a testing and inspecting agency acceptable to authorities having jurisdiction.
7. AISI Specifications and Standards: Comply with AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members" and its "Standard for Cold-Formed Steel Framing - General Provisions."
 - a. Comply with AISI's "Standard for Cold-Formed Steel Framing - Truss Design."
 - b. Comply with AISI's "Standard for Cold-Formed Steel Framing - Header Design."
8. Comply with AISI's "Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings" as applicable.
9. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Protect cold-formed metal framing from corrosion, deformation, and other damage during delivery, storage, and handling.
2. Store cold-formed metal framing, protect with a waterproof covering, and ventilate to avoid condensation.



1.2 PRODUCTS

A. Materials

1. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Steel Sheet: ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of grade and coating weight as follows:
 - a. Grade: ST33H (ST230H) **OR** ST50H (ST340H) **OR** As required by structural performance, **as directed**.
 - b. Coating: G60 (Z180), A60 (ZF180), AZ50 (AZ150), or GF30 (ZGF90) **OR** G90 (Z275) or equivalent, **as directed**.
3. Steel Sheet for Vertical Deflection **OR** Drift, **as directed**, Clips: ASTM A 653/A 653M, structural steel, zinc coated, of grade and coating as follows:
 - a. Grade: 50 (340), Class 1 or 2 **OR** As required by structural performance, **as directed**.
 - b. Coating: G90 (Z275).

B. Load-Bearing Wall Framing

1. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges.
2. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with straight flanges.
3. Steel Box or Back-to-Back Headers: Manufacturer's standard C-shapes used to form header beams, of web depths indicated, punched, with stiffened flanges.
4. Steel Double-L Headers: Manufacturer's standard L-shapes used to form header beams, of web depths indicated.

C. Exterior Non-Load-Bearing Wall Framing

1. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges.
2. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with unstiffened flanges.
3. Vertical Deflection Clips: Manufacturer's standard bypass **OR** head, **as directed**, clips, capable of accommodating upward and downward vertical displacement of primary structure through positive mechanical attachment to stud web.
4. Single Deflection Track: Manufacturer's single, deep-leg, U-shaped steel track; unpunched, with unstiffened flanges, of web depth to contain studs while allowing free vertical movement, with flanges designed to support horizontal and lateral loads and transfer them to the primary structure.
5. Double Deflection Tracks: Manufacturer's double, deep-leg, U-shaped steel tracks, consisting of nested inner and outer tracks; unpunched, with unstiffened flanges.
 - a. Outer Track: Of web depth to allow free vertical movement of inner track, with flanges designed to support horizontal and lateral loads and transfer them to the primary structure.
 - b. Inner Track: Of web depth indicated, and as follows:
6. Drift Clips: Manufacturer's standard bypass or head clips, capable of isolating wall stud from upward and downward vertical displacement and lateral drift of primary structure.

D. Floor Joist Framing

1. Steel Joists: Manufacturer's standard C-shaped steel joists, of web depths indicated, unpunched, **OR** punched, **OR** punched, with enlarged service holes, **as directed**, with stiffened flanges, and as follows:
2. Steel Joist Track: Manufacturer's standard U-shaped steel joist track, of web depths indicated, unpunched, with unstiffened flanges, and as follows:

E. Roof Trusses

1. Roof Truss Members:



- a. Manufacturer's standard-shape steel sections.
OR
Manufacturer's standard C-shaped steel sections, of web depths indicated, unpunched, with stiffened flanges.
- F. Roof-Rafter Framing
- 1. Steel Rafters: Manufacturer's standard C-shaped steel sections, of web depths indicated, unpunched, with stiffened flanges.
 - 2. Built-up Members: Built-up members of manufacturer's standard C-shaped steel section, with stiffened flanges, nested into a U-shaped steel section joist track, with unstiffened flanges; unpunched; of web depths indicated.
- G. Ceiling Joist Framing
- 1. Steel Ceiling Joists: Manufacturer's standard C-shaped steel sections, of web depths indicated, unpunched, **OR** punched with enlarged service holes, **as directed**, with stiffened flanges, and as follows:
- H. Framing Accessories
- 1. Fabricate steel-framing accessories from steel sheet, ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of same grade and coating weight used for framing members.
 - 2. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:
 - a. Supplementary framing.
 - b. Bracing, bridging, and solid blocking.
 - c. Web stiffeners.
 - d. Anchor clips.
 - e. End clips.
 - f. Foundation clips.
 - g. Gusset plates.
 - h. Stud kickers, knee braces, and girts.
 - i. Joist hangers and end closures.
 - j. Hole reinforcing plates.
 - k. Backer plates.
- I. Anchors, Clips, And Fasteners
- 1. Steel Shapes and Clips: ASTM A 36/A 36M, zinc coated by hot-dip process according to ASTM A 123/A 123M.
 - 2. Anchor Bolts: ASTM F 1554, Grade 36 **OR** 55, **as directed**, threaded carbon-steel hex-headed bolts **OR** headless, hooked bolts **OR** headless bolts, with encased end threaded, **as directed**, and carbon-steel nuts; and flat, hardened-steel washers; zinc coated by hot-dip process according to ASTM A 153/A 153M, Class C **OR** mechanically deposition according to ASTM B 695, Class 50, **as directed**.
 - 3. Expansion Anchors: Fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 5 times design load, as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.
 - 4. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 10 times design load, as determined by testing per ASTM E 1190 conducted by a qualified independent testing agency.
 - 5. Mechanical Fasteners: ASTM C 1513, corrosion-resistant-coated, self-drilling, self-tapping steel drill screws.
 - a. Head Type: Low-profile head beneath sheathing, manufacturer's standard elsewhere.
 - 6. Welding Electrodes: Comply with AWS standards.
- J. Miscellaneous Materials



1. Galvanizing Repair Paint: SSPC-Paint 20 or DOD-P-21035 **OR** ASTM A 780, **as directed**.
2. Cement Grout: Portland cement, ASTM C 150, Type I; and clean, natural sand, ASTM C 404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
3. Nonmetallic, Nonshrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, and plasticizing and water-reducing agents, complying with ASTM C 1107, with fluid consistency and 30-minute working time.
4. Shims: Load bearing, high-density multimonomer plastic, nonleaching.
5. Sealer Gaskets: Closed-cell neoprene foam, 1/4 inch (6.4 mm) thick, selected from manufacturer's standard widths to match width of bottom track or rim track members.

K. Fabrication

1. Fabricate cold-formed metal framing and accessories plumb, square, and true to line, and with connections securely fastened, according to referenced AISI's specifications and standards, manufacturer's written instructions, and requirements in this Section.
 - a. Fabricate framing assemblies using jigs or templates.
 - b. Cut framing members by sawing or shearing; do not torch cut.
 - c. Fasten cold-formed metal framing members by welding, screw fastening, clinch fastening, or riveting as standard with fabricator. Wire tying of framing members is not permitted.
 - 1) Comply with AWS D1.3 requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 - 2) Locate mechanical fasteners and install according to Shop Drawings, with screw penetrating joined members by not less than three exposed screw threads.
 - d. Fasten other materials to cold-formed metal framing by welding, bolting, or screw fastening, according to Shop Drawings.
2. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies to prevent damage or permanent distortion.
3. Fabrication Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
 - a. Spacing: Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
 - b. Squareness: Fabricate each cold-formed metal framing assembly to a maximum out-of-square tolerance of 1/8 inch (3 mm).

1.3 EXECUTION

A. Preparation

1. Before sprayed fire-resistive materials are applied, attach continuous angles, supplementary framing, or tracks to structural members indicated to receive sprayed fire-resistive materials.
2. After applying sprayed fire-resistive materials, remove only as much of these materials as needed to complete installation of cold-formed framing without reducing thickness of fire-resistive materials below that are required to obtain fire-resistance rating indicated. Protect remaining fire-resistive materials from damage.
3. Install load bearing shims or grout between the underside of wall bottom track or rim track and the top of foundation wall or slab at stud or joist locations to ensure a uniform bearing surface on supporting concrete or masonry construction.
4. Install sealer gaskets to isolate the underside of wall bottom track or rim track and the top of foundation wall or slab at stud or joist locations.

B. Installation, General

1. Cold-formed metal framing may be shop or field fabricated for installation, or it may be field assembled.



2. Install cold-formed metal framing according to AISI's "Standard for Cold-Formed Steel Framing - General Provisions" and to manufacturer's written instructions unless more stringent requirements are indicated.
3. Install shop- or field-fabricated, cold-formed framing and securely anchor to supporting structure.
 - a. Screw, bolt, or weld wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch (1.6 mm).
4. Install cold-formed metal framing and accessories plumb, square, and true to line, and with connections securely fastened.
 - a. Cut framing members by sawing or shearing; do not torch cut.
 - b. Fasten cold-formed metal framing members by welding, screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.
 - 1) Comply with AWS D1.3 requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 - 2) Locate mechanical fasteners and install according to Shop Drawings, and complying with requirements for spacing, edge distances, and screw penetration.
5. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.
6. Install temporary bracing and supports to secure framing and support loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.
7. Do not bridge building expansion and control joints with cold-formed metal framing. Independently frame both sides of joints.
8. Install insulation, specified in Division 07 Section "Thermal Insulation", in built-up exterior framing members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.
9. Fasten hole reinforcing plate over web penetrations that exceed size of manufacturer's standard punched openings.
10. Erection Tolerances: Install cold-formed metal framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
 - a. Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

C. Load-Bearing Wall Installation

1. Install continuous top and bottom tracks sized to match studs. Align tracks accurately and securely anchor at corners and ends, and at spacings as follows:
 - a. Anchor Spacing: 24 inches (610 mm) **OR** 32 inches (813 mm) **OR** To match stud spacing **OR** As shown on Shop Drawings, **as directed**.
2. Squarely seat studs against top and bottom tracks with gap not exceeding of 1/8 inch (3 mm) between the end of wall framing member and the web of track. Fasten both flanges of studs to top and bottom tracks. Space studs as follows:
 - a. Stud Spacing:
 - 1) 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 19.2 inches (488 mm) **OR** 24 inches (610 mm) **OR** As indicated, **as directed**.
 - 2) 300 mm **OR** 400 mm **OR** 600 mm **OR** As indicated, **as directed**.
3. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar configurations.
4. Align studs vertically where floor framing interrupts wall-framing continuity. Where studs cannot be aligned, continuously reinforce track to transfer loads.
5. Align floor and roof framing over studs. Where framing cannot be aligned, continuously reinforce track to transfer loads.
6. Anchor studs abutting structural columns or walls, including masonry walls, to supporting structure as indicated.



7. Install headers over wall openings wider than stud spacing. Locate headers above openings as indicated. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.
 - a. Frame wall openings with not less than a double stud at each jamb of frame as indicated on Shop Drawings. Fasten jamb members together to uniformly distribute loads.
 - b. Install runner tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with clip angles or by welding, and space jack studs same as full-height wall studs.
 8. Install supplementary framing, blocking, and bracing in stud framing indicated to support fixtures, equipment, services, casework, heavy trim, furnishings, and similar work requiring attachment to framing.
 - a. If type of supplementary support is not indicated, comply with stud manufacturer's written recommendations and industry standards in each case, considering weight or load resulting from item supported.
 9. Install horizontal bridging in stud system, spaced 48 inches (1220 mm) **OR** as indicated **OR** as indicated on Shop Drawings, **as directed**. Fasten at each stud intersection.
 - a. Bridging:
 - 1) Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs with a minimum of 2 screws into each flange of the clip angle for framing members up to 6 inches (150 mm) deep.
OR
Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.
OR
Proprietary bridging bars installed according to manufacturer's written instructions.
 10. Install steel sheet diagonal bracing straps to both stud flanges, terminate at and fasten to reinforced top and bottom tracks. Fasten clip-angle connectors to multiple studs at ends of bracing and anchor to structure.
 11. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.
- D. Exterior Non-Load-Bearing Wall Installation
1. Install continuous tracks sized to match studs. Align tracks accurately and securely anchor to supporting structure as indicated.
 2. Fasten both flanges of studs to bottom **OR** top and bottom, **as directed**, track, unless otherwise indicated. Space studs as follows:
 - a. Stud Spacing:
 - 1) 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 19.2 inches (488 mm) **OR** 24 inches (610 mm) **OR** As indicated, **as directed**.
 - 2) 300 mm **OR** 400 mm **OR** 480 mm **OR** 600 mm **OR** As indicated, **as directed**.
 3. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar requirements.
 4. Isolate non-load-bearing steel framing from building structure to prevent transfer of vertical loads while providing lateral support.
 - a. Install single-leg deflection tracks and anchor to building structure.
 - b. Install double deep-leg deflection tracks and anchor outer track to building structure.
 - c. Connect vertical deflection clips to bypassing **OR** infill, **as directed**, studs and anchor to building structure.
 - d. Connect drift clips to cold formed metal framing and anchor to building structure.
 5. Install horizontal bridging in wall studs, spaced in rows indicated on Shop Drawings but not more than 48 inches (1220 mm) apart. Fasten at each stud intersection.
 - a. Top Bridging for Single Deflection Track: Install row of horizontal bridging within 12 inches (305 mm) **OR** 18 inches (450 mm), **as directed**, of single deflection track. Install a combination of flat, taut, steel sheet straps of width and thickness indicated and stud or



stud-track solid blocking of width and thickness matching studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.

- 1) Install solid blocking at 96-inch (2440-mm) centers **OR** centers indicated **OR** centers indicated on Shop Drawings, **as directed**.
- b. Bridging:
 - 1) Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs.

OR

 Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.

OR

 Proprietary bridging bars installed according to manufacturer's written instructions.
6. Install miscellaneous framing and connections, including stud kickers, web stiffeners, clip angles, continuous angles, anchors, fasteners, and stud girts, to provide a complete and stable wall-framing system.

E. Joist Installation

1. Install perimeter joist track sized to match joists. Align and securely anchor or fasten track to supporting structure at corners, ends, and spacings indicated on Shop Drawings.
2. Install joists bearing on supporting frame, level, straight, and plumb; adjust to final position, brace, and reinforce. Fasten joists to both flanges of joist track.
 - a. Install joists over supporting frame with a minimum end bearing of 1-1/2 inches (38 mm).
 - b. Reinforce ends and bearing points of joists with web stiffeners, end clips, joist hangers, steel clip angles, or steel-stud sections as indicated on Shop Drawings.
3. Space joists not more than 2 inches (51 mm) from abutting walls, and as follows:
 - a. Joist Spacing:
 - 1) 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 19.2 inches (488 mm) **OR** 24 inches (610 mm) **OR** As indicated, **as directed**.
 - 2) 300 mm **OR** 400 mm **OR** 480 mm **OR** 600 mm **OR** As indicated, **as directed**.
4. Frame openings with built-up joist headers consisting of joist and joist track, nesting joists, or another combination of connected joists if indicated.
5. Install joist reinforcement at interior supports with single, short length of joist section located directly over interior support, with lapped joists of equal length to joist reinforcement, or as indicated **OR** as indicated on Shop Drawings, **as directed**.
 - a. Install web stiffeners to transfer axial loads of walls above.
6. Install bridging at intervals indicated **OR** indicated on Shop Drawings, **as directed**. Fasten bridging at each joist intersection as follows:
 - a. Bridging:
 - 1) Joist-track solid blocking of width and thickness indicated, secured to joist webs.

OR

 Combination of flat, taut, steel sheet straps of width and thickness indicated and joist-track solid blocking of width and thickness indicated. Fasten flat straps to bottom flange of joists and secure solid blocking to joist webs.
7. Secure joists to load-bearing interior walls to prevent lateral movement of bottom flange.
8. Install miscellaneous joist framing and connections, including web stiffeners, closure pieces, clip angles, continuous angles, hold-down angles, anchors, and fasteners, to provide a complete and stable joist-framing assembly.

F. Truss Installation

1. Install, bridge, and brace trusses according to Shop Drawings and requirements in this Section.
2. Truss Spacing:
 - a. 16 inches (406 mm) **OR** 19.2 inches (488 mm) **OR** 24 inches (610 mm) **OR** 32 inches (813 mm) **OR** 48 inches (1220 mm) **OR** As indicated, **as directed**.
 - b. 400 mm **OR** 480 mm **OR** 600 mm **OR** 800 mm **OR** 1200 mm, **as directed**.



3. Do not alter, cut, or remove framing members or connections of trusses.
4. Erect trusses with plane of truss webs plumb and parallel to each other, align, and accurately position at spacings indicated.
5. Erect trusses without damaging framing members or connections.
6. Align webs of bottom chords and load-bearing studs or continuously reinforce track to transfer loads to structure. Anchor trusses securely at all bearing points.
7. Install continuous bridging and permanently brace trusses as indicated on Shop Drawings and designed according to LGSEA's Technical Note 551e, "Design Guide for Permanent Bracing of Cold-Formed Steel Trusses," **as directed**.

G. Field Quality Control

1. Testing: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
2. Field and shop welds will be subject to testing and inspecting.
3. Testing agency will report test results promptly and in writing to Contractor and the Owner.
4. Remove and replace work where test results indicate that it does not comply with specified requirements.
5. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

H. Repairs And Protection

1. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed metal framing with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
2. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that cold-formed metal framing is without damage or deterioration at time of Final Completion.

END OF SECTION 05 12 23 00



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Task	Specification	Specification Description
05 12 23 00	05 05 23 00	Structural Steel
05 12 23 00	05 50 00 00	Metal Fabrications
05 13 00 00	05 50 00 00	Metal Fabrications



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SECTION 05 14 16 00 - STRUCTURAL ALUMINUM

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for structural aluminum. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Performance Requirements

1. Connections: Provide details of simple shear connections required by the Contract Documents to be selected or completed by structural-aluminum fabricator to withstand loads indicated and comply with other information and restrictions indicated.
 - a. Select and complete connections using schematic details indicated and in accordance with minimum mechanical properties and applicable buckling formula constants published by The Aluminum Association's "Aluminum Construction Manual."

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show fabrication of structural-aluminum components.
3. Welding certificates.
4. Mill test reports.
5. Source quality-control test reports.

D. Quality Assurance

1. Fabricator Qualifications: A qualified fabricator who has provided successful structural aluminum fabrication for a minimum of 5 years.
2. Welding: Qualify procedures and personnel according to AWS D1.2, "Structural Welding Code--Aluminum."
3. Comply with applicable provisions of The Aluminum Association's "Aluminum Construction Manual."
4. Preinstallation Conference: Conduct conference at Project site.

1.2 PRODUCTS

A. Structural-Aluminum Materials

1. W-Shapes, Channels, Angles, Plate and Bar, Cold-Formed Hollow Structural Sections, and Pipe: Structural shapes indicating minimum mechanical properties and applicable buckling formula constants are listed in Table 3.3.1, Section 3, of "Specifications for Aluminum Structures," Construction Manual Series Section 1, as published by The Aluminum Association. Applicable ASTM Designations include B209, B210, B211, B221, B241, B247, B308, and B429
2. Allowable Stresses:
 - a. Building Type Structures: Basic allowable tensile stresses for buildings, structural supports for highway signs, luminaires, traffic signals and similar structures shall be the lesser of the minimum yield strength divided by a factor of safety of 1.65, or the minimum ultimate tensile strength divided by a factor of safety of 1.95. Other allowable stresses for buildings and similar structures shall be based upon the factors of safety shown in Table 3.3.3 of "Specifications for Aluminum Structures."
 - b. Bridge Type Structures: Basic allowable tensile stresses for bridge type structures shall be the lesser of the minimum yield strength divided by a factor of safety of 1.85, or the minimum ultimate tensile strength divided by a factor of safety of 2.2. Other allowable



stresses for bridge and similar structures shall be based upon the factors of safety shown in Table 3.3.3 of "Specifications for Aluminum Structures."

3. Welding Electrodes: Comply with AWS requirements.

B. Bolts and Connectors

1. Rivets and Bolts:
 - a. Aluminum alloys used for rivets and bolts shall be those listed in Tables 5.1.1b and 5.1.1c of "Specifications for Aluminum Structures."
 - b. Nuts:
 - 1) For bolts 1/4" and smaller: Alloy 2024-T4. For improved corrosion resistance, apply 0.0002" minimum thickness anodic coating.
 - 2) For bolts larger than 1/4": 6061-T6 or 6262-T9.
 - 3) Flat Washers: Alclad 2024-T4.
 - 4) Spring Lock Washers: Alloy 7075-T6.
 - c. Steel Bolts: Hot-dip galvanized, electro-galvanized, cadmium plated or aluminized steel bolts and Series 300 stainless steel bolts may be used instead of aluminum bolts. Plating thickness on steel shall be adequate to provide corrosion protection for the anticipated environ and service life.

C. Grout

1. Cement Grout: Portland cement, ASTM C 150, Type I; and clean, natural sand, ASTM C 404, Size No. 2. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
2. Metallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, metallic aggregate grout, mixed with water to consistency suitable for application and a 30-minute working time.
3. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

D. Fabrication

1. Structural Aluminum: Fabricate and assemble in shop to greatest extent possible. Fabricate according to The Aluminum Association's "Aluminum Construction Manual."

E. Source Quality Control

1. Engage an independent testing and inspecting agency to perform shop tests and inspections and prepare test reports. Comply with testing and inspection requirements of Part 1.3, Article "Field Quality Control."
2. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

1.3 EXECUTION

A. Erection

1. Examination: Verify elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments, with erector present, for compliance with requirements.
 - a. Proceed with installation only after unsatisfactory conditions have been corrected.
2. Set structural aluminum accurately in locations and to elevations indicated and according to The Aluminum Association's "Aluminum Construction Manual."
3. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting base and bearing plates. Clean bottom surface of base and bearing plates.
 - a. Set base and bearing plates for structural members on wedges, shims, or setting nuts as required.



- b. Weld plate washers to top of base plate.
 - c. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of base or bearing plate before packing with grout.
 - d. Promptly pack grout solidly between bearing surfaces and base or bearing plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
4. Maintain erection tolerances of structural aluminum within The Aluminum Association's "Aluminum Construction Manual."
- B. Field Connections
1. Bolts: Shop install bolts according to The Aluminum Association's "Aluminum Construction Manual" for type of bolt and type of joint specified.
 2. Weld Connections: Comply with AWS D1.2 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work.
 - a. Comply with The Aluminum Association's "Aluminum Construction Manual" for bearing, adequacy of temporary connections, and alignment.
- C. Field Quality Control
1. Testing Agency: Engage a qualified independent testing and inspecting agency to inspect field welds and high-strength bolted connections.
 2. Bolted Connections: Shop-bolted connections shall be tested and inspected according to The Aluminum Association's "Aluminum Construction Manual."
 3. Welded Connections: Field welds shall be visually inspected according to AWS D1.2.
 - a. In addition to visual inspection, field welds shall be tested according to AWS D1.2.
 4. Correct deficiencies in Work that test reports and inspections indicate are not in compliance with the Contract Documents.

END OF SECTION 05 14 16 00



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Task	Specification	Specification Description
05 14 16 00	01 22 16 00	No Specification Required
05 15 16 00	05 50 00 00	Metal Fabrications



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SECTION 05 21 19 00 - STEEL JOISTS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for steel joists. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. K-series steel joists.
 - b. KCS-type K-series steel joists.
 - c. K-series steel joist substitutes.
 - d. Long-span steel joists.
 - e. Joist girders.
 - f. Joist accessories.

C. Definitions

1. SJI "Specifications": Steel Joist Institute's "Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders."
2. Special Joists: Steel joists or joist girders requiring modification by manufacturer to support nonuniform, unequal, or special loading conditions that invalidate load tables in SJI's "Specifications."

D. Performance Requirements

1. Structural Performance: Provide special joists and connections capable of withstanding design loads indicated.
2. Design special joists to withstand design loads with live load deflections no greater than the following:
 - a. Floor Joists: Vertical deflection of 1/360 **OR** 1/240, **as directed**, of the span.
 - b. Roof Joists: Vertical deflection of 1/360 **OR** 1/240, **as directed**, of the span.

E. Submittals

1. Product Data: For each type of joist, accessory, and product indicated.
2. LEED Submittal:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Show layout, designation, number, type, location, and spacings of joists. Include joining and anchorage details, bracing, bridging, joist accessories; splice and connection locations and details; and attachments to other construction.
4. Welding certificates.
5. Manufacturer Certificates
6. Mill Certificates: For bolts.
7. Field quality-control test and inspection reports.
8. Research/Evaluation Reports: For joists.

F. Quality Assurance

1. Manufacturer Qualifications: A manufacturer certified by SJI to manufacture joists complying with applicable standard specifications and load tables of SJI "Specifications."



- a. Manufacturer's responsibilities include providing professional engineering services for designing special joists to comply with performance requirements.
2. SJI Specifications: Comply with standard specifications in SJI's "Specifications" that are applicable to types of joists indicated.
3. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

G. Delivery, Storage, And Handling

1. Deliver, store, and handle joists as recommended in SJI's "Specifications."
2. Protect joists from corrosion, deformation, and other damage during delivery, storage, and handling.

H. Sequencing

1. Deliver steel bearing plates to be built into cast-in-place concrete and masonry construction.

1.2 PRODUCTS

A. Materials

1. Steel: Comply with SJI's "Specifications" for web and steel-angle chord members.
 - a. Recycled Content: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 **OR** 50 **OR** 60, **as directed**, percent.
2. Steel Bearing Plates: ASTM A 36/A 36M.
3. Carbon-Steel Bolts and Threaded Fasteners: ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), carbon-steel, hex-head bolts and threaded fasteners; carbon-steel nuts; and flat, unhardened steel washers.
 - a. Finish: Plain, uncoated **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
4. High-Strength Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1, heavy hex steel structural bolts; ASTM A 563 (ASTM A 563M) heavy hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M) hardened carbon-steel washers.
 - a. Finish: Plain, uncoated **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
5. Welding Electrodes: Comply with AWS standards.
6. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20 **OR** ASTM A 780, **as directed**.

B. Primers

1. Primer:
 - a. SSPC-Paint 15, or manufacturer's standard shop primer complying with performance requirements in SSPC-Paint 15.
OR
Provide shop primer that complies with Division 07.

C. K-Series Steel Joists

1. Manufacture steel joists of type indicated according to "Standard Specifications for Open Web Steel Joists, K-Series" in SJI's "Specifications," with steel-angle top- and bottom-chord members, underslung ends, and parallel top chord.
 - a. Joist Type: K-series steel joists **OR** KCS-type K-series steel joists, **as directed**.
2. Steel Joist Substitutes: Manufacture according to "Standard Specifications for Open Web Steel Joists, K-Series" in SJI's "Specifications," with steel-angle or -channel members.
3. Comply with AWS requirements and procedures for shop welding, appearance, quality of welds, and methods used in correcting welding work.
4. Provide holes in chord members for connecting and securing other construction to joists.



5. Top-Chord Extensions: Extend top chords of joists with SJI's Type S top-chord extensions where indicated, complying with SJI's "Specifications."
 6. Extended Ends: Extend bearing ends of joists with SJI's Type R extended ends where indicated, complying with SJI's "Specifications."
 7. Do not camber joists.
 8. Camber joists according to SJI's "Specifications," **OR** as indicated, **as directed**.
 9. Equip bearing ends of joists with manufacturer's standard beveled ends or sloped shoes if joist slope exceeds 1/4 inch per 12 inches (1:48).
- D. Long-Span Steel Joists
1. Manufacture steel joists according to "Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series" in SJI's "Specifications," with steel-angle top- and bottom-chord members; of joist type and end and top-chord arrangements as follows **OR** as indicated, **as directed**.
 - a. Joist Type: LH-series steel joists **OR** DLH-series steel joists, **as directed**.
 - b. End Arrangement: Underslung **OR** Square, **as directed**.
 - c. Top-Chord Arrangement: Parallel **OR** Pitched 1/8 inch per 12 inches (1:96), 1 way **OR** Pitched 1/8 inch per 12 inches (1:96), 2 ways, **as directed**.
 2. Comply with AWS requirements and procedures for shop welding, appearance, quality of welds, and methods used in correcting welding work.
 3. Provide holes in chord members for connecting and securing other construction to joists.
 4. Camber long-span steel joists according to SJI's "Specifications" **OR** as indicated, **as directed**.
 5. Equip bearing ends of joists with manufacturer's standard beveled ends or sloped shoes if joist slope exceeds 1/4 inch per 12 inches (1:48).
- E. Joist Girders
1. Manufacture joist girders according to "Standard Specifications for Joist Girders" in SJI's "Specifications," with steel-angle top- and bottom-chord members; with end and top-chord arrangements as follows **OR** as indicated, **as directed**.
 - a. End Arrangement: Underslung **OR** Underslung with bottom-chord extensions **OR** Square, **as directed**.
 - b. Top-Chord Arrangement: Parallel **OR** Pitched 1/8 inch per 12 inches (1:96), 1 way **OR** Pitched 1/8 inch per 12 inches (1:96), 2 ways, **as directed**.
 2. Comply with AWS requirements and procedures for shop welding, appearance, quality of welds, and methods used in correcting welding work.
 3. Provide holes in chord members for connecting and securing other construction to joist girders.
 4. Camber joist girders according to SJI's "Specifications" **OR** as indicated, **as directed**.
 5. Equip bearing ends of joists with manufacturer's standard beveled ends or sloped shoes if joist slope exceeds 1/4 inch per 12 inches (1:48).
- F. Joist Accessories
1. Bridging: Provide bridging anchors and number of rows of horizontal **OR** diagonal, **as directed**, bridging of material, size, and type required by SJI's "Specifications" for type of joist, chord size, spacing, and span. Furnish additional erection bridging if required for stability.
 2. Bridging: Schematically indicated. Detail and fabricate according to SJI's "Specifications." Furnish additional erection bridging if required for stability.
 3. Bridging: Fabricate as indicated and according to SJI's "Specifications." Furnish additional erection bridging if required for stability.
 4. Fabricate steel bearing plates with integral anchorages of sizes and thicknesses indicated. Shop prime paint **OR** Hot-dip zinc coat according to ASTM A 123/A 123M, **as directed**.
 5. Supply ceiling extensions, either extended bottom-chord elements or a separate extension unit of enough strength to support ceiling construction. Extend ends to within 1/2 inch (13 mm) of finished wall surface, unless otherwise indicated.
 6. Supply miscellaneous accessories, including splice plates and bolts required by joist manufacturer to complete joist installation.



G. Cleaning And Shop Painting

1. Clean and remove loose scale, heavy rust, and other foreign materials from fabricated joists and accessories by hand-tool cleaning, SSPC-SP 2 **OR** power-tool cleaning, SSPC-SP 3, **as directed**.
2. Do not prime paint joists and accessories to receive sprayed fire-resistive materials, **as directed**.
3. Apply 1 coat of shop primer to joists and joist accessories to be primed to provide a continuous, dry paint film not less than 1 mil (0.025 mm) thick.
OR
Shop priming of joists and joist accessories is specified in Division 07.

1.3 EXECUTION

A. Installation

1. Do not install joists until supporting construction is in place and secured.
2. Install joists and accessories plumb, square, and true to line; securely fasten to supporting construction according to SJI's "Specifications," joist manufacturer's written recommendations, and requirements in this Section.
 - a. Before installation, splice joists delivered to Project site in more than one piece.
 - b. Space, adjust, and align joists accurately in location before permanently fastening.
 - c. Install temporary bracing and erection bridging, connections, and anchors to ensure that joists are stabilized during construction.
 - d. Delay rigidly connecting bottom-chord extensions to columns or supports until dead loads have been applied.
3. Field weld joists to supporting steel bearing plates and framework. Coordinate welding sequence and procedure with placement of joists. Comply with AWS requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
4. Bolt joists to supporting steel framework using carbon-steel bolts.
OR
Bolt joists to supporting steel framework using high-strength structural bolts. Comply with RCSC's "Specification for Structural Joints Using ASTM A 325 or ASTM A 490 Bolts" for high-strength structural bolt installation and tightening requirements.
5. Install and connect bridging concurrently with joist erection, before construction loads are applied. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams.

B. Field Quality Control

1. Testing Agency: Engage a qualified independent testing and inspecting agency to inspect field welds and bolted connections and to perform field tests and inspections and prepare test and inspection reports.
2. Field welds will be visually inspected according to AWS D1.1/D1.1M.
3. In addition to visual inspection, field welds will be tested according to AWS D1.1/D1.1M and the following procedures, as applicable:
 - a. Radiographic Testing: ASTM E 94.
 - b. Magnetic Particle Inspection: ASTM E 709.
 - c. Ultrasonic Testing: ASTM E 164.
 - d. Liquid Penetrant Inspection: ASTM E 165.
4. Bolted connections will be visually inspected.
5. High-strength, field-bolted connections will be tested and verified according to procedures in RCSC's "Specification for Structural Joints Using ASTM A 325 or ASTM A 490 Bolts."
6. Correct deficiencies in Work that test and inspection reports have indicated are not in compliance with specified requirements.
7. Additional testing will be performed to determine compliance of corrected Work with specified requirements.

C. Repairs And Protection



1. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
2. Touchup Painting:
 - a. After installation, promptly clean, prepare, and prime or reprime field connections, rust spots, and abraded surfaces of prime-painted joists, bearing plates, abutting structural steel, and accessories.
 - 1) Clean and prepare surfaces by hand-tool cleaning, SSPC-SP 2, or power-tool cleaning, SSPC-SP 3.
 - 2) Apply a compatible primer of same type as shop primer used on adjacent surfaces.
3. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that joists and accessories are without damage or deterioration at time of Final Completion.

END OF SECTION 05 21 19 00



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SECTION 05 31 00 00 - STEEL DECK

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for steel deck. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Roof deck.
 - b. Acoustical roof deck.
 - c. Cellular roof deck.
 - d. Acoustical cellular roof deck.
 - e. Composite floor deck.
 - f. Electrified cellular floor deck.
 - g. Noncomposite form deck.
 - h. Noncomposite vented form deck.

C. Submittals

1. Product Data: For each type of deck, accessory, and product indicated.
2. LEED Submittal:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Show layout and types of deck panels, anchorage details, reinforcing channels, pans, cut deck openings, special jointing, accessories, and attachments to other construction.
4. Product Certificates.
5. Welding certificates.
6. Field quality-control test and inspection reports.
7. Research/Evaluation Reports: For steel deck.

D. Quality Assurance

1. Welding: Qualify procedures and personnel according to AWS D1.3, "Structural Welding Code - Sheet Steel."
2. Fire-Test-Response Characteristics: Where indicated, provide steel deck units identical to those tested for fire resistance per ASTM E 119 by a testing and inspecting agency acceptable to authorities having jurisdiction.
 - a. Fire-Resistance Ratings: Indicated by design designations of applicable testing and inspecting agency.
 - b. Steel deck units shall be identified with appropriate markings of applicable testing and inspecting agency.
3. AISI Specifications: Comply with calculated structural characteristics of steel deck according to AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."
4. Electrical Raceway Units: Provide UL-labeled cellular floor-deck units complying with UL 209 and listed in UL's "Electrical Construction Equipment Directory" for use with standard header ducts and outlets for electrical distribution systems.
5. FMG Listing: Provide steel roof deck evaluated by FMG and listed in its "Approval Guide, Building Materials" for Class 1 fire rating and Class 1-90 windstorm ratings.



6. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.

E. Delivery, Storage, And Handling

1. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.
2. Stack steel deck on platforms or pallets and slope to provide drainage. Protect with a waterproof covering and ventilate to avoid condensation.
 - a. Protect and ventilate acoustical cellular roof deck with factory-installed insulation to maintain insulation free of moisture.

1.2 PRODUCTS

A. Roof Deck

- a. Steel Roof Deck: Fabricate panels, without top-flange stiffening grooves, to comply with "SDI Specifications and Commentary for Steel Roof Deck," in SDI Publication No. 30, and with the following:
- b. Prime-Painted Steel Sheet: ASTM A 1008/A 1008M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, minimum, shop primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - 1) Color: Manufacturer's standard **OR** Gray **OR** White **OR** Gray top surface with white underside, **as directed**.
- c. Galvanized Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, G60 (Z180) **OR** G90 (Z275), **as directed**, zinc coating.
- d. Galvanized and Shop-Primed Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, G60 (Z180) zinc coating; cleaned, pretreated, and primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - 1) Color: Manufacturer's standard **OR** Gray **OR** White **OR** Gray top surface with white underside, **as directed**.
- e. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Structural Steel (SS), Grade 33 (230) minimum, AZ50 (AZ150) aluminum-zinc alloy coating.
- f. Deck Profile: As indicated **OR** Type NR, narrow rib **OR** Type IR, intermediate rib **OR** Type WR, wide rib **OR** Type 3DR, deep rib **OR** Long span, **as directed**.
- g. Cellular Deck Profile: As indicated **OR** Type WR, wide rib **OR** Type 3DR, deep rib **OR** Long span, **as directed**, with bottom plate.
- h. Profile Depth: As indicated **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm) **OR** 4-1/2 inches (114 mm) **OR** 6 inches (152 mm) **OR** 7-1/2 inches (190 mm), **as directed**.
- i. Design Uncoated-Steel Thickness: As indicated **OR** 0.0295 inch (0.75 mm) **OR** 0.0358 inch (0.91 mm) **OR** 0.0474 inch (1.20 mm) **OR** 0.0598 inch (1.52 mm) **OR** 0.0747 inch (1.90 mm), **as directed**.
- j. Design Uncoated-Steel Thicknesses; Deck Unit/Bottom Plate: As indicated **OR** 0.0358/0.0358 inch (0.91/0.91 mm) **OR** 0.0358/0.0474 inch (0.91/1.20 mm) **OR** 0.0474/0.0474 inch (1.20/1.20 mm) **OR** 0.0474/0.0598 inch (1.20/1.52 mm) **OR** 0.0598/0.0474 inch (1.52/1.20 mm) **OR** 0.0598/0.0598 inch (1.52/1.52 mm), **as directed**.
- k. Span Condition: As indicated **OR** Simple span **OR** Double span **OR** Triple span or more, **as directed**.
- l. Side Laps: Overlapped **OR** Interlocking seam, **as directed**.

B. Acoustical Roof Deck

1. Acoustical Steel Roof Deck: Fabricate panels, without top-flange stiffening grooves, to comply with "SDI Specifications and Commentary for Steel Roof Deck," in SDI Publication No. 30, and with the following:



- a. Prime-Painted Steel Sheet: ASTM A 1008/A 1008M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, minimum, shop primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - 1) Color: Manufacturer's standard **OR** Gray **OR** White **OR** Gray top surface with white underside, **as directed**.
- b. Galvanized Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, G60 (Z180) **OR** G90 (Z275), **as directed**, zinc coating.
- c. Galvanized and Shop-Primed Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, G60 (Z180) zinc coating; cleaned, pretreated, and primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - 1) Color: Manufacturer's standard **OR** Gray **OR** White **OR** Gray top surface with white underside, **as directed**.
- d. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Structural Steel (SS), Grade 33 (230) minimum, AZ50 (AZ150) aluminum-zinc alloy coating.
- e. Deck Profile: As indicated **OR** Type WR, wide rib **OR** Type 3DR, deep rib **OR** Long span, **as directed**.
- f. Cellular Deck Profile: As indicated **OR** Type WR, wide rib **OR** Type 3DR, deep rib **OR** Long span, **as directed**, with bottom plate.
- g. Profile Depth: As indicated **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm) **OR** 4-1/2 inches (114 mm) **OR** 6 inches (152 mm) **OR** 7-1/2 inches (190 mm), **as directed**.
- h. Design Uncoated-Steel Thickness: As indicated **OR** 0.0295 inch (0.75 mm) **OR** 0.0358 inch (0.91 mm) **OR** 0.0474 inch (1.20 mm) **OR** 0.0598 inch (1.52 mm), **as directed**.
- i. Design Uncoated-Steel Thicknesses; Deck Unit/Bottom Plate: As indicated **OR** 0.0358/0.0358 inch (0.91/0.91 mm) **OR** 0.0358/0.0474 inch (0.91/1.20 mm) **OR** 0.0474/0.0358 inch (1.20/0.91 mm) **OR** 0.0474/0.0474 inch (1.20/1.20 mm) **OR** 0.0474/0.0598 inch (1.20/1.52 mm) **OR** 0.0598/0.0474 inch (1.52/1.20 mm) **OR** 0.0598/0.0598 inch (1.52/1.52 mm), **as directed**.
- j. Span Condition: As indicated **OR** Simple span **OR** Double span **OR** Triple span or more, **as directed**.
- k. Side Laps: Overlapped **OR** Interlocking seam, **as directed**.
- l. Acoustical Perforations: Deck units with manufacturer's standard perforated vertical webs **OR** Cellular deck units with manufacturer's standard perforated flat-bottom plate welded to ribbed deck, **as directed**.
- m. Sound-Absorbing Insulation: Manufacturer's standard premolded roll or strip of glass or mineral fiber.
 - 1) Factory install sound-absorbing insulation into cells of cellular deck.
 - 2) Installation of sound-absorbing insulation is specified in Division 07.
- n. Acoustical Performance: NRC 0.65 **OR** 0.75 **OR** 0.80 **OR** 0.85 **OR** 0.90, **as directed**, tested according to ASTM C 423.

C. Composite Floor Deck

1. Composite Steel Floor Deck: Fabricate panels, with integrally embossed or raised pattern ribs and interlocking side laps, to comply with "SDI Specifications and Commentary for Composite Steel Floor Deck," in SDI Publication No. 30, with the minimum section properties indicated, and with the following:
 - a. Prime-Painted Steel Sheet: ASTM A 1008/A 1008M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, minimum, with top surface phosphatized and unpainted and underside surface shop primed with manufacturers' standard gray **OR** white, **as directed**, baked-on, rust-inhibitive primer.
 - b. Galvanized Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230), G30 (Z90) **OR** G60 (Z180) **OR** G90 (Z275), **as directed**, zinc coating.
 - c. Galvanized and Shop-Primed Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230), G30 (Z90) **OR** G60 (Z180), **as directed**, zinc coating; with unpainted top surface and cleaned and pretreated bottom surface primed with manufacturer's standard gray **OR** white, **as directed**, baked-on, rust-inhibitive primer.



- d. Profile Depth: 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm) **OR** As indicated, **as directed**.
- e. Design Uncoated-Steel Thickness: 0.0295 inch (0.75 mm) **OR** 0.0358 inch (0.91 mm) **OR** 0.0474 inch (1.20 mm) **OR** 0.0598 inch (1.52 mm), **as directed**.
- f. Span Condition: As indicated **OR** Simple span **OR** Double span **OR** Triple span or more, **as directed**.

D. Electrified Cellular Floor Deck

1. Electrified Cellular Floor Deck: Fabricate steel sheet cellular floor-deck panels, consisting of a ribbed top section welded to a lower flat-bottom sheet with interlocking side laps, to comply with "SDI Specifications and Commentary for Composite Steel Floor Deck" in SDI Publication No. 30. Fabricate deck to the minimum section properties, width of panel, number and area of cells per panel indicated, and the following:
 - a. Cellular Deck Type: Composite **OR** Noncomposite, **as directed**.
 - b. Galvanized Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230), G60 (Z180) **OR** G90 (Z275), **as directed**, zinc coating.
 - c. Galvanized and Shop-Primed Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230), G60 (Z180) zinc coating; with underside surface cleaned, pretreated, and primed with manufacturer's standard gray **OR** white, **as directed**, baked-on, rust-inhibitive primer.
 - d. Profile Depth: 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm) **OR** As indicated, **as directed**.
 - e. Design Uncoated-Steel Thicknesses; Deck Unit/Bottom Plate: 0.0358/0.0358 inch (0.91/0.91 mm) **OR** 0.0358/0.0474 inch (0.91/1.20 mm) **OR** 0.0358/0.0598 inch (0.91/1.52 mm) **OR** 0.0474/0.0358 inch (1.20/0.91 mm) **OR** 0.0474/0.0474 inch (1.20/1.20 mm) **OR** 0.0474/0.0598 inch (1.20/1.52 mm) **OR** 0.0598/0.0474 inch (1.52/1.20 mm) **OR** 0.0598/0.0598 inch (1.52/1.52 mm), **as directed**.
 - f. Span Condition: As indicated **OR** Simple span **OR** Double span **OR** Triple span or more, **as directed**.
 - g. Factory punch holes, of size and arrangement indicated, into each deck cell at preset inserts and header duct locations.

E. Noncomposite Form Deck

1. Noncomposite Steel Form Deck: Fabricate ribbed-steel sheet noncomposite form-deck panels to comply with "SDI Specifications and Commentary for Noncomposite Steel Form Deck," in SDI Publication No. 30, with the minimum section properties indicated, and with the following:
 - a. Uncoated Steel Sheet: ASTM A 1008/A 1008M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, minimum.
 - b. Prime-Painted Steel Sheet: ASTM A 1008/A 1008M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, minimum, with underside **OR** top and underside, **as directed**, surface shop primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - 1) Color: Manufacturer's standard **OR** Gray **OR** White **OR** Gray top surface with white underside, **as directed**.
 - c. Galvanized Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, G30 (Z90) **OR** G60 (Z180) **OR** G90 (Z275), **as directed**, zinc coating.
 - d. Galvanized and Shop-Primed Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) **OR** 80 (550), **as directed**, G60 (Z180) zinc coating; cleaned, pretreated, and primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - 1) Color: Manufacturer's standard **OR** Gray **OR** White **OR** Gray top surface with white underside, **as directed**.
 - e. Profile Depth: 9/16 inch (14 mm) **OR** 15/16 inch (24 mm) **OR** 1-5/16 inches (33 mm) **OR** 1-1/2 inches (38 mm), **as directed**.



- f. Design Uncoated-Steel Thickness: 0.0149 inch (0.38 mm) **OR** 0.0179 inch (0.45 mm) **OR** 0.0239 inch (0.61 mm) **OR** 0.0295 inch (0.75 mm) **OR** 0.0358 inch (0.91 mm) **OR** 0.0474 inch (1.20 mm) **OR** 0.0598 inch (1.52 mm), **as directed**.
 - g. Span Condition: As indicated **OR** Simple span **OR** Double span **OR** Triple span or more, **as directed**.
 - h. Side Laps: Overlapped **OR** Interlocking seam, **as directed**.
- F. Noncomposite Vented Form Deck
- 1. Noncomposite Vented Steel Form Deck: Fabricate ribbed- and vented-steel sheet noncomposite form-deck panels to comply with "SDI Specifications and Commentary for Noncomposite Steel Form Deck," in SDI Publication No. 30, and with the following:
 - a. Galvanized Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) **OR** 40 (275) **OR** 80 (550), **as directed**, G30 (Z90) **OR** G60 (Z180) **OR** G90 (Z275), **as directed**, zinc coating.
 - b. Galvanized and Shop-Primed Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) **OR** 80 (550), **as directed**, G30 (Z90) **OR** G60 (Z180), **as directed**, zinc coating; cleaned, pretreated, and primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - 1) Color: Manufacturer's standard **OR** Gray **OR** White **OR** Gray top surface with white underside, **as directed**.
 - c. Profile Depth: 9/16 inch (14 mm) **OR** 15/16 inch (24 mm) **OR** 1-5/16 inches (33 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - d. Design Uncoated-Steel Thickness: 0.0149 inch (0.38 mm) **OR** 0.0179 inch (0.45 mm) **OR** 0.0239 inch (0.61 mm) **OR** 0.0295 inch (0.75 mm) **OR** 0.0358 inch (0.91 mm) **OR** 0.0474 inch (1.20 mm) **OR** 0.0598 inch (1.52 mm), **as directed**.
 - e. Span Condition: As indicated **OR** Simple span **OR** Double span **OR** Triple span or more, **as directed**.
 - f. Side Laps: Overlapped **OR** Interlocking seam, **as directed**.
 - g. Vent Slot Area: Manufacturer's standard vent slots providing 1-1/2 percent open area.
- G. Accessories
- 1. General: Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.
 - 2. Mechanical Fasteners: Corrosion-resistant, low-velocity, power-actuated or pneumatically driven carbon-steel fasteners; or self-drilling, self-threading screws.
 - 3. Side-Lap Fasteners: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, No. 10 (4.8-mm) minimum diameter.
 - 4. Flexible Closure Strips: Vulcanized, closed-cell, synthetic rubber.
 - 5. Miscellaneous Sheet Metal Deck Accessories: Steel sheet, minimum yield strength of 33,000 psi (230 MPa), not less than 0.0359-inch (0.91-mm) design uncoated thickness, of same material and finish as deck; of profile indicated or required for application.
 - 6. Pour Stops and Girder Fillers: Steel sheet, minimum yield strength of 33,000 psi (230 MPa), of same material and finish as deck, and of thickness and profile indicated **OR** recommended by SDI Publication No. 30 for overhang and slab depth, **as directed**.
 - 7. Column Closures, End Closures, Z-Closures, and Cover Plates: Steel sheet, of same material, finish, and thickness as deck, unless otherwise indicated.
 - 8. Piercing Hanger Tabs: Piercing steel sheet hanger attachment devices for use with floor deck.
 - 9. Weld Washers: Uncoated steel sheet, shaped to fit deck rib, 0.0598 inch (1.52 mm) **OR** 0.0747 inch (1.90 mm), **as directed**, thick, with factory-punched hole of 3/8-inch (9.5-mm) minimum diameter.
 - 10. Recessed Sump Pans: Single-piece steel sheet, 0.0747 inch (1.90 mm) thick, of same material and finish as deck, with 3-inch- (76-mm-) wide flanges and level **OR** sloped, **as directed**, recessed pans of 1-1/2-inch (38-mm) minimum depth. For drains, cut holes in the field.
 - 11. Flat Sump Plate: Single-piece steel sheet, 0.0747 inch (1.90 mm) thick, of same material and finish as deck. For drains, cut holes in the field.



12. Galvanizing Repair Paint: ASTM A 780 **OR** SSPC-Paint 20 or DOD-P-21035, with dry film containing a minimum of 94 percent zinc dust by weight, **as directed**.
13. Repair Paint: Manufacturer's standard rust-inhibitive primer of same color as primer.

1.3 EXECUTION

A. Installation, General

1. Install deck panels and accessories according to applicable specifications and commentary in SDI Publication No. 30, manufacturer's written instructions, and requirements in this Section.
2. Install temporary shoring before placing deck panels, if required to meet deflection limitations.
3. Locate deck bundles to prevent overloading of supporting members.
4. Place deck panels on supporting frame and adjust to final position with ends accurately aligned and bearing on supporting frame before being permanently fastened. Do not stretch or contract side-lap interlocks.
 - a. Align cellular deck panels over full length of cell runs and align cells at ends of abutting panels.
5. Place deck panels flat and square and fasten to supporting frame without warp or deflection.
6. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to deck.
7. Provide additional reinforcement and closure pieces at openings as required for strength, continuity of deck, and support of other work.
8. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work.
9. Mechanical fasteners may be used in lieu of welding to fasten deck. Locate mechanical fasteners and install according to deck manufacturer's written instructions.

B. Roof-Deck Installation

1. Fasten roof-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated or arc seam welds with an equal perimeter that is not less than 1-1/2 inches (38 mm) long, and as follows:
 - a. Weld Diameter: 5/8 inch (16 mm) **OR** 3/4 inch (19 mm), **as directed**, nominal.
 - b. Weld Spacing: Weld edge and interior ribs of deck units with a minimum of two welds per deck unit at each support. Space welds 18 inches (450 mm) apart, maximum **OR** 12 inches (305 mm) apart in the field of roof and 6 inches (150 mm) apart in roof corners and perimeter, based on roof-area definitions in FMG Loss Prevention Data Sheet 1-28 **OR** as indicated, **as directed**.
 - c. Weld Washers: Install weld washers at each weld location.
2. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of 1/2 of the span or 18 inches (450 mm) **OR** 36 inches (910 mm), **as directed**, and as follows:
 - a. Mechanically fasten with self-drilling, No. 10 (4.8-mm-) diameter or larger, carbon-steel screws.
 - b. Mechanically clinch or button punch.
 - c. Fasten with a minimum of 1-1/2-inch- (38-mm-) long welds.
3. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches (38 mm), with end joints as follows:
 - a. End Joints: Lapped 2 inches (51 mm) minimum **OR** Butted **OR** Lapped 2 inches (51 mm) minimum or butted at Contractor's option, **as directed**.
4. Roof Sump Pans and Sump Plates: Install over openings provided in roof deck and weld **OR** mechanically fasten, **as directed**, flanges to top of deck. Space welds **OR** mechanical fasteners, **as directed**, not more than 12 inches (305 mm) apart with at least one weld **OR** fastener, **as directed**, at each corner.
 - a. Install reinforcing channels or zees in ribs to span between supports and weld **OR** mechanically fasten, **as directed**.



5. Miscellaneous Roof-Deck Accessories: Install ridge and valley plates, finish strips, end closures, and reinforcing channels according to deck manufacturer's written instructions. Weld **OR** Mechanically fasten, **as directed**, to substrate to provide a complete deck installation.
 - a. Weld cover plates at changes in direction of roof-deck panels, unless otherwise indicated.
 6. Flexible Closure Strips: Install flexible closure strips over partitions, walls, and where indicated. Install with adhesive according to manufacturer's written instructions to ensure complete closure.
 7. Sound-Absorbing Insulation: Installation into topside ribs of deck as specified in Division 07.
- C. Floor-Deck Installation
1. Fasten floor-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated and as follows:
 - a. Weld Diameter: 5/8 inch (16 mm) **OR** 3/4 inch (19 mm), **as directed**, nominal.
 - b. Weld Spacing: Weld edge ribs of panels at each support. Space additional welds an average of 12 inches (305 mm) apart, but not more than 18 inches (457 mm) apart.
OR
Weld Spacing: Space and locate welds as indicated.
 - c. Weld Washers: Install weld washers at each weld location.
 2. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of half of the span or 36 inches (910 mm), and as follows:
 - a. Mechanically fasten with self-drilling, No. 10 (4.8-mm-) diameter or larger, carbon-steel screws.
 - b. Mechanically clinch or button punch.
 - c. Fasten with a minimum of 1-1/2-inch- (38-mm-) long welds.
 3. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches (38 mm), with end joints as follows:
 - a. End Joints: Lapped **OR** Butted, **as directed**.
 4. Pour Stops and Girder Fillers: Weld steel sheet pour stops and girder fillers to supporting structure according to SDI recommendations, unless otherwise indicated.
 5. Floor-Deck Closures: Weld steel sheet column closures, cell closures, and Z-closures to deck, according to SDI recommendations, to provide tight-fitting closures at open ends of ribs and sides of deck.
 6. Electrified Cellular Floor Deck: Install cellular floor system with deck assembled from all-cellular units **OR** alternating cellular units with noncellular composite units **OR** units indicated, **as directed**.
 7. Install piercing hanger tabs at 14 inches (355 mm) apart in both directions, within 9 inches (228 mm) of walls at ends, and not more than 12 inches (305 mm) from walls at sides, unless otherwise indicated.
- D. Field Quality Control
1. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
 2. Field welds will be subject to inspection.
 3. Testing agency will report inspection results promptly and in writing to Contractor and the Owner.
 4. Remove and replace work that does not comply with specified requirements.
 5. Additional inspecting, at Contractor's expense, will be performed to determine compliance of corrected work with specified requirements.
- E. Repairs And Protection
1. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on both surfaces of deck with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
 2. Repair Painting: Wire brush and clean rust spots, welds, and abraded areas on both surfaces **OR** top surface, **as directed**, of prime-painted deck immediately after installation, and apply repair paint.
 - a. Apply repair paint, of same color as adjacent shop-primed deck, to bottom surfaces of deck exposed to view.



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3. Provide final protection and maintain conditions to ensure that steel deck is without damage or deterioration at time of Final Completion.

END OF SECTION 05 31 00 00



Task	Specification	Specification Description
05 36 00 00	05 31 00 00	Steel Deck
05 41 00 00	05 12 23 00	Cold-Formed Metal Framing
05 42 33 00	05 12 23 00	Cold-Formed Metal Framing
05 43 00 00	01 22 16 00	No Specification Required
05 43 00 00	05 12 23 00	Cold-Formed Metal Framing
05 43 00 00	05 50 00 00	Metal Fabrications



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SECTION 05 50 00 00 - METAL FABRICATIONS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for metal fabrications. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Steel framing and supports for ceiling-hung toilet compartments.
 - b. Steel framing and supports for operable partitions.
 - c. Steel framing and supports for overhead doors and grilles.
 - d. Steel framing and supports for countertops.
 - e. Steel framing and supports for mechanical and electrical equipment.
 - f. Steel framing and supports for applications where framing and supports are not specified in other Sections.
 - g. Steel framing and supports (outriggers) for window-washing equipment including mounting brackets and anchorages.
OR
Mounting brackets and anchorages for window-washing equipment.
 - h. Elevator machine beams, hoist beams, and divider beams.
 - i. Steel shapes for supporting elevator door sills.
 - j. Steel girders for supporting wood frame construction.
 - k. Steel pipe columns for supporting wood frame construction.
 - l. Prefabricated building columns.
 - m. Shelf angles.
 - n. Metal ladders.
 - o. Ladder safety cages.
 - p. Alternating tread devices.
 - q. Metal ships' ladders and pipe crossovers.
 - r. Metal floor plate and supports.
 - s. Structural-steel door frames.
 - t. Miscellaneous steel trim including steel angle corner guards, steel edgings, and loading-dock edge angles.
 - u. Metal bollards.
 - v. Pipe **OR** Downspout, **as directed**, guards.
 - w. Abrasive metal nosings, treads, and thresholds.
 - x. Cast-iron wheel guards.
 - y. Metal downspout boots.
 - z. Loose bearing and leveling plates for applications where they are not specified in other Sections.
2. Products furnished, but not installed, under this Section:
 - a. Loose steel lintels.
 - b. Anchor bolts, steel pipe sleeves, slotted-channel inserts, and wedge-type inserts indicated to be cast into concrete or built into unit masonry.
 - c. Steel weld plates and angles for casting into concrete for applications where they are not specified in other Sections.

C. Performance Requirements



1. Delegated Design: Design ladders and alternating tread devices, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance of Aluminum Ladders: Aluminum ladders, including landings, shall withstand the effects of loads and stresses within limits and under conditions specified in ANSI A14.3.
3. Structural Performance of Alternating Tread Devices: Alternating tread devices shall withstand the effects of loads and stresses within limits and under conditions specified in ICC's International Building Code.
4. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.
 - a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

D. Submittals

1. Product Data: For the following:
 - a. Nonslip aggregates and nonslip-aggregate surface finishes.
 - b. Prefabricated building columns.
 - c. Metal nosings and treads.
 - d. Paint products.
 - e. Grout.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: Indicating percentages by weight of postconsumer and preconsumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Show fabrication and installation details for metal fabrications.
 - a. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.
4. Samples: For each type and finish of extruded nosing and tread.
5. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
6. Qualification Data: For qualified professional engineer.
7. Mill Certificates: Signed by manufacturers of stainless-steel certifying that products furnished comply with requirements.
8. Welding certificates.
9. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.6, "Structural Welding Code - Stainless Steel."

F. Project Conditions

1. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

G. Coordination



1. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
2. Coordinate installation of anchorages and steel weld plates and angles for casting into concrete. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.2 PRODUCTS

A. Metals, General

1. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Ferrous Metals

1. Recycled Content of Steel Products: Provide products with average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
3. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666, Type 304 **OR** Type 316L, **as directed**.
4. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304 **OR** Type 316L, **as directed**.
5. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.
6. Rolled-Stainless-Steel Floor Plate: ASTM A 793.
7. Abrasive-Surface Floor Plate: Steel plate with abrasive granules rolled into surface or with abrasive material metallurgically bonded to steel.
8. Steel Tubing: ASTM A 500, cold-formed steel tubing.
9. Steel Pipe: ASTM A 53/A 53M, standard weight (Schedule 40) unless otherwise indicated.
10. Slotted Channel Framing: Cold-formed metal box channels (struts) complying with MFMA-4.
 - a. Size of Channels: 1-5/8 by 1-5/8 inches (41 by 41 mm) **OR** As indicated, **as directed**.
 - b. Material: Galvanized steel, ASTM A 653/A 653M, commercial steel, Type B **OR** structural steel, Grade 33 (Grade 230), **as directed**, with G90 (Z275) coating; 0.108-inch (2.8-mm) (12 gage) **OR** 0.079-inch (2-mm) (14 gage) **OR** 0.064-inch (1.6-mm) (16 gage), **as directed**, nominal thickness.
OR
Material: Cold-rolled steel, ASTM A 1008/A 1008M, commercial steel, Type B **OR** structural steel, Grade 33 (Grade 230), **as directed**; 0.0966-inch (2.5-mm) (12 gage) **OR** 0.0677-inch (1.7-mm) (14 gage) **OR** 0.0528-inch (1.35-mm) (16 gage), **as directed**, minimum thickness; unfinished **OR** coated with rust-inhibitive, baked-on, acrylic enamel **OR** hot-dip galvanized after fabrication, **as directed**.
11. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

C. Nonferrous Metals

1. Aluminum Plate and Sheet: ASTM B 209 (ASTM B 209M), Alloy 6061-T6.
2. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T6.
3. Aluminum-Alloy Rolled Tread Plate: ASTM B 632/B 632M, Alloy 6061-T6.
4. Aluminum Castings: ASTM B 26/B 26M, Alloy 443.0-F.
5. Bronze Plate, Sheet, Strip, and Bars: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal, 60 percent copper).
6. Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (extruded architectural bronze).
7. Bronze Castings: ASTM B 584, Alloy UNS No. C83600 (leaded red brass) or No. C84400 (leaded semired brass).



8. Nickel Silver Extrusions: ASTM B 151/B 151M, Alloy UNS No. C74500.
9. Nickel Silver Castings: ASTM B 584, Alloy UNS No. C97600 (20 percent leaded nickel bronze).

D. Fasteners

1. General: Unless otherwise indicated, provide Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
 - a. Provide stainless-steel fasteners for fastening aluminum.
 - b. Provide stainless-steel fasteners for fastening stainless steel.
 - c. Provide stainless-steel fasteners for fastening nickel silver.
 - d. Provide bronze fasteners for fastening bronze.
2. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with hex nuts, ASTM A 563 (ASTM A 563M); and, where indicated, flat washers.
3. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 325, Type 3 (ASTM A 325M, Type 3); with hex nuts, ASTM A 563, Grade C3 (ASTM A 563M, Class 8S3); and, where indicated, flat washers.
4. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F 593 (ASTM F 738M); with hex nuts, ASTM F 594 (ASTM F 836M); and, where indicated, flat washers; Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**.
5. Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563; and, where indicated, flat washers.
 - a. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.
6. Eyebolts: ASTM A 489.
7. Machine Screws: ASME B18.6.3 (ASME B18.6.7M).
8. Lag Screws: ASME B18.2.1 (ASME B18.2.3.8M).
9. Wood Screws: Flat head, ASME B18.6.1.
10. Plain Washers: Round, ASME B18.22.1 (ASME B18.22M).
11. Lock Washers: Helical, spring type, ASME B18.21.1 (ASME B18.21.2M).
12. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
13. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F 2329.
14. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
 - a. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
 - b. Material for Exterior Locations and Where Stainless Steel is Indicated: Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**, stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).
15. Slotted-Channel Inserts: Cold-formed, hot-dip galvanized-steel box channels (struts) complying with MFMA-4, 1-5/8 by 7/8 inches (41 by 22 mm) by length indicated with anchor straps or studs not less than 3 inches (75 mm) long at not more than 8 inches (200 mm) o.c. Provide with temporary filler and tee-head bolts, complete with washers and nuts, all zinc-plated to comply with ASTM B 633, Class Fe/Zn 5, as needed for fastening to inserts.

E. Miscellaneous Materials

1. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.



2. Shop Primers: Provide primers that comply with Division 07 OR Division 09 Section(s) "High-performance Coatings" **OR** Division 07 AND Division 09 Section(s) "High-performance Coatings", **as directed**.
3. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - a. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
4. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
5. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
6. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
7. Nonshrink, Metallic Grout: Factory-packaged, ferrous-aggregate grout complying with ASTM C 1107, specifically recommended by manufacturer for heavy-duty loading applications.
8. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.
9. Concrete: Comply with requirements in Division 03 Section "Cast-in-place Concrete" for normal-weight, air-entrained, concrete with a minimum 28-day compressive strength of 3000 psi (20 MPa).

F. Fabrication, General

1. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
2. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
3. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
4. Form exposed work with accurate angles and surfaces and straight edges.
5. Weld corners and seams continuously to comply with the following:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
6. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
7. Fabricate seams and other connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
8. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
9. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
 - a. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8 by 1-1/2 inches (3.2 by 38 mm), with a minimum 6-inch (150-mm) embedment and 2-inch (50-mm) hook, not less than 8 inches (200 mm) from ends and corners of units and 24 inches (600 mm) o.c., unless otherwise indicated.

G. Miscellaneous Framing And Supports

1. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.



2. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.
 - a. Fabricate units from slotted channel framing where indicated.
 - b. Furnish inserts for units installed after concrete is placed.
3. Fabricate supports for operable partitions from continuous steel beams of sizes indicated **OR** recommended by partition manufacturer, **as directed**, with attached bearing plates, anchors, and braces as indicated **OR** recommended by partition manufacturer, **as directed**. Drill or punch bottom flanges of beams to receive partition track hanger rods; locate holes where indicated on operable partition Shop Drawings.
4. Fabricate steel girders for wood frame construction from continuous steel shapes of sizes indicated.
 - a. Provide bearing plates welded to beams where indicated.
 - b. Drill or punch girders and plates for field-bolted connections where indicated.
 - c. Where wood nailers are attached to girders with bolts or lag screws, drill or punch holes at 24 inches (600 mm) o.c.
5. Fabricate steel pipe columns for supporting wood frame construction from steel pipe with steel baseplates and top plates as indicated. Drill or punch baseplates and top plates for anchor and connection bolts and weld to pipe with fillet welds all around. Make welds the same size as pipe wall thickness unless otherwise indicated.
 - a. Unless otherwise indicated, fabricate from Schedule 40 steel pipe.
 - b. Unless otherwise indicated, provide 1/2-inch (12.7-mm) baseplates with four 5/8-inch (16-mm) anchor bolts and 1/4-inch (6.4-mm) top plates.
6. Galvanize miscellaneous framing and supports where indicated.
OR
Prime miscellaneous framing and supports with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**, where indicated.

H. Prefabricated Building Columns

1. General: Provide prefabricated building columns consisting of load-bearing structural-steel members protected by concrete fireproofing encased in an outer non-load-bearing steel shell. Fabricate connections to comply with details shown or as needed to suit type of structure indicated.
2. Fire-Resistance Ratings: Provide prefabricated building columns listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction for ratings indicated, based on testing according to ASTM E 119.
 - a. Fire-Resistance Rating: 4 hours **OR** 3 hours **OR** 2 hours **OR** As indicated, **as directed**.

I. Shelf Angles

1. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch (19-mm) bolts, spaced not more than 6 inches (150 mm) from ends and 24 inches (600 mm) o.c., unless otherwise indicated.
 - a. Provide mitered and welded units at corners.
 - b. Provide open joints in shelf angles at expansion and control joints. Make open joint approximately 2 inches (50 mm) larger than expansion or control joint.
2. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete.
3. Galvanize shelf angles located in exterior walls.
OR
Prime shelf angles located in exterior walls with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
4. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

J. Metal Ladders



1. General:
 - a. Comply with ANSI A14.3 unless otherwise indicated.
 - b. For elevator pit ladders, comply with ASME A17.1.
 2. Steel Ladders:
 - a. Space siderails 16 inches (406 mm) **OR** 18 inches (457 mm), **as directed**, apart unless otherwise indicated.
 - b. Space siderails of elevator pit ladders 12 inches (300 mm) apart.
 - c. Siderails: Continuous, 3/8-by-2-1/2-inch (9.5-by-64-mm) **OR** 1/2-by-2-1/2-inch (12.7-by-64-mm), **as directed**, steel flat bars, with eased edges.
 - d. Rungs: 3/4-inch- (19-mm-) diameter **OR** 3/4-inch- (19-mm-) square **OR** 1-inch- (25-mm-) diameter **OR** 1-inch- (25-mm-) square, **as directed**, steel bars.
 - e. Fit rungs in centerline of siderails; plug-weld and grind smooth on outer rail faces.
 - f. Provide nonslip surfaces on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.
 - g. Provide nonslip surfaces on top of each rung by coating with abrasive material metallurgically bonded to rung.
 - h. Provide platforms as indicated fabricated from welded or pressure-locked steel bar grating, supported by steel angles. Limit openings in gratings to no more than 1/2 inch (12 mm) **OR** 3/4 inch (19 mm), **as directed**, in least dimension.
 - i. Support each ladder at top and bottom and not more than 60 inches (1500 mm) o.c. with welded or bolted steel brackets.
 - j. Galvanize ladders **OR** exterior ladders, **as directed**, including brackets and fasteners.
OR
Prime ladders **OR** exterior ladders, **as directed**, including brackets and fasteners, with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
 3. Aluminum Ladders:
 - a. Space siderails 16 inches (406 mm) **OR** 18 inches (457 mm), **as directed**, apart unless otherwise indicated.
 - b. Siderails: Continuous extruded-aluminum channels or tubes, not less than 2-1/2 inches (64 mm) deep, 3/4 inch (19 mm) wide, and 1/8 inch (3.2 mm) thick.
 - c. Rungs: Extruded-aluminum tubes, not less than 3/4 inch (19 mm) deep and not less than 1/8 inch (3.2 mm) thick, with ribbed tread surfaces.
 - d. Fit rungs in centerline of siderails; fasten by welding or with stainless-steel fasteners or brackets and aluminum rivets.
 - e. Provide platforms as indicated fabricated from pressure-locked aluminum bar grating or extruded-aluminum plank grating, supported by extruded-aluminum framing. Limit openings in gratings to no more than 1/2 inch (12 mm) **OR** 3/4 inch (19 mm), **as directed**, in least dimension.
 - f. Support each ladder at top and bottom and not more than 60 inches (1500 mm) o.c. with welded or bolted aluminum brackets.
 - g. Provide minimum 72-inch- (1830-mm-) high, hinged security door with padlock hasp at foot of ladder to prevent unauthorized ladder use.
- K. Ladder Safety Cages
1. General:
 - a. Fabricate ladder safety cages to comply with ANSI A14.3 **OR** OSHA regulations, **as directed**. Assemble by welding or with stainless-steel fasteners.
 - b. Provide primary hoops at tops and bottoms of cages and spaced not more than 20 feet (6 m) o.c. Provide secondary intermediate hoops spaced not more than 48 inches (1200 mm) o.c. between primary hoops.
 - c. Fasten assembled safety cage to ladder rails and adjacent construction by welding or with stainless-steel fasteners unless otherwise indicated.
 2. Steel Ladder Safety Cages:
 - a. Primary Hoops: 1/4-by-4-inch (6.4-by-100-mm) flat bar hoops.



- b. Secondary Intermediate Hoops: 1/4-by-2-inch (6.4-by-50-mm) flat bar hoops.
- c. Vertical Bars: 3/16-by-1-1/2-inch (4.8-by-38-mm) flat bars secured to each hoop.
- d. Galvanize ladder safety cages, including brackets and fasteners.

OR

Prime ladder safety cages, including brackets and fasteners, with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.

3. Aluminum Ladder Safety Cages:

- a. Primary Hoops: 1/4-by-4-inch (6.4-by-100-mm) flat bar hoops.
- b. Secondary Intermediate Hoops: 1/4-by-2-inch (6.4-by-50-mm) flat bar hoops.
- c. Vertical Bars: 1/4-by-2-inch (6.4-by-50-mm) flat bars secured to each hoop.

L. Alternating Tread Devices

- 1. Alternating Tread Devices: Fabricate alternating tread devices to comply with ICC's International Building Code. Fabricate of open-type construction with channel or plate stringers and pipe and tube railings unless otherwise indicated. Provide brackets and fittings for installation.
 - a. Fabricate from steel **OR** stainless steel **OR** aluminum, **as directed**, and assemble by welding or with stainless-steel fasteners.
 - b. Comply with applicable railing requirements in Division 05 Section "Pipe And Tube Railings".
- 2. Galvanize steel **OR** exterior steel, **as directed**, alternating tread devices, including treads, railings, brackets, and fasteners.

OR

Prime steel **OR** exterior steel, **as directed**, alternating tread devices, including treads, railings, brackets, and fasteners, with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.

M. Metal Ships' Ladders And Pipe Crossovers

- 1. Provide metal ships' ladders and pipe crossovers where indicated. Fabricate of open-type construction with channel or plate stringers and pipe and tube railings unless otherwise indicated. Provide brackets and fittings for installation.
 - a. Fabricate ships' ladders and pipe crossovers, including railings from steel **OR** stainless steel **OR** aluminum, **as directed**.
 - b. Fabricate treads **OR** treads and platforms, **as directed**, from welded or pressure-locked steel bar grating **OR** pressure-locked stainless-steel bar grating **OR** pressure-locked aluminum bar grating **OR** extruded-aluminum plank grating, **as directed**. Limit openings in gratings to no more than 1/2 inch (12 mm) **OR** 3/4 inch (19 mm), **as directed**, in least dimension.
 - c. Fabricate treads **OR** treads and platforms, **as directed**, from rolled-steel floor plate **OR** rolled-stainless-steel floor plate **OR** rolled-aluminum-alloy tread plate **OR** abrasive-surface floor plate, **as directed**.
 - d. Comply with applicable railing requirements in Division 5 Section "Pipe and Tube Railings."
- 2. Galvanize steel **OR** exterior steel, **as directed**, ships' ladders and pipe crossovers, including treads, railings, brackets, and fasteners.

OR

Prime steel **OR** exterior steel, **as directed**, ships' ladders and pipe crossovers, including treads, railings, brackets, and fasteners, with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.

N. Metal Floor Plate

- 1. Fabricate from rolled-steel floor **OR** rolled-stainless-steel floor **OR** rolled-aluminum-alloy tread **OR** abrasive-surface floor, **as directed**, plate of thickness indicated below:
 - a. Thickness: 1/8 inch (3.2 mm) **OR** 3/16 inch (4.8 mm) **OR** 1/4 inch (6.4 mm) **OR** 5/16 inch (8 mm) **OR** 3/8 inch (9.5 mm) **OR** As indicated, **as directed**.
- 2. Provide grating sections where indicated fabricated from welded or pressure-locked steel bar grating **OR** pressure-locked stainless steel bar grating **OR** pressure-locked aluminum bar grating



- OR** extruded-aluminum plank grating, **as directed**. Limit openings in gratings to no more than 1/2 inch (12 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, in least dimension.
3. Provide steel **OR** stainless-steel **OR** aluminum, **as directed**, angle supports as indicated.
 4. Include steel **OR** stainless-steel **OR** aluminum, **as directed**, angle stiffeners, and fixed and removable sections as indicated.
 5. Provide flush steel **OR** stainless-steel **OR** aluminum, **as directed**, bar drop handles for lifting removable sections, one at each end of each section.
- O. Structural-Steel Door Frames
1. Fabricate structural-steel door frames from steel shapes, plates, and bars of size and to dimensions indicated, fully welded together, with 5/8-by-1-1/2-inch (16-by-38-mm) steel channel stops, unless otherwise indicated. Plug-weld built-up members and continuously weld exposed joints. Secure removable stops to frame with countersunk machine screws, uniformly spaced at not more than 10 inches (250 mm) o.c. Reinforce frames and drill and tap as necessary to accept finish hardware.
 - a. Provide with integrally welded steel strap anchors for securing door frames into adjoining concrete or masonry.
 2. Extend bottom of frames to floor elevation indicated with steel angle clips welded to frames for anchoring frame to floor with expansion shields and bolts.
 3. Galvanize steel **OR** exterior steel, **as directed**, frames.
OR
Prime steel **OR** exterior steel, **as directed**, frames with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
- P. Miscellaneous Steel Trim
1. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.
 2. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.
 - a. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.
 3. Galvanize miscellaneous steel **OR** exterior miscellaneous steel, **as directed**, trim.
OR
Prime miscellaneous steel **OR** exterior miscellaneous steel, **as directed**, trim with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
- Q. Metal Bollards
1. Fabricate metal bollards from Schedule 40 steel pipe **OR** Schedule 80 steel pipe **OR** 1/4-inch (6.4-mm) wall-thickness rectangular steel tubing **OR** steel shapes, as indicated, **as directed**.
 - a. Cap bollards with 1/4-inch- (6.4-mm-) thick steel plate (not required if bollards are concrete filled).
 - b. Where bollards are indicated to receive controls for door operators, provide necessary cutouts for controls and holes for wire.
 - c. Where bollards are indicated to receive light fixtures, provide necessary cutouts for fixtures and holes for wire.
 2. Fabricate bollards with 3/8-inch- (9.5-mm-) thick steel baseplates for bolting to concrete slab (for mounting bollards on structural slab or on existing pavement). Drill baseplates at all four corners for 3/4-inch (19-mm) anchor bolts.
 - a. Where bollards are to be anchored to sloping concrete slabs, angle baseplates for plumb alignment of bollards.
 3. Fabricate sleeves for bollard anchorage from steel pipe or tubing with 1/4-inch- (6.4-mm-) thick steel plate welded to bottom of sleeve. Make sleeves not less than 8 inches (200 mm) deep and 3/4 inch (19 mm) larger than OD of bollard.



4. Fabricate internal sleeves for removable bollards from Schedule 40 steel pipe or 1/4-inch (6.4-mm) wall-thickness steel tubing with an OD approximately 1/16 inch (1.5 mm) less than ID of bollards. Match drill sleeve and bollard for 3/4 inch (19 mm) steel machine bolt.
 5. Prime bollards with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
- R. Pipe Or Downspout Guards
1. Fabricate pipe **OR** downspout, **as directed**, guards from 3/8-inch- (9.5-mm-) thick by 12-inch- (300-mm-) wide steel plate, bent to fit flat against the wall or column at both ends and to fit around pipe with 2-inch (50-mm) clearance between pipe and pipe guard. Drill each end for two 3/4-inch (19-mm) anchor bolts.
 2. Galvanize pipe **OR** downspout, **as directed**, guards.
OR
Prime pipe **OR** downspout, **as directed**, guards with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
- S. Abrasive Metal Nosings, Treads And Thresholds
1. Cast-Metal Units: Cast iron **OR** aluminum **OR** bronze (leaded red or semired brass) **OR** nickel silver (leaded nickel bronze), **as directed**, with an integral-abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - a. Nosings: Cross-hatched units, 4 inches (100 mm) wide with 1/4-inch (6-mm) **OR** 1-inch (25-mm), **as directed**, lip, for casting into concrete steps.
OR
Nosings: Cross-hatched units, 1-1/2 by 1-1/2 inches (38 by 38 mm), for casting into concrete curbs.
 - b. Treads: Cross-hatched units, full depth of tread with 3/4-by-3/4-inch (19-by-19-mm) nosing, for application over bent plate treads or existing stairs.
 - c. Thresholds: Fluted-saddle-type units, 5 inches (125 mm) wide by 1/2 inch (12 mm) high, with tapered edges.
OR
Thresholds: Fluted-interlocking- (hook-strip-) type units, 5 inches (125 mm) wide by 5/8 inch (16 mm) high, with tapered edge.
OR
Thresholds: Plain-stepped- (stop-) type units, 5 inches (125 mm) wide by 1/2 inch (12 mm) high, with 1/2-inch (12-mm) step.
 2. Extruded Units: Aluminum **OR** Bronze, **as directed**, with abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - a. Provide ribbed units, with abrasive filler strips projecting 1/16 inch (1.5 mm) above aluminum extrusion.
OR
Provide solid-abrasive-type units without ribs.
 - b. Nosings: Square-back units, 1-7/8 inches (48 mm) **OR** 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, wide, for casting into concrete steps.
OR
Nosings: Beveled-back units, 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, wide with 1-3/8-inch (35-mm) lip, for surface mounting on existing stairs.
OR
Nosings: Two-piece units, 3 inches (75 mm) wide, with subchannel for casting into concrete steps.
 - c. Treads: Square **OR** Beveled, **as directed**, -back units, full depth of tread with 1-3/8-inch (35-mm) lip, for application over existing stairs.
 3. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.



4. Drill for mechanical anchors and countersink. Locate holes not more than 4 inches (100 mm) from ends and not more than 12 inches (300 mm) o.c., evenly spaced between ends, unless otherwise indicated. Provide closer spacing if recommended by manufacturer.
 - a. Provide two rows of holes for units more than 5 inches (125 mm) wide, with two holes aligned at ends and intermediate holes staggered.
 5. Apply bituminous paint to concealed surfaces of cast-metal units.
 6. Apply clear lacquer to concealed surfaces of extruded units.
- T. Cast-Iron Wheel Guards
1. Provide wheel guards made from cast iron, 3/4 inch (19 mm) thick, hollow-core construction, of size and shape indicated. Provide holes for countersunk anchor bolts and grouting.
 2. Prime cast iron wheel guards with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
- U. Metal Downspout Boots
1. Provide downspout boots made from cast iron **OR** cast aluminum, **as directed**, in heights indicated with inlets of size and shape to suit downspouts. Provide units with flanges and holes for countersunk anchor bolts.
 - a. Outlet: Vertical, to discharge into pipe **OR** Horizontal, to discharge into pipe **OR** At 35 degrees from horizontal, to discharge onto splash block or pavement, **as directed**.
 2. Prime cast iron downspout boots with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
- V. Loose Bearing And Leveling Plates
1. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.
 2. Galvanize plates.
OR
Prime plates with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
- W. Loose Steel Lintels
1. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Fabricate in single lengths for each opening unless otherwise indicated. Weld adjoining members together to form a single unit where indicated.
 2. Size loose lintels to provide bearing length at each side of openings equal to 1/12 of clear span but not less than 8 inches (200 mm) unless otherwise indicated.
 3. Galvanize loose steel lintels located in exterior walls.
 4. Prime loose steel lintels located in exterior walls with zinc-rich primer **OR** primer specified in Division 09 Section "High-performance Coatings", **as directed**.
- X. Steel Weld Plates And Angles
1. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.
- Y. Finishes, General
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 2. Finish metal fabrications after assembly.
 3. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.
- Z. Steel And Iron Finishes



1. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.
 - a. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
2. Shop prime iron and steel items not indicated to be galvanized, **as directed**, unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.
 - a. Shop prime with universal shop primer **OR** primers specified in Division 07, **as directed**, unless zinc-rich primer is **OR** primers specified in Division 09 Section "High-performance Coatings" are, **as directed**, indicated.
3. Preparation for Shop Priming: Prepare surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" **OR** SSPC-SP 3, "Power Tool Cleaning" **OR** requirements indicated below, **as directed**:
 - a. Exterior Items: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - c. Items Indicated to Receive Primers Specified in Division 9 Section "High-Performance Coatings": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - d. Other Items: SSPC-SP 3, "Power Tool Cleaning."
4. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
 - a. Stripe paint corners, crevices, bolts, welds, and sharp edges.

AA. Aluminum Finishes

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. As-Fabricated Finish: AA-M10 (Mechanical Finish: as fabricated, unspecified).
3. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

1.3 EXECUTION

A. Installation, General

1. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
2. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
3. Field Welding: Comply with the following requirements:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
4. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
5. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.



6. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:
 - a. Cast Aluminum: Heavy coat of bituminous paint.
 - b. Extruded Aluminum: Two coats of clear lacquer.

- B. Installing Miscellaneous Framing And Supports
 1. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.
 2. Anchor supports for operable partitions securely to and rigidly brace from building structure.
 3. Support steel girders on solid grouted masonry, concrete, or steel pipe columns. Secure girders with anchor bolts embedded in grouted masonry or concrete or with bolts through top plates of pipe columns.
 - a. Where grout space under bearing plates is indicated for girders supported on concrete or masonry, install as specified in "Installing Bearing and Leveling Plates" Article.
 4. Install pipe columns on concrete footings with grouted baseplates. Position and grout column baseplates as specified in "Installing Bearing and Leveling Plates" Article.
 - a. Grout baseplates of columns supporting steel girders after girders are installed and leveled.

- C. Installing Prefabricated Building Columns
 1. Install prefabricated building columns to comply with AISC's "Specification for Structural Steel Buildings" and with requirements applicable to listing and labeling for fire-resistance rating indicated.

- D. Installing Metal Bollards
 1. Fill metal-capped bollards solidly with concrete and allow concrete to cure seven days before installing.
 - a. Do not fill removable bollards with concrete.
 2. Anchor bollards to existing construction with expansion anchors **OR** anchor bolts **OR** through bolts, **as directed**. Provide four 3/4-inch (19-mm) bolts at each bollard unless otherwise indicated.
 - a. Embed anchor bolts at least 4 inches (100 mm) in concrete.
 3. Anchor bollards in concrete with pipe sleeves preset and anchored into concrete **OR** in formed or core-drilled holes not less than 8 inches (200 mm) deep and 3/4 inch (19 mm) larger than OD of bollard, **as directed**. Fill annular space around bollard solidly with nonshrink, nonmetallic grout; mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/8 inch (3 mm) toward bollard.
 4. Anchor bollards in place with concrete footings. Center and align bollards in holes 3 inches (75 mm) above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.
 5. Anchor internal sleeves for removable bollards in concrete by inserting into pipe sleeves preset into concrete **OR** formed or core-drilled holes not less than 8 inches (200 mm) deep and 3/4 inch (19 mm) larger than OD of sleeve, **as directed**. Fill annular space around internal sleeves solidly with nonshrink, nonmetallic grout; mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/8 inch (3 mm) toward internal sleeve.
 6. Anchor internal sleeves for removable bollards in place with concrete footings. Center and align sleeves in holes 3 inches (75 mm) above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace sleeves in position until concrete has cured.
 7. Place removable bollards over internal sleeves and secure with 3/4-inch (19-mm) machine bolts and nuts. After tightening nuts, drill holes in bolts for inserting padlocks. the Owner will furnish padlocks.
 8. Fill bollards solidly with concrete, mounding top surface to shed water.
 - a. Do not fill removable bollards with concrete.

- E. Installing Pipe Guards



1. Provide pipe guards at exposed vertical pipes in parking garage where not protected by curbs or other barriers. Install by bolting to wall or column with expansion anchors. Provide four 3/4-inch (19-mm) bolts at each pipe guard. Mount pipe guards with top edge 26 inches (660 mm) above driving surface.
- F. Installing Nosings, Treads, And Thresholds
1. Center nosings on tread widths unless otherwise indicated.
 2. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.
 3. Seal thresholds exposed to exterior with elastomeric sealant complying with Division 07 Section "Joint Sealants" to provide a watertight installation.
- G. Installing Cast-Iron Wheel Guards
1. Anchor wheel guards to concrete or masonry construction to comply with manufacturer's written instructions. Fill cores solidly with concrete.
- H. Installing Bearing And Leveling Plates
1. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of plates.
 2. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.
 - a. Use nonshrink grout, either metallic or nonmetallic, in concealed locations where not exposed to moisture; use nonshrink, nonmetallic grout in exposed locations unless otherwise indicated.
 - b. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.
- I. Adjusting And Cleaning
1. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.

OR

Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 07.
 2. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

END OF SECTION 05 50 00 00



SECTION 05 51 13 00 - METAL STAIRS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for metal stairs. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Preassembled steel stairs with concrete-filled, precast concrete, epoxy-resin-filled, and abrasive-coating-finished formed-metal treads.
 - b. Industrial-type stairs with steel floor plate and grating treads.
 - c. Ornamental steel-framed stairs.
 - d. Railings and Steel tube railings attached to metal stairs.
 - e. Handrails and Steel tube handrails attached to walls adjacent to metal stairs.
 - f. Railing gates at the level of exit discharge.

C. Performance Requirements

1. Delegated Design: Design metal stairs, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance of Stairs: Metal stairs shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.
 - a. The following are based on the 2006 International Building Code (IBC):
 - 1) Uniform Load: 100 lbf/sq. ft. (4.79 kN/sq. m).
 - 2) Concentrated Load: 300 lbf (1.33 kN) applied on an area of 4 sq. in. (2580 sq. mm).
 - 3) Uniform and concentrated loads need not be assumed to act concurrently.
 - b. Stair Framing: Capable of withstanding stresses resulting from railing loads in addition to loads specified above, **as applicable**.
 - c. Limit deflection of treads, platforms, and framing members to L/240 **OR** L/360, **as directed**, or 1/4 inch (6.4 mm), whichever is less. Preassembled steel stair manufacturers usually design stairs to L/240; retaining L/360 will decrease bounce and may be required to prevent cracking of plaster or gypsum board soffits. If brittle materials such as marble, granite, or ceramic tiles are used on treads and platforms, deflection limit should be reduced to L/720.
3. Structural Performance of Railings: Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated. The following loads are based on the 2006 IBC.
 - a. Handrails and Top Rails of Guards:
 - 1) Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
 - 2) Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - 3) Uniform and concentrated loads need not be assumed to act concurrently.
 - b. Infill of Guards:
 - 1) Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - 2) Infill load and other loads need not be assumed to act concurrently.
4. Seismic Performance: Metal stairs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. Component Importance Factor is 1.5.

D. Submittals

1. Product Data: For metal stairs and the following:



- a. Prefilled metal-pan stair treads.
 - b. Precast concrete treads.
 - c. Epoxy-resin-filled stair treads.
 - d. Nonslip aggregates and nonslip-aggregate finishes.
 - e. Abrasive nosings.
 - f. Metal floor plate treads.
 - g. Paint products.
 - h. Grout.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: Indicating percentages by weight of postconsumer and preconsumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
 3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 4. Samples: For the following products, in manufacturer's standard sizes:
 - a. Precast concrete treads.
 - b. Epoxy-resin-filled stair treads.
 - c. Stair treads with nonslip-aggregate surface finish.
 - d. Metal floor plate treads.
 - e. Grating treads.
 - f. Abrasive nosings.
 5. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 6. Qualification Data: For qualified professional engineer **OR** testing agency, **as directed**.
 7. Welding certificates.
 8. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.
 9. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for stairs and railings.
 - a. Test railings according ASTM E 894 and ASTM E 935.
- E. Quality Assurance
1. Installer Qualifications: Fabricator of products.
 2. NAAMM Stair Standard: Comply with "Recommended Voluntary Minimum Standards for Fixed Metal Stairs" in NAAMM AMP 510, "Metal Stairs Manual," for class of stair designated, unless more stringent requirements are indicated.
 - a. Preassembled Stairs:
 - 1) Commercial class - typical enclosed stair (welds are required to be smooth).
 - 2) Service class - economy enclosed stair.
 - b. Industrial-Type Stairs: Industrial class - typical for exposed locations in industrial facilities or for exterior stairs.
 - c. Ornamental Stairs: Architectural class - ornamental stairs in exposed locations (joints are required to be concealed to maximum extent possible).
 3. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 4. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.3, "Structural Welding Code - Sheet Steel."
- F. Coordination
1. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
 2. Coordinate installation of anchorages for metal stairs. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items



with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

3. Coordinate locations of hanger rods and struts with other work so that they will not encroach on required stair width and will be within the fire-resistance-rated stair enclosure.

1.2 PRODUCTS

A. Metals, General

1. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Ferrous Metals

1. Recycled Content of Steel Products: Provide products with average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
3. Steel Tubing: ASTM A 500 (cold formed) **OR** ASTM A 513, **as directed**.
4. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.
5. Abrasive-Surface Floor Plate: Steel plate with abrasive granules rolled into surface or with abrasive material metallurgically bonded to steel.
6. Steel Bars for Grating Treads: ASTM A 36/A 36M or steel strip, ASTM A 1011/A 1011M or ASTM A 1018/A 1018M.
7. Wire Rod for Grating Crossbars: ASTM A 510 (ASTM A 510M).
8. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.
9. Uncoated, Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, either commercial steel, Type B, or structural steel, Grade 25 (Grade 170), unless another grade is required by design loads; exposed.
10. Uncoated, Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, either commercial steel, Type B, or structural steel, Grade 30 (Grade 205), unless another grade is required by design loads.
11. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating, either commercial steel, Type B, or structural steel, Grade 33 (Grade 230), unless another grade is required by design loads.
12. Expanded-Metal, Carbon Steel: ASTM F 1267, Type I (expanded) **OR** Type II (expanded and flattened), **as directed**, Class 1 (uncoated).
 - a. Style Designation: 3/4 number 13 **OR** 1-1/2 number 10, **as directed**.
13. Perforated Metal: Cold-rolled steel sheet, ASTM A 1008/A 1008M, or hot-rolled steel sheet, ASTM A 1011/A 1011M, commercial steel Type B, 0.060 inch (1.52 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows **OR** with 1/8-by-1-inch (3.2-by-25.4-mm) round end slotted holes in staggered rows, **as directed**.
14. Perforated Metal: Galvanized-steel sheet, ASTM A 653/A 653M, G90 (Z275) coating, commercial steel Type B, 0.064 inch (1.63 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.
15. Woven-Wire Mesh: Intermediate-crimp, diamond **OR** square, **as directed**, pattern, 2-inch (50-mm) woven-wire mesh, made from 0.135-inch (3.5-mm) nominal diameter wire complying with ASTM A 510 (ASTM A 510M).

C. Nonferrous Metals

1. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T6.
2. Aluminum Castings: ASTM B 26/B 26M, Alloy 443.0-F.
3. Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (extruded architectural bronze).
4. Bronze Castings: ASTM B 584, Alloy UNS No. C83600 (leaded red brass) or No. C84400 (leaded semired brass).



5. Nickel Silver Castings: ASTM B 584, Alloy UNS No. C97600 (20 percent leaded nickel bronze).

D. Abrasive Nosings

1. Cast-Metal Units: Cast iron **OR** aluminum **OR** bronze **OR** nickel silver, **as directed**, with an integral abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - a. Configuration: Cross-hatched units, 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, wide without lip.

OR

 Configuration: Cross-hatched angle-shaped units, same depth as bar-grating treads and 1 to 1-1/2 inches (25 to 38 mm) wide.
2. Extruded Units: Aluminum **OR** Bronze, **as directed**, units with abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - a. Provide ribbed units, with abrasive filler strips projecting 1/16 inch (1.5 mm) above aluminum extrusion.

OR

 Provide solid-abrasive-type units without ribs.
 - b. Nosings: Square-back units, 1-7/8 inches (48 mm) **OR** 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, wide, without lip.

OR

 Nosings: Two-piece units, 3 inches (75 mm) wide, with subchannel for casting into concrete.
3. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.
4. Apply bituminous paint to concealed surfaces of cast-metal units set into concrete.
5. Apply clear lacquer to concealed surfaces of extruded units set into concrete.

E. Fasteners

1. General: Provide zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 12 for exterior use, and Class Fe/Zn 5 where built into exterior walls. Select fasteners for type, grade, and class required.
2. Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with hex nuts, ASTM A 563 (ASTM A 563M); and, where indicated, flat washers.
3. Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563 (ASTM A 563M); and, where indicated, flat washers.
 - a. Provide mechanically deposited or hot-dip, zinc-coated anchor bolts for exterior stairs **OR** stairs indicated to be galvanized **OR** stairs indicated to be shop primed with zinc-rich primer, **as directed**.
4. Machine Screws: ASME B18.6.3 (ASME B18.6.7M).
5. Lag Screws: ASME B18.2.1 (ASME B18.2.3.8M).
6. Plain Washers: Round, ASME B18.22.1 (ASME B18.22M).
7. Lock Washers: Helical, spring type, ASME B18.21.1 (ASME B18.21.2M).
8. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
 - a. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
 - b. Material for Exterior Locations and Where Stainless Steel is Indicated: Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**, stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

F. Miscellaneous Materials



1. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 2. Shop Primers: Provide primers that comply with Division 07 OR Division 09 Section(s) "High-performance Coatings" **OR** Division 07 AND Division 09 Section(s) "High-performance Coatings", **as directed**.
 3. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - a. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
 4. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
 5. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
 6. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
 7. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.
 8. Concrete Materials and Properties: Comply with requirements in Division 3 Section "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mix concrete with a minimum 28-day compressive strength of 3000 psi (20 MPa) unless otherwise indicated.
 9. Nonslip-Aggregate Concrete Finish: Factory-packaged abrasive aggregate made from fused, aluminum-oxide grits or crushed emery; rustproof and nonglazing; unaffected by freezing, moisture, or cleaning materials.
 10. Welded Wire Fabric: ASTM A 185/A 185M, 6 by 6 inches (152 by 152 mm), W1.4 by W1.4, unless otherwise indicated.
- G. Precast Concrete Treads
1. Concrete Materials and Properties: Comply with requirements in Division 03 Section "Cast-in-place Concrete" for normal-weight, ready-mixed concrete with a minimum 28-day compressive strength of 5000 psi (35 MPa) and a total air content of not less than 4 percent or more than 6 percent.
 2. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2 by 2 inches (50 by 50 mm) by 0.062-inch- (1.6-mm-) diameter wire; comply with ASTM A 185/A 185M and ASTM A 82/A 82M, except for minimum wire size.
- H. Fabrication, General
1. Provide complete stair assemblies, including metal framing, hangers, struts, railings, **as directed**, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
 - a. Join components by welding unless otherwise indicated.
 - b. Use connections that maintain structural value of joined pieces.
 - c. Fabricate treads and platforms of exterior stairs so finished walking surfaces slope to drain.
 2. Preassembled Stairs: Assemble stairs in shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
 3. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
 4. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
 5. Form exposed work with accurate angles and surfaces and straight edges.
 6. Weld connections to comply with the following:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. Weld exposed corners and seams continuously unless otherwise indicated.



- e. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 1 welds: no evidence of a welded joint **OR** Type 2 welds: completely sanded joint, some undercutting and pinholes okay **OR** Type 3 welds: partially dressed weld with spatter removed **OR** Type 4 welds: good quality, uniform undressed weld with minimal splatter, **as directed**.
7. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts unless otherwise indicated. Locate joints where least conspicuous.
8. Fabricate joints that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- I. Steel-Framed Stairs
1. Stair Framing:
- a. Fabricate stringers of steel plates **OR** channels **OR** tubes, **as directed**.
 1) Provide closures for exposed ends of channel **OR** tube, **as directed**, stringers.
- b. Construct platforms of steel plate **OR** channel **OR** tube, **as directed**, headers and miscellaneous framing members as needed to comply with performance requirements **OR** indicated, **as directed**.
- c. Weld or bolt, **as directed**, stringers to headers; weld or bolt, **as directed**, framing members to stringers and headers. If using bolts, fabricate and join so bolts are not exposed on finished surfaces.
- d. Where stairs are enclosed by gypsum board **OR** gypsum board shaft-wall, **as directed**, assemblies, provide hanger rods or struts to support landings from floor construction above or below. Locate hanger rods and struts where they will not encroach on required stair width and will be within the fire-resistance-rated stair enclosure.
- e. Where masonry walls support metal stairs, provide temporary supporting struts designed for erecting steel stair components before installing masonry.
2. Metal-Pan Stairs: Form risers, subreads pans, and subplatforms to configurations shown from steel sheet of thickness needed to comply with performance requirements but not less than 0.067 inch (1.7 mm) **OR** indicated, **as directed**.
- a. Steel Sheet: Uncoated cold **OR** hot, **as directed**,-rolled steel sheet unless otherwise indicated.
OR
 Steel Sheet: Galvanized-steel sheet, where indicated.
- b. Directly weld metal pans to stringers; locate welds on top of subreads where they will be concealed by concrete fill. Do not weld risers to stringers.
OR
 Attach risers and subreads to stringers with brackets made of steel angles or bars. Weld brackets to stringers and attach metal pans to brackets by welding, riveting, or bolting.
- c. Shape metal pans to include nosing integral with riser.
- d. Attach abrasive nosings to risers.
- e. At Contractor's option, provide stair assemblies with metal-pan subreads filled with reinforced concrete during fabrication.
- f. Provide epoxy-resin-filled treads, reinforced with glass fibers, with slip-resistant, abrasive surface.
- g. Provide subplatforms of configuration indicated or, if not indicated, the same as subreads. Weld subplatforms to platform framing.
 1) Smooth Soffit Construction: Construct subplatforms with flat metal under surfaces to produce smooth soffits.
3. Abrasive-Coating-Finished, Formed-Metal Stairs: Form risers, treads, and platforms to configurations shown from steel sheet of thickness needed to comply with performance requirements but not less than 0.097 inch (2.5 mm) **OR** indicated, **as directed**.
- a. Steel Sheet: Uncoated hot-rolled steel sheet unless otherwise indicated.
- b. Directly weld risers and treads to stringers; locate welds on underside of stairs.



- c. Provide platforms of configuration indicated or, if not indicated, the same as treads. Weld platforms to platform framing.
 - d. Finish tread and platform surfaces with manufacturer's standard epoxy-bonded abrasive finish.
 4. Metal Floor Plate Stairs: Form treads and platforms to configurations shown from rolled-steel **OR** abrasive-surface, **as directed**, floor plate of thickness needed to comply with performance requirements, but not less than 1/4 inch (6.4 mm) **OR** needed to comply with performance requirements, but not less than 3/16 inch (4.8 mm) **OR** needed to comply with performance requirements, but not less than 1/8 inch (3.2 mm) **OR** indicated, **as directed**.
 - a. Form treads with integral nosing and back edge stiffener. Form risers of same material as treads.
OR
Form treads with integral nosing and back edge stiffener. Form risers from steel sheet not less than 0.097 inch (2.5 mm) thick, welded to tread nosings and stiffeners and to platforms.
OR
Form treads with integral nosing and back edge stiffener, and with open risers.
 - b. Weld steel supporting brackets to stringers and weld treads to brackets.
 - c. Fabricate platforms with integral nosings matching treads and weld to platform framing.
 5. Metal Bar-Grating Stairs: Form treads and platforms to configurations shown from metal bar grating; fabricate to comply with NAAMM MBG 531, "Metal Bar Grating Manual."
 - a. Fabricate treads and platforms from welded or pressure-locked steel grating with 1-1/4-by-3/16-inch (32-by-5-mm) bearing bars at 15/16 inch (24 mm) o.c. **OR** 1-by-3/16-inch (25-by-5-mm) bearing bars at 11/16 inch (17 mm) o.c. **OR** 1-by-1/8-inch (25-by-3-mm) bearing bars at 7/16 inch (11 mm) o.c., **as directed**, and crossbars at 4 inches (100 mm) o.c.
OR
Fabricate treads and platforms from welded or pressure-locked steel grating with openings in gratings no more than 5/16 inch (8 mm) **OR** 1/2 inch (12 mm) **OR** 3/4 inch (19 mm), **as directed**, in least dimension.
 - b. Surface: Plain **OR** Serrated, **as directed**.
 - c. Finish: Shop primed **OR** Painted **OR** Galvanized, **as directed**.
 - d. Fabricate grating treads with rolled-steel floor plate **OR** cast abrasive, **as directed**, nosing and with steel angle or steel plate carrier at each end for stringer connections. Secure treads to stringers with bolts.
 - e. Fabricate grating platforms with nosing matching that on grating treads. Provide toeplates at open-sided edges of grating platforms. Weld grating to platform framing.
- J. Stair Railings
 1. Comply with applicable requirements in Division 05 Section(s) "Pipe And Tube Railings" **OR** "Decorative Metal Railings", **as directed**.
 - a. Fabricate newels of square steel tubing and provide newel caps of pressed steel **OR** gray-iron castings, **as directed**, as shown.
 - b. Rails may be bent at corners, rail returns, and wall returns, instead of using prefabricated fittings.
 - c. Connect posts to stair framing by direct welding unless otherwise indicated.
 2. Steel Tube Railings: Fabricate railings to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of tube, post spacings, and anchorage, but not less than that needed to withstand indicated loads.
 - a. Rails and Posts: 1-5/8-inch- (41-mm-) diameter **OR** 1-1/2-inch- (38-mm-) square, **as directed**, top and bottom rails and 1-1/2-inch- (38-mm-) square posts.
 - b. Picket Infill: 1/2-inch- (13-mm-) square pickets spaced less than 4 inches (100 mm) clear.
 - c. Expanded-Metal Infill: Expanded-metal panels edged with U-shaped channels made from steel sheet not less than 0.043 inch (1.1 mm) thick. Orient expanded metal with long dimension of diamonds parallel to top rail **OR** perpendicular to top rail **OR** vertical, **as directed**.



- d. Perforated-Metal Infill: Perforated-metal panels edged with U-shaped channels made from metal sheet, of same metal as perforated metal and not less than 0.043 inch (1.1 mm) thick. Orient perforated metal with pattern parallel to top rail **OR** perpendicular to top rail **OR** horizontal **OR** vertical **OR** as indicated on Drawings, **as directed**.
 - e. Mesh Infill: Woven wire mesh crimped into 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) steel channel frames. Orient wire mesh with diamonds vertical **OR** wires perpendicular and parallel to top rail **OR** wires horizontal and vertical, **as directed**.
 - f. Intermediate Rails Infill: 1-5/8-inch- (41-mm-) diameter **OR** 1-1/2-inch- (38-mm-) square, **as directed**, intermediate rails spaced less than 12 inches (305 mm) **OR** 21 inches (533 mm), **as directed**, clear.
 - g. Gates: Form gates from steel tube of same size and shape as top rails, with infill to match guards. Provide with cam-type, self-closing **OR** spring, **as directed**, hinges for fastening to wall and overlapping stop with rubber bumper to prevent gate from opening in direction opposite egress.
3. Welded Connections: Fabricate railings with welded connections. Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - a. Finish welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 1 welds: no evidence of a welded joint **OR** Type 2 welds: completely sanded joint, some undercutting and pinholes okay **OR** Type 3 welds: partially dressed weld with spatter removed **OR** Type 4 welds: good quality, uniform undressed weld with minimal splatter, **as directed**.
 4. Form changes in direction of railings as follows:
 - a. As detailed.
OR
By bending or by inserting prefabricated elbow fittings.
OR
By flush bends or by inserting prefabricated flush-elbow fittings.
OR
By radius bends of radius indicated or by inserting prefabricated elbow fittings of radius indicated.
OR
By inserting prefabricated elbow fittings **OR** flush-elbow fittings **OR** elbow fittings of radius indicated, **as directed**.
 5. Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
 6. Close exposed ends of railing members with prefabricated end fittings.
 7. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
 8. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, end closures, flanges, miscellaneous fittings, and anchors for interconnecting components and for attaching to other work. Furnish inserts and other anchorage devices for connecting to concrete or masonry work.
 - a. Connect posts to stair framing by direct welding unless otherwise indicated.
 - b. For galvanized railings, provide galvanized fittings, brackets, fasteners, sleeves, and other ferrous-metal components.
 - c. For nongalvanized railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors embedded in exterior masonry and concrete construction.
 9. Fillers: Provide fillers made from steel plate, or other suitably crush-resistant material, where needed to transfer wall bracket loads through wall finishes to structural supports. Size fillers to suit wall finish thicknesses and to produce adequate bearing area to prevent bracket rotation and overstressing of substrate.

K. Finishes



1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Finish metal stairs after assembly.
3. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.
 - a. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
 - b. Fill vent and drain holes that will be exposed in finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
4. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" **OR** SSPC-SP 3, "Power Tool Cleaning" **OR** minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed products, **as directed**:
 - a. Exterior Stairs: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Interior Stairs: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" for stairs that are to receive zinc-rich primer or primer specified in Division 09 Section "High-performance Coatings".
OR
Interior Stairs: SSPC-SP 3, "Power Tool Cleaning."
5. Apply shop primer to uncoated surfaces of metal stair components, except those with galvanized finishes and those to be embedded in concrete or masonry unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
 - a. Stripe paint corners, crevices, bolts, welds, and sharp edges.

1.3 EXECUTION

A. Installation, General

1. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.
2. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.
3. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete unless otherwise indicated.
4. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
5. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
6. Field Welding: Comply with requirements for welding in "Fabrication, General" Article.
7. Place and finish concrete fill for treads and platforms to comply with Division 03 Section "Cast-in-place Concrete"
 - a. Install abrasive nosings with anchors fully embedded in concrete. Center nosings on tread width.
8. Install precast concrete treads with adhesive supplied by manufacturer.

B. Installing Metal Stairs With Grouted Baseplates

1. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of baseplates.
2. Set steel stair baseplates on wedges, shims, or leveling nuts. After stairs have been positioned and aligned, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.



- a. Use nonmetallic, nonshrink grout unless otherwise indicated.
- b. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

C. Installing Railings

1. Adjust railing systems before anchoring to ensure matching alignment at abutting joints. Space posts at spacing indicated or, if not indicated, as required by design loads. Plumb posts in each direction. Secure posts and rail ends to building construction as follows:
 - a. Anchor posts to steel by welding directly to steel supporting members.
 - b. Anchor handrail ends to concrete and masonry with steel round flanges welded to rail ends and anchored with postinstalled anchors and bolts.
2. Attach handrails to wall with wall brackets. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt **OR** with predrilled hole for exposed bolt anchorage, **as directed**. Provide bracket with 1-1/2-inch (38-mm) clearance from inside face of handrail and finished wall surface. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads. Secure wall brackets to building construction as required to comply with performance requirements **OR** as follows, **as directed**:
 - a. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
 - b. For hollow masonry anchorage, use toggle bolts.
 - c. For wood stud partitions, use hanger or lag bolts set into studs or wood backing between studs. Coordinate with carpentry work to locate backing members.
 - d. For steel-framed partitions, use hanger or lag bolts set into fire-retardant-treated, **as directed**, wood backing between studs. Coordinate with stud installation to locate backing members.

OR

For steel-framed partitions, use self-tapping screws fastened to steel framing or to concealed steel reinforcements.

OR

For steel-framed partitions, use toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

D. Adjusting And Cleaning

1. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.

OR

Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 07 OR Division 09 Section(s) "High-performance Coatings" **OR** Division 07 AND Division 09 Section(s) "High-performance Coatings", **as directed**.
2. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

END OF SECTION 05 51 13 00



SECTION 05 51 13 00a - FABRICATED SPIRAL STAIRS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fabricated spiral stairs. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes fabricated spiral stairs with steel central-supporting columns and radiating treads.

C. Performance Requirements

1. Delegated Design: Design fabricated spiral stairs, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance of Stairs: Fabricated spiral stairs shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to SEI/ASCE 7:
 - a. Uniform Load: 40 lbf/sq. ft. (1.92 kN/sq. m) **OR** 100 lbf/sq. ft. (4.79 kN/sq. m), **as directed**.
 - b. Concentrated Load: 300 lbf (1.33 kN) applied on an area of 4 sq. in. (2580 sq. mm).
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - d. Railing Loads: Stairs shall withstand stresses resulting from railing loads in addition to loads specified above.
3. Structural Performance of Railings: Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to SEI/ASCE 7:
 - a. Handrails:
 - 1) Uniform load of 20 lbf/ft. (0.29 kN/m) **OR** 50 lbf/ft. (0.73 kN/m), **as directed**, applied in any direction.
 - 2) Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - 3) Uniform and concentrated loads need not be assumed to act concurrently.
 - b. Top Rails of Guards:
 - 1) Uniform load of 20 lbf/ft. (0.29 kN/m) applied in any direction **OR** 50 lbf/ft. (0.73 kN/m) applied in any direction **OR** 50 lbf/ft. (0.73 kN/m) applied horizontally and concurrently, with 100 lbf/ft. (1.46 kN/m) applied vertically downward, **as directed**.
 - 2) Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - 3) Uniform and concentrated loads need not be assumed to act concurrently.
 - c. Infill of Guards:
 - 1) Concentrated load of 50 lbf (0.22 kN) **OR** 200 lbf (0.89 kN), **as directed**, applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - 2) Uniform load of 25 lbf/sq. ft. (1.2 kN/sq. m) applied horizontally.
 - 3) Infill load and other loads need not be assumed to act concurrently.
4. Seismic Performance: Fabricated spiral stairs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. Component Importance Factor is 1.5 **OR** 1.0, **as directed**.
5. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.

D. Submittals

1. Product Data: For each type of product indicated.



2. LEED Submittal:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed:** For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
3. Shop Drawings.
4. Samples: For the following products, in manufacturer's standard sizes:
 - a. Treads.
 - b. Metal with painted finish.
 - c. Railing members.
5. Delegated-Design Submittal: For fabricated spiral stairs indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
6. Welding certificates.

E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.2 PRODUCTS

A. Materials

1. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
2. Brackets, Flanges, and Anchors: Same metal and finish as supported item unless otherwise indicated.
3. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
4. Steel Bars for Grating Treads and Platforms: ASTM A 36/A 36M or ASTM A 1011/A 1011M.
5. Wire Rod for Grating Crossbars: ASTM A 510 (ASTM A 510M).
6. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or Grade D.
7. Steel Pipe Columns: ASTM A 53/A 53M, Schedule 40. Provide Schedule 80 for columns larger than NPS 4 (DN 100) and where required to support loads.
8. Steel Pipe Railings: ASTM A 53/A 53M, Schedule 40.
9. Steel Tubing: Either cold-formed steel tubing complying with ASTM A 500 or mandrel-drawn mechanical tubing complying with ASTM A 513, Type 5.
10. Iron Castings: Either gray iron complying with ASTM A 48/A 48M or malleable iron complying with ASTM A 47/A 47M unless otherwise indicated or required by structural loads.
11. Aluminum Sheet and Plate: ASTM B 209 (ASTM B 209M), Alloy 6061-T6.
12. Aluminum-Alloy Rolled Tread Plate: ASTM B 632/B 632M, Alloy 6061-T6.
13. Aluminum Pipe and Structural Round Tubing: ASTM B 429, Alloy 6063-T6.
14. Extruded-Aluminum Tubing: ASTM B 221 (ASTM B 221M), Alloy 6063-T5/T52.
15. Aluminum Castings: ASTM B 26/B 26M, Alloy 319.0-F.
16. Extruded-Bronze Handrails: ASTM B 455, Alloy UNS No. C38500 (architectural bronze).
17. Seamless Bronze Tubing: ASTM B 135 (ASTM B 135M), Alloy UNS No. C23000 (red brass, 85 percent copper).
18. Seamless Brass Tubing: ASTM B 135 (ASTM B 135M), Alloy UNS No. C26000 (cartridge brass, 70 percent copper).
19. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.

B. Miscellaneous Materials



1. Fasteners: For connecting stair components and for anchoring stairs to other construction, select fasteners of the type, grade, and class required to produce connections capable of withstanding design loadings.
 - a. For aluminum, provide fasteners fabricated from Type 304 stainless steel.
 - b. For steel and cast iron, use plated steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating.
2. Lacquer for Copper Alloys: Clear, air-drying, acrylic lacquer specially developed for coating copper-alloy products.
3. Shop Primers: Provide primers that comply with Division 09 Section(s) "Exterior Painting" OR "Interior Painting" **as directed**.
4. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with finish paint systems indicated.
5. Shop Primer for Galvanized Steel: Primer formulated for use over zinc-coated metal and compatible with finish paint systems indicated.
6. Shop Primer for Aluminum: Primer formulated for use over aluminum and compatible with finish paint systems indicated.
7. Wood for Stair Treads, Handrails, and Platforms: Unless directed otherwise, laminated red oak, sanded to 120-grit smoothness. Apply uniform coat of manufacturer's standard clear sealer.
8. Rubber Wearing Surfaces: Manufacturer's standard, 1/4-inch- (6-mm-) thick, molded-rubber covering in pattern and color indicated or, if not indicated, as selected by the Owner from manufacturer's standard colors and patterns.

C. Fabrication

1. Assemble spiral stairs in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.
2. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
3. Form work true to line and level with accurate angles and surfaces.
4. Fabricate connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
5. Cut, reinforce, drill, and tap as needed to receive hardware, screws, and similar items.
6. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove flux immediately.
 - d. Provide Type 1 **OR** Type 2 **OR** Type 3, **as directed**, welds according to NOMMA Guideline 1, "Joint Finishes."
 - e. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and, except for fillet welds, welded surface matches contours of adjoining surfaces.
7. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts unless otherwise indicated. Locate joints where least conspicuous.
8. Fabricate center column from steel **OR** aluminum, **as directed**, pipe welded to baseplate for anchorage to floor structure. Brace column at upper floors by means of landings attached to column and floor structure unless otherwise indicated. Provide cap for column if top is exposed.
9. Provide cast-aluminum **OR** cast-iron, **as directed**, treads and platforms, **as directed**, with integral frames, legs, and hubs.
 - a. Provide treads and platforms, **as directed**, with abrasive surfaces.
10. Provide steel-bar grating treads and platforms, **as directed**, with welded hubs and as follows:
 - a. Radial grating treads.



- OR**
Abrasive **OR** Rolled-steel, floor-plate, **as directed**, nosings.
- OR**
Straight flanges and welded-on legs.
- OR**
Tapered flanges without legs.
11. Provide formed steel **OR** aluminum, **as directed**, -plate treads and platforms, **as directed**, welded to hubs or center column and as follows:
- a. Straight flanges and welded-on legs.
- OR**
Tapered flanges without legs.
- OR**
Pan treads without legs.
- OR**
One-piece treads and risers, without legs.
- OR**
Rolled-steel, floor-plate wearing surfaces.
- OR**
Aluminum-alloy, rolled tread-plate wearing surfaces.
- OR**
Smooth steel-plate wearing surfaces.
- OR**
Rubber wearing surfaces.
- OR**
Plywood subread for covering with finish flooring specified in another Section.
12. Provide steel-framed treads and platforms, **as directed**, welded to hubs or center column and without legs; wearing surface as follows:
- a. Cast iron with integral abrasive.
- OR**
Smooth steel plate with integral abrasive.
- OR**
Wood.
- OR**
Plywood insert for covering with finish flooring specified in another Section.
13. Railings: Provide railing system indicated, uniformly bent to spiral shape, and continuing at top to form guardrail around floor opening.
- a. Space balusters less than 4 inches (102 mm), clear.
- OR**
Space balusters to provide one baluster per tread, but spaced less than 21 inches (533 mm), clear.
- b. Space intermediate rails less than 4 inches (101 mm) **OR** 21 inches (533 mm), **as directed**, clear.
- c. Locate bottom rail so that a 6-inch- (152-mm-) diameter sphere cannot pass between the stair and rail.
- d. Fabricate top rail from 1-1/4- to 2-inch- (32- to 51-mm-) OD steel pipe or round tubing.
- OR**
Fabricate top rail from steel of shape and size indicated.
- OR**
Fabricate top rail from 1-1/4- to 2-inch- (32- to 51-mm-) OD round aluminum **OR** bronze **OR** brass **OR** stainless-steel, **as directed**, tubing.
- OR**
Fabricate top rail from extruded bronze of shape and size indicated.
- OR**
Fabricate top rail from wood of shape and size indicated.



- e. Fabricate balusters from 7/8-inch- (22-mm-) OD **OR** 1-inch- (25-mm-) OD **OR** 1-1/4-inch- (32-mm-) OD steel pipe or round tubing.
OR
Fabricate balusters from 1/2-inch- (13-mm-) OD **OR** 5/8-inch- (16-mm-) OD round steel bars **OR** tubing, **as directed**.
OR
Fabricate balusters from 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, square steel bars **OR** tubing, **as directed**.
OR
Fabricate balusters from 5/8-inch- (16-mm-) OD **OR** 3/4-inch- (19-mm-) OD, **as directed**, round aluminum tubing.
- f. Fabricate intermediate rails from 7/8-inch- (22-mm-) OD **OR** 1-inch- (25-mm-) OD **OR** 1-1/4-inch- (32-mm-) OD, **as directed**, steel pipe or round tubing.
OR
Fabricate intermediate rails from steel pipe or round tubing same size as top rail.
OR
Fabricate intermediate rails from 5/8-inch- (16-mm-) OD **OR** 3/4-inch- (19-mm-) OD, **as directed**, round steel bars **OR** tubing, **as directed**.
OR
Fabricate intermediate rails from 5/8-inch- (16-mm-) OD **OR** 3/4-inch- (19-mm-) OD **OR** 1-inch- (25-mm-) OD **OR** 1-1/4-inch- (32-mm-) OD, **as directed**, round aluminum tubing.
OR
Fabricate intermediate rails from round aluminum tubing same size as top rail.

D. Steel And Iron Finishes

1. Galvanized Finish: Hot-dip galvanize stairs after fabrication to comply with ASTM A 123/A 123M.
2. Preparation for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic phosphate process.
3. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC's surface-preparation specifications and environmental exposure conditions of installed stairs:
 - a. Exteriors (SSPC Zone 1B): SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Interiors (SSPC Zone 1A): SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
4. Apply shop primer to prepared surfaces of handrails and railing components unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

E. Aluminum Finishes

1. Conversion-Coated and Factory-Primed Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid chromate-fluoride-phosphate conversion coating; Organic Coating: shop primer).
 - a. Apply shop primer with a minimum dry film thickness of 1.5 mils (0.04 mm).
2. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - a. Color and Gloss: As selected by the Owner from manufacturer's full range.

F. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish indicated, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - c. Directional Satin Finish: No. 4.
 - d. Reflective, Directional Polish: No. 7.



e. Mirrorlike Reflective, Nondirectional Polish: No. 8.

G. Copper-Alloy Finishes

1. Finish designations for copper alloys comply with the system established for designating copper-alloy finish systems defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
2. Buffed Finish: M21 (Mechanical Finish: buffed, smooth specular).
3. Buffed Finish, Lacquered: M21-O6x (Mechanical Finish: buffed, smooth specular; Coating: clear organic, air drying, as specified below).
4. Medium-Satin Finish, Lacquered: M32-O6x (Mechanical Finish: directionally textured, medium satin; Coating: clear organic, air drying, as specified below).
 - a. Clear Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
5. Statuary Conversion Coating over Satin Finish: M31-C55 (Mechanical Finish: directionally textured, fine satin; Chemical Finish: conversion coating, sulfide).
 - a. Color: Match the Owner's sample.

1.3 EXECUTION

A. Installation

1. Fastening to In-Place Construction: Provide anchorage devices and fasteners where needed for securing fabricated spiral stairs to in-place construction; include threaded fasteners for concrete and masonry inserts, through bolts, lag bolts, wood screws, and other connectors as required.
2. Assemble fabricated spiral stair components to comply with manufacturer's written instructions, with each component aligned and in correct relation to each other, securely anchored to the supporting column and adjacent structure.
3. Do not cut, alter, or drill stair components in the field that do not fit properly. Return components that do not fit to manufacturer for adjustment.
4. Install fabricated spiral stairs accurately in location, alignment, and elevation; level and plumb; and according to manufacturer's written instructions.
5. Install fabricated spiral stairs by welding to steel structure or to weld plates cast into concrete unless otherwise indicated.
6. Field Welding:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.

B. Cleaning And Protection

1. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint and paint exposed areas with same material.
2. For galvanized surfaces, clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A 780.
 - a. Paint repaired areas with same material used for shop painting.
3. Protect finished tread surfaces during construction by covering with 1/2-inch- (13-mm-) thick plywood secured with plastic strapping or another nonmarring fastening method.

END OF SECTION 05 51 13 00a



Task	Specification	Specification Description
05 51 13 00	05 50 00 00	Metal Fabrications
05 51 19 00	05 50 00 00	Metal Fabrications
05 51 19 00	05 51 13 00	Metal Stairs
05 51 19 00	05 51 13 00a	Fabricated Spiral Stairs
05 51 33 13	05 50 00 00	Metal Fabrications
05 51 33 13	05 52 13 00	Pipe And Tube Railings
05 51 33 16	05 50 00 00	Metal Fabrications
05 51 33 23	05 50 00 00	Metal Fabrications
05 51 33 23	05 52 13 00	Pipe And Tube Railings



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SECTION 05 52 13 00 - PIPE AND TUBE RAILINGS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for pipe and tube railings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Steel pipe and tube railings.
 - b. Aluminum pipe and tube railings.
 - c. Stainless-steel pipe and tube railings.

C. Performance Requirements

1. Delegated Design: Design railings, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. General: In engineering railings to withstand structural loads indicated, determine allowable design working stresses of railing materials based on the following:
 - a. Steel: 72 percent of minimum yield strength.
 - b. Aluminum: The lesser of minimum yield strength divided by 1.65 or minimum ultimate tensile strength divided by 1.95.
 - c. Stainless Steel: 60 percent of minimum yield strength.
3. Structural Performance: Railings shall withstand the effects of gravity loads and loads and stresses within limits and under conditions indicated. Following loads are examples only and are based on the 2006 International Building Code (IBC).
 - a. Handrails and Top Rails of Guards:
 - 1) Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
 - 2) Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - 3) Uniform and concentrated loads need not be assumed to act concurrently.
 - b. Infill of Guards:
 - 1) Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - 2) Infill load and other loads need not be assumed to act concurrently.
4. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.
 - a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
5. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

D. Submittals

1. Product Data: For the following:
 - a. Manufacturer's product lines of mechanically connected railings.
 - b. Railing brackets.
 - c. Grout, anchoring cement, and paint products.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: Indicating percentages by weight of postconsumer and preconsumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.



4. Samples: For each type of exposed finish required.
 - a. Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters.
 - b. Fittings and brackets.
 - c. Assembled Sample of railing system, made from full-size components, including top rail, post, handrail, and infill. Sample need not be full height.
 - 1) Show method of finishing **OR** connecting, **as directed**, members at intersections.
5. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
6. Qualification Data: For qualified professional engineer **OR** testing agency, .
7. Mill Certificates: Signed by manufacturers of stainless-steel products certifying that products furnished comply with requirements.
8. Welding certificates.
9. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.
10. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

E. Quality Assurance

1. Source Limitations: Obtain each type of railing from single source from single manufacturer.
2. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.6, "Structural Welding Code - Stainless Steel."

F. Project Conditions

1. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

G. Coordination And Scheduling

1. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
2. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
3. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

1.2 PRODUCTS

A. Metals, General

1. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
2. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.

B. Steel And Iron



1. Recycled Content of Steel Products: Provide products with average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Tubing: ASTM A 500 (cold formed) or ASTM A 513.
3. Pipe: ASTM A 53/A 53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
 - a. Provide galvanized finish for exterior installations and where indicated.
4. Plates, Shapes, and Bars: ASTM A 36/A 36M.
5. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.
6. Expanded Metal: ASTM F 1267, Type I (expanded) **OR** Type II (expanded and flattened), **as directed**, Class 1 (uncoated).
 - a. Style Designation: 3/4 number 13 **OR** 1-1/2 number 10, **as directed**.
7. Perforated Metal: Cold-rolled steel sheet, ASTM A 1008/A 1008M, or hot-rolled steel sheet, ASTM A 1011/A 1011M, commercial steel Type B, 0.060 inch (1.52 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.
8. Perforated Metal: Galvanized-steel sheet, ASTM A 653/A 653M, G90 (Z275) coating, commercial steel Type B, 0.064 inch (1.63 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows **OR** with 1/8-by-1-inch (3.2-by-25.4-mm) round end slotted holes in staggered rows, **as directed**.
9. Woven-Wire Mesh: Intermediate-crimp, diamond **OR** square, **as directed**, pattern, 2-inch (50-mm) woven-wire mesh, made from 0.135-inch (3.5-mm) nominal diameter wire complying with ASTM A 510 (ASTM A 510M).

C. Aluminum

1. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.
2. Extruded Bars and Tubing: ASTM B 221 (ASTM B 221M), Alloy 6063-T5/T52.
3. Extruded Structural Pipe and Round Tubing: ASTM B 429/B 429M, Alloy 6063-T6.
 - a. Provide Standard Weight (Schedule 40) pipe, unless otherwise indicated.
4. Drawn Seamless Tubing: ASTM B 210 (ASTM B 210M), Alloy 6063-T832.
5. Plate and Sheet: ASTM B 209 (ASTM B 209M), Alloy 6061-T6.
6. Die and Hand Forgings: ASTM B 247 (ASTM B 247M), Alloy 6061-T6.
7. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.
8. Perforated Metal: Aluminum sheet, ASTM B 209 (ASTM B 209M), Alloy 6061-T6, 0.063 inch (1.60 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.
9. Woven-Wire Mesh: Intermediate-crimp, diamond **OR** square, **as directed**, pattern, 2-inch (50-mm) woven-wire mesh, made from 0.162-inch (4.1-mm) nominal diameter wire complying with ASTM B 211 (ASTM B 211M), Alloy 6061-T94.

D. Stainless Steel

1. Tubing: ASTM A 554, Grade MT 304 **OR** Grade MT 316L, **as directed**.
2. Pipe: ASTM A 312/A 312M, Grade TP 304 **OR** Grade TP 316L, **as directed**.
3. Castings: ASTM A 743/A 743M, Grade CF 8 or CF 20 **OR** Grade CF 8M or CF 3M, **as directed**.
4. Plate and Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304 **OR** Type 316L, **as directed**.
5. Expanded Metal: ASTM F 1267, Type I (expanded) **OR** Type II (expanded and flattened), **as directed**, Class 3 (corrosion-resistant steel), made from stainless-steel sheet, ASTM A 240/A 240M or ASTM A 666, Type 304 **OR** Type 316, **as directed**.
 - a. Style Designation: 3/4 number 13 **OR** 1-1/2 number 10, **as directed**.
6. Perforated Metal: Stainless-steel sheet, ASTM A 240/A 240M or ASTM A 666, Type 304 **OR** Type 316L, **as directed**, 0.062 inch (1.59 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.
7. Woven-Wire Mesh: Intermediate-crimp, diamond **OR** square, **as directed**, pattern, 2-inch (50-mm) woven-wire mesh, made from 0.135-inch (3.5-mm) nominal diameter wire complying with ASTM A 580/A 580M, Type 304 **OR** Type 316, **as directed**.



E. Fasteners

1. General: Provide the following:
 - a. Ungalvanized-Steel Railings: Plated steel fasteners complying with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5 for zinc coating.
 - b. Hot-Dip Galvanized Railings: Type 304 stainless-steel or hot-dip zinc-coated steel fasteners complying with ASTM A 153/A 153M or ASTM F 2329 for zinc coating.
 - c. Aluminum Railings: Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners.
 - d. Stainless-Steel Railings: Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners.
2. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads, **as directed**.
3. Fasteners for Interconnecting Railing Components:
 - a. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.
OR
Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.
 - b. Provide Phillips **OR** tamper-resistant **OR** square or hex socket, **as directed**, flat-head machine screws for exposed fasteners unless otherwise indicated.
4. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
 - a. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
 - b. Material for Exterior Locations and Where Stainless Steel is Indicated: Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**, stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

F. Miscellaneous Materials

1. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 - a. For aluminum and stainless-steel railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
2. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
3. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
4. Shop Primers: Provide primers that comply with Division 07 **OR** Division 09 Section(s) "High-performance Coatings" **OR** Division 07 **AND** Division 09 Section(s) "High-performance Coatings", **as directed**.
5. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - a. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
6. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
7. Shop Primer for Galvanized Steel: Cementitious galvanized metal primer complying with MPI#26 **OR** Vinyl wash primer complying with MPI#80 **OR** Water based galvanized metal primer complying with MPI#134, **as directed**.
8. Intermediate Coats and Topcoats: Provide products that comply with Division 07 **OR** Division 09 Section(s) "High-performance Coatings" **OR** Division 07 **AND** Division 09 Section(s) "High-performance Coatings", **as directed**.
9. Epoxy Intermediate Coat: Complying with MPI #77 and compatible with primer and topcoat.
10. Polyurethane Topcoat: Complying with MPI #72 and compatible with undercoat.



11. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
12. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.
13. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.
 - a. Water-Resistant Product: At exterior locations and where indicated provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

G. Fabrication

1. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
2. Assemble railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.
3. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
4. Form work true to line and level with accurate angles and surfaces.
5. Fabricate connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
6. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
7. Connections: Fabricate railings with welded **OR** nonwelded, **as directed**, connections unless otherwise indicated.
8. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove flux immediately.
 - d. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.
9. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.
10. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
 - a. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.
11. Form changes in direction as follows:
 - a. As detailed.
OR
By bending or by inserting prefabricated elbow fittings.
OR
By flush bends or by inserting prefabricated flush-elbow fittings.
OR
By radius bends of radius indicated or by inserting prefabricated elbow fittings of radius indicated.
12. Bend members in jigs to produce uniform curvature for each configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
13. Close exposed ends of railing members with prefabricated end fittings.



14. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
15. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
 - a. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers, or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.
16. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.
17. For railing posts set in concrete, provide steel **OR** stainless-steel, **as directed**, sleeves not less than 6 inches (150 mm) long with inside dimensions not less than 1/2 inch (13 mm) greater than outside dimensions of post, with metal plate forming bottom closure.
18. For removable railing posts, fabricate slip-fit sockets from steel **OR** stainless-steel, **as directed**, tube or pipe whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height. Provide socket covers designed and fabricated to resist being dislodged.
 - a. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.
19. Expanded-Metal Infill Panels: Fabricate infill panels from expanded metal made from same metal as railings in which they are installed.
 - a. Edge panels with U-shaped channels made from metal sheet, of same metal as expanded metal and not less than 0.043 inch (1.1 mm) thick.
 - b. Orient expanded metal with long dimension of diamonds parallel to top rail **OR** perpendicular to top rail **OR** horizontal **OR** vertical, **as directed**.
20. Perforated-Metal Infill Panels: Fabricate infill panels from perforated metal made from steel **OR** galvanized steel **OR** aluminum **OR** stainless steel **OR** same metal as railings in which they are installed, **as directed**.
 - a. Edge panels with U-shaped channels made from metal sheet, of same metal as perforated metal and not less than 0.043 inch (1.1 mm) thick.
 - b. Orient perforated metal with pattern parallel to top rail **OR** perpendicular to top rail **OR** horizontal **OR** vertical **OR** as indicated on Drawings, **as directed**.
21. Woven-Wire Mesh Infill Panels: Fabricate infill panels from woven-wire mesh crimped into 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) metal channel frames. Make wire mesh and frames from same metal as railings in which they are installed.
 - a. Orient wire mesh with diamonds vertical **OR** wires perpendicular and parallel to top rail **OR** wires horizontal and vertical, **as directed**.
22. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

H. Finishes, General

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
4. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

I. Steel And Iron Finishes

1. Galvanized Railings:



- a. Hot-dip galvanize steel **OR** exterior steel, **as directed**, and iron railings, including hardware, after fabrication.
OR
Hot-dip galvanize indicated steel and iron railings, including hardware, after fabrication.
 - b. Comply with ASTM A 123/A 123M for hot-dip galvanized railings.
 - c. Comply with ASTM A 153/A 153M for hot-dip galvanized hardware.
 - d. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
 - e. Fill vent and drain holes that will be exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
 2. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.
 3. Preparing Galvanized Railings for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.
 4. For nongalvanized steel railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors to be embedded in exterior concrete or masonry.
 5. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" **OR** SSPC-SP 3, "Power Tool Cleaning" **OR** requirements indicated below, **as directed**:
 - a. Exterior Railings: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Railings Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - c. Railings Indicated to Receive Primers Specified in Division 9 Section "High-Performance Coatings": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - d. Other Railings: SSPC-SP 3, "Power Tool Cleaning."
 6. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.
 - a. Shop prime uncoated railings with universal shop primer **OR** primers specified in Division 07, **as directed**, unless zinc-rich primer is **OR** primers specified in Division 09 Section "High-performance Coatings" are, **as directed**, indicated.
 - b. Do not apply primer to galvanized surfaces.
 7. Shop-Painted Finish: Comply with Division 09 Section(s) "Exterior Painting" **OR** "High-performance Coatings", **as directed**.
 - a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 8. High-Performance Coating: Apply epoxy intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.
 - a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
- J. Aluminum Finishes
1. Mechanical Finish: AA-M12 (Mechanical Finish: nonspecular as fabricated).
 2. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
 3. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - a. Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from full range of industry colors and color densities, **as directed**.
 4. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.



- a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
5. High-Performance Organic Finish: Two-coat fluoropolymer finish complying with AAMA 2604 **OR** AAMA 2605, **as directed**, and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

OR

 High-Performance Organic Finish: Three **OR** Four, **as directed**, -coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - b. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

K. Stainless-Steel Finishes

1. Remove tool and die marks and stretch lines, or blend into finish.
2. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
3. 180-Grit Polished Finish: Oil-ground, uniform, directionally textured finish.
4. 320-Grit Polished Finish: Oil-ground, uniform, fine, directionally textured finish.
5. Polished and Buffed Finish: Oil-ground, 180-grit finish followed by buffing.
6. Directional Satin Finish: No. 4.
7. Dull Satin Finish: No. 6.
8. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

1.3 EXECUTION

A. Examination

1. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements have been clearly marked for Installer. Locate reinforcements and mark locations if not already done.

B. Installation, General

1. Fit exposed connections together to form tight, hairline joints.
2. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.
 - a. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 - b. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
 - c. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (5 mm in 3 m).
3. Corrosion Protection: Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
4. Adjust railings before anchoring to ensure matching alignment at abutting joints.
5. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

C. Railing Connections



1. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of railings.
 2. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.
 3. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches (50 mm) beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches (150 mm) of post.
- D. Anchoring Posts
1. Use metal sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.
 2. Form or core-drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.
 3. Cover anchorage joint with flange of same metal as post, welded to post after placing anchoring material **OR** attached to post with set screws, **as directed**.
OR
Leave anchorage joint exposed with 1/8-inch (3-mm) buildup, sloped away from post **OR** anchoring material flush with adjacent surface, **as directed**.
 4. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:
 - a. For aluminum pipe railings, attach posts using fittings designed and engineered for this purpose.
 - b. For stainless-steel pipe railings, weld flanges to post and bolt to supporting surfaces.
 - c. For steel pipe railings, weld flanges to post and bolt to metal supporting surfaces.
 5. Install removable railing sections, where indicated, in slip-fit metal sockets cast in concrete.
- E. Attaching Railings
1. Anchor railing ends at walls with round flanges anchored to wall construction and welded to railing ends or connected to railing ends using nonwelded connections.
 2. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends or connected to railing ends using nonwelded connections.
 3. Attach railings to wall with wall brackets, except where end flanges are used. Provide brackets with 1-1/2-inch (38-mm) clearance from inside face of handrail and finished wall surface. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
 - a. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt **OR** predrilled hole for exposed bolt anchorage, **as directed**.
 - b. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
 4. Secure wall brackets and railing end flanges to building construction as follows:
 - a. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
 - b. For hollow masonry anchorage, use toggle bolts.
 - c. For wood stud partitions, use hanger or lag bolts set into studs or wood backing between studs. Coordinate with carpentry work to locate backing members.
 - d. For steel-framed partitions, use hanger or lag bolts set into fire-retardant-treated, **as directed**, wood backing between studs. Coordinate with stud installation to locate backing members.**OR**



For steel-framed partitions, use self-tapping screws fastened to steel framing or to concealed steel reinforcements.

OR

For steel-framed partitions, use toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

F. Adjusting And Cleaning

1. Clean aluminum and stainless steel by washing thoroughly with clean water and soap and rinsing with clean water.
2. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
3. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 07 OR Division 09 Section(s) "High-performance Coatings" **OR** Division 07 AND Division 09 Section(s) "High-performance Coatings", **as directed**.
4. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

G. Protection

1. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Final Completion.

END OF SECTION 05 52 13 00



Task	Specification	Specification Description
05 52 13 00	05 50 00 00	Metal Fabrications



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SECTION 05 53 13 00 - GRATINGS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for gratings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Metal bar gratings.
 - b. Expanded-metal gratings.
 - c. Formed-metal plank gratings.
 - d. Extruded-aluminum plank gratings.
 - e. Glass-fiber-reinforced plastic gratings.
 - f. Metal frames and supports for gratings.

C. Performance Requirements

1. Delegated Design: Design gratings, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Gratings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.
 - a. Loads in subparagraphs below are examples based on the 2006 International Building Code and ASCE/SEI 7. Adjust to local Project requirements.
 - 1) Floors (light manufacturing): Uniform load of 125 lbf/sq. ft. (6.00 kN/sq. m) or concentrated load of 2000 lbf (8.90 kN), whichever produces the greater stress.
 - 2) Floors (heavy manufacturing): Uniform load of 250 lbf/sq. ft. (11.97 kN/sq. m) or concentrated load of 3000 lbf (13.40 kN), whichever produces the greater stress.
 - 3) Walkways and Elevated Platforms Other Than Exits: Uniform load of 60 lbf/sq. ft. (2.87 kN/sq. m).
 - 4) Walkways and Elevated Platforms Used as Exits: Uniform load of 100 lbf/sq. ft. (4.79 kN/sq. m).
 - 5) Sidewalks and Vehicular Driveways, Subject to Trucking: Uniform load of 250 lbf/sq. ft. (11.97 kN/sq. m) or concentrated load of 8000 lbf (35.60 kN), whichever produces the greater stress.
 - 6) Limit deflection to L/240 **OR** L/360, **as directed**, or 1/4 inch (6.4 mm), whichever is less.
3. Seismic Performance: Provide gratings capable of withstanding the effects of earthquake motions determined according to ASCE/SEI 7.

D. Submittals

1. Product Data: For the following:
 - a. Formed-metal plank gratings.
 - b. Extruded-aluminum plank gratings.
 - c. Glass-fiber-reinforced plastic gratings.
 - d. Clips and anchorage devices for gratings.
 - e. Paint products.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: Indicating percentages by weight of postconsumer and preconsumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Include plans, sections, details, and attachments to other work.



4. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Qualification Data: For qualified professional engineer.
6. Mill Certificates: Signed by manufacturers of stainless-steel sheet certifying that products furnished comply with requirements.
7. Welding certificates.
8. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

E. Quality Assurance

1. Metal Bar Grating Standards: Comply with NAAMM MBG 531, "Metal Bar Grating Manual" and NAAMM MBG 532, "Heavy-Duty Metal Bar Grating Manual."
2. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - d. AWS D1.6, "Structural Welding Code - Stainless Steel."

F. Project Conditions

1. Field Measurements: Verify actual locations of walls and other construction contiguous with gratings by field measurements before fabrication.

G. Coordination

1. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
2. Coordinate installation of anchorages for gratings, grating frames, and supports. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.2 PRODUCTS

A. Ferrous Metals

1. Recycled Content of Steel Products: Provide products with average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
3. Steel Bars for Bar Gratings: ASTM A 36/A 36M or steel strip, ASTM A 1011/A 1011M or ASTM A 1018/A 1018M.
4. Wire Rod for Bar Grating Crossbars: ASTM A 510 (ASTM A 510M).
5. Uncoated Steel Sheet: ASTM A 1011/A 1011M, structural steel, Grade 30 (Grade 205).
6. Galvanized-Steel Sheet: ASTM A 653/A 653M, structural quality, Grade 33 (Grade 230), with G90 (Z275) coating.
7. Expanded-Metal Carbon Steel: ASTM F 1267, Class 1.
8. Expanded-Metal Galvanized Steel: ASTM F 1267, Class 2, Grade A.
9. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 304 **OR** Type 316, **as directed**.
10. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304 **OR** Type 316, **as directed**.
11. Expanded-Metal Stainless Steel: ASTM F 1267, Class 3, made from stainless-steel sheet, ASTM A 666, Type 304 **OR** Type 316, **as directed**.

B. Aluminum



1. Aluminum, General: Provide alloy and temper recommended by aluminum producer for type of use indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.
 2. Extruded Bars and Shapes: ASTM B 221 (ASTM B 221M), alloys as follows:
 - a. 6061-T6 or 6063-T6, for bearing bars of gratings and shapes.
 - b. 6061-T1, for grating crossbars.
 3. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 5052-H32.
- C. Fasteners
1. General: Unless otherwise indicated, provide Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
 - a. Provide stainless-steel fasteners for fastening aluminum.
 - b. Provide stainless steel fasteners for fastening stainless steel.
 2. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with hex nuts, ASTM A 563 (ASTM A 563M); and, where indicated, flat washers.
 3. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, nuts, and, where indicated, flat washers; ASTM F 593 (ASTM F 738M) for bolts and ASTM F 594 (ASTM F 836M) for nuts, Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**.
 4. Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563 (ASTM A 563M); and, where indicated, flat washers.
 - a. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.
 5. Plain Washers: Round, ASME B18.22.1 (ASME B18.22M).
 6. Lock Washers: Helical, spring type, ASME B18.21.1 (ASME B18.21.2M).
 7. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
 - a. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
 - b. Material for Exterior Locations and Where Stainless Steel is Indicated: Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**, stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).
- D. Miscellaneous Materials
1. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy that is welded.
 2. Shop Primers: Provide primers that comply with Division 07 **OR** Division 09 Section(s) "High-performance Coatings" **OR** Division 07 **AND** Division 09 Section(s) "High-performance Coatings", **as directed**.
 3. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - a. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
 4. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
 5. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
 6. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
- E. Fabrication
1. Shop Assembly: Fabricate grating sections in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling



limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

2. Cut, drill, and punch material cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
3. Form from materials of size, thickness, and shapes indicated, but not less than that needed to support indicated loads.
4. Fit exposed connections accurately together to form hairline joints.
5. Welding: Comply with AWS recommendations and the following:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
6. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space the anchoring devices to secure gratings, frames, and supports rigidly in place and to support indicated loads.
 - a. Fabricate toeplates to fit grating units and weld to units in shop unless otherwise indicated.
OR
Fabricate toeplates for attaching in the field.
 - b. Toeplate Height: 4 inches (100 mm) unless otherwise indicated.

F. Metal Bar Gratings

1. Welded Steel Grating:
 - a. Bearing Bar Spacing: 7/16 or 1/2 inch (11 or 13 mm) **OR** 11/16 inch (17 mm) **OR** 15/16 inch (24 mm) **OR** 1-3/16 inches (30 mm) **OR** 1-3/8 inches (35 mm) **OR** 1-7/8 inches (48 mm) **OR** 2-3/8 inches (60 mm), **as directed**, o.c.
 - b. Bearing Bar Depth: 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-3/4 inches (44 mm) **OR** 2 inches (51 mm) **OR** 2-1/4 inches (57 mm) **OR** 2-1/2 inches (64 mm) **OR** 3 inches (76 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (102 mm) **OR** 4-1/2 inches (114 mm) **OR** 5 inches (127 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - c. Bearing Bar Thickness: 1/8 inch (3.2 mm) **OR** 3/16 inch (4.8 mm) **OR** 1/4 inch (6.4 mm) **OR** 3/8 inch (9.5 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - d. Crossbar Spacing: 2 inches (51 mm) **OR** 4 inches (102 mm), **as directed**, o.c.
 - e. Grating Mark W-11-4 (1 x 3/16) STEEL: 1-by-3/16-inch (25-by-4.8-mm) bearing bars at 11/16 inch (18 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - f. Grating Mark W-15-4 (1 x 1/8) STEEL: 1-by-1/8-inch (25-by-3.2-mm) bearing bars at 15/16 inch (24 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - g. Grating Mark W-19-4 (1-1/4 x 3/16) STEEL: 1-1/4-by-3/16-inch (32-by-4.8-mm) bearing bars at 1-3/16 inches (30 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - h. Grating Mark W-19-4 (1-1/2 x 3/16) STEEL: 1-1/2-by-3/16-inch (38-by-4.8-mm) bearing bars at 1-3/16 inches (30 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - i. Grating Mark W-19-4 (2 x 1/4) STEEL: 2-by-1/4-inch (51-by-6.4-mm) bearing bars at 1-3/16 inches (30 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - j. Grating Mark W-30-4 (5 x 3/8) STEEL: 5-by-3/8-inch (127-by-9.5-mm) bearing bars at 1-7/8 inches (60 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - k. Grating Mark: As indicated.
 - l. Traffic Surface: Plain **OR** Serrated **OR** Knurled **OR** Applied abrasive finish consisting of aluminum-oxide aggregate in an epoxy-resin adhesive **OR** As indicated, **as directed**.
 - m. Steel Finish: Shop primed **OR** Hot-dip galvanized with a coating weight of not less than 1.8 oz./sq. ft. (550 g/sq. m) of coated surface, **as directed**.
2. Pressure-Locked Steel Grating: Fabricated by pressing rectangular flush-top crossbars into slotted bearing bars or swaging crossbars between bearing bars.



- a. Bearing Bar Spacing: 7/16 or 1/2 inch (11 or 13 mm) **OR** 11/16 inch (17 mm) **OR** 15/16 inch (24 mm) **OR** 1-3/16 inches (30 mm), **as directed**, o.c.
 - b. Bearing Bar Depth: 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-3/4 inches (44 mm) **OR** 2 inches (51 mm) **OR** 2-1/4 inches (57 mm) **OR** 2-1/2 inches (64 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - c. Bearing Bar Thickness: 1/8 inch (3.2 mm) **OR** 3/16 inch (4.8 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - d. Crossbar Spacing: 2 inches (51 mm) **OR** 4 inches (102 mm), **as directed**, o.c.
 - e. Grating Mark P-11-4 (1 x 3/16) STEEL: 1-by-3/16-inch (25-by-4.8-mm) bearing bars at 11/16 inch (18 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - f. Grating Mark P-15-4 (1-1/4 x 1/8) STEEL: 1-1/4-by-1/8-inch (32-by-3.2-mm) bearing bars at 15/16 inch (24 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - g. Grating Mark P-19-4 (1-1/2 x 3/16) STEEL: 1-1/2-by-3/16-inch (38-by-4.8-mm) bearing bars at 1-3/16 inches (30 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - h. Grating Mark: As indicated.
 - i. Traffic Surface: Plain **OR** Serrated **OR** Knurled **OR** Applied abrasive finish consisting of aluminum-oxide aggregate in an epoxy-resin adhesive **OR** As indicated, **as directed**.
 - j. Steel Finish: Shop primed **OR** Hot-dip galvanized with a coating weight of not less than 1.8 oz./sq. ft. (550 g/sq. m) of coated surface, **as directed**.
3. Riveted Steel Grating:
- a. Bearing Bar Spacing: 3/4 inch (19 mm) **OR** 1-1/8 inches (29 mm) **OR** 2-5/16 inches (59 mm), **as directed**, clear.
 - b. Bearing Bar Depth: 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-3/4 inches (44 mm) **OR** 2 inches (51 mm) **OR** 2-1/4 inches (57 mm) **OR** 2-1/2 inches (64 mm) **OR** 3 inches (76 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (102 mm) **OR** 4-1/2 inches (114 mm) **OR** 5 inches (127 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - c. Bearing Bar Thickness: 1/8 inch (3.2 mm) **OR** 3/16 inch (4.8 mm) **OR** 1/4 inch (6.4 mm) **OR** 3/8 inch (9.5 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - d. Rivet Spacing: 3-1/2 inches (89 mm) **OR** 5 inches (127 mm) **OR** 7 inches (178 mm), **as directed**, o.c. along bearing bar.
 - e. Grating Mark R-12-3-1/2 (1 x 1/8) STEEL: 1-by-1/8-inch (25-by-3.2-mm) bearing bars with 3/4-inch (19-mm) clear space between bearing bars, and rivets at 3-1/2 inches (89 mm) o.c. along bearing bar.
 - f. Grating Mark R-18-7 (1-1/2 x 3/16) STEEL: 1-1/2-by-3/16-inch (38-by-4.8-mm) bearing bars with 1-1/8-inch (29-mm) clear space between bearing bars, and rivets at 7 inches (178 mm) o.c. along bearing bar.
 - g. Grating Mark R-37-5 (4 x 1/4) STEEL: 4-by-1/4-inch (102-by-6.4-mm) bearing bars with 2-5/16-inch (59-mm) clear space between bearing bars, and rivets at 5 inches (127 mm) o.c. along bearing bar.
 - h. Grating Mark R-37-5 (5 x 3/8) STEEL: 5-by-3/8-inch (127-by-9.5-mm) bearing bars with 2-5/16-inch (59-mm) clear space between bearing bars, and rivets at 5 inches (127 mm) o.c. along bearing bar.
 - i. Grating Mark: As indicated.
 - j. Traffic Surface: Plain **OR** Serrated **OR** Knurled **OR** Applied abrasive finish consisting of aluminum-oxide aggregate in an epoxy-resin adhesive **OR** As indicated, **as directed**.
 - k. Steel Finish: Shop primed **OR** Hot-dip galvanized with a coating weight of not less than 1.8 oz./sq. ft. (550 g/sq. m) of coated surface, **as directed**.
4. Pressure-Locked, Stainless-Steel Grating: Fabricated by pressing rectangular flush-top crossbars into slotted bearing bars or swaging crossbars between bearing bars, **as directed**.
- a. Bearing Bar Spacing: 7/16 or 1/2 inch (11 or 13 mm) **OR** 11/16 inch (17 mm) **OR** 15/16 inch (24 mm) **OR** 1-3/16 inches (30 mm) **OR** 1-3/8 inches (35 mm) **OR** 1-7/8 inches (48 mm) **OR** 2-3/8 inches (60 mm), **as directed**, o.c.



- b. Bearing Bar Depth: 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-3/4 inches (44 mm) **OR** 2 inches (51 mm) **OR** 2-1/4 inches (57 mm) **OR** 2-1/2 inches (64 mm) **OR** 3 inches (76 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (102 mm) **OR** 4-1/2 inches (114 mm) **OR** 5 inches (127 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - c. Bearing Bar Thickness: 1/8 inch (3.2 mm) **OR** 3/16 inch (4.8 mm) **OR** 1/4 inch (6.4 mm) **OR** 3/8 inch (9.5 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - d. Crossbar Spacing: 2 inches (51 mm) **OR** 4 inches (102 mm), **as directed**, o.c.
 - e. Grating Mark P-11-4 (1 x 3/16) STAINLESS STEEL: 1-by-3/16-inch (25-by-4.8-mm) bearing bars at 11/16 inch (18 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - f. Grating Mark P-15-2 (1 x 1/8) STAINLESS STEEL: 1-by-1/8-inch (25-by-3.2-mm) bearing bars at 15/16 inch (24 mm) o.c., and crossbars at 2 inches (51 mm) o.c.
 - g. Grating Mark P-19-4 (1-1/2 x 3/16) STAINLESS STEEL: 1-1/2-by-3/16-inch (38-by-4.8-mm) bearing bars at 1-3/16 inches (30 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - h. Grating Mark P-30-4 (3 x 3/8) STAINLESS STEEL: 3-by-3/8-inch (76-by-9.5-mm) bearing bars at 1-7/8 inches (48 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - i. Grating Mark: As indicated.
 - j. Traffic Surface: Plain **OR** Serrated **OR** Knurled **OR** Applied abrasive finish consisting of aluminum-oxide aggregate in an epoxy-resin adhesive **OR** As indicated, **as directed**.
 - k. Finish: Mill finish **OR** Abrasive blasted **OR** Electropolished, **as directed**.
5. Pressure-Locked, Rectangular Bar Aluminum Grating: Fabricated by pressing rectangular flush-top crossbars into slotted bearing bars or swaging crossbars between bearing bars.
- a. Bearing Bar Spacing: 7/16 or 1/2 inch (11 or 13 mm) **OR** 11/16 inch (17.5 mm) **OR** 15/16 inch (24 mm) **OR** 1-3/16 inches (30 mm), **as directed**, o.c.
 - b. Bearing Bar Depth: 1 inch (25 mm) **OR** 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-3/4 inches (44 mm) **OR** 2 inches (51 mm) **OR** 2-1/4 inches (57 mm) **OR** 2-1/2 inches (64 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - c. Bearing Bar Thickness: 1/8 inch (3.2 mm) **OR** 3/16 inch (4.8 mm) **OR** 1/4 inch (6.4 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - d. Crossbar Spacing: 2 inches (51 mm) **OR** 4 inches (102 mm), **as directed**, o.c.
 - e. Grating Mark P-7-4 (1 x 1/8) ALUMINUM: 1-by-1/8-inch (25-by-3.2-mm) bearing bars at 7/16 inch (11 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - f. Grating Mark P-11-4 (1 x 3/16) ALUMINUM: 1-by-3/16-inch (25-by-4.8-mm) bearing bars at 11/16 inch (18 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - g. Grating Mark P-15-4 (1-1/2 x 3/16) ALUMINUM: 1-1/2-by-3/16-inch (38-by-4.8-mm) bearing bars at 15/16 inch (24 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - h. Grating Mark P-19-4 (2 x 3/16) ALUMINUM: 2-by-3/16-inch (51-by-4.8-mm) bearing bars at 1-3/16 inches (30 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - i. Grating Mark: As indicated.
 - j. Traffic Surface: Plain **OR** Applied abrasive finish consisting of aluminum-oxide aggregate in an epoxy-resin adhesive **OR** As indicated, **as directed**.
 - k. Aluminum Finish: Mill finish **OR** Class I, clear, anodized finish, **as directed**.
6. Pressure-Locked, Aluminum I-Bar Grating: Fabricated by swaging crossbars between bearing bars.
- a. Bearing Bar Spacing: 7/16 or 1/2 inch (11 or 13 mm) **OR** 11/16 inch (17 mm) **OR** 15/16 inch (24 mm) **OR** 1-3/16 inches (30 mm), **as directed**, o.c.
 - b. Bearing Bar Depth: 1 inch (25 mm) **OR** 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-3/4 inches (44 mm) **OR** 2 inches (51 mm) **OR** 2-1/4 inches (57 mm) **OR** 2-1/2 inches (64 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - c. Bearing Bar Flange Width: 1/4 inch (6.4 mm).
 - d. Crossbar Spacing: 2 inches (51 mm) **OR** 4 inches (102 mm), **as directed**, o.c.
 - e. Grating Mark P-11-4 (1 I-Bar) ALUMINUM: 1-inch (25-mm) I-bar bearing bars at 11/16 inch (18 mm) o.c., and crossbars at 4 inches (102 mm) o.c.



- f. Grating Mark P-15-2 (1 I-Bar) ALUMINUM: 1-inch (25-mm) I-bar bearing bars at 15/16 inch (24 mm) o.c., and crossbars at 2 inches (51 mm) o.c.
 - g. Grating Mark P-19-4 (1-1/2 I-Bar) ALUMINUM: 1-1/2-inch (38-mm) I-bar bearing bars at 1-3/16 inches (30 mm) o.c., and crossbars at 4 inches (102 mm) o.c.
 - h. Grating Mark: As indicated.
 - i. Traffic Surface: Plain **OR** Grooved **OR** Applied abrasive finish consisting of aluminum-oxide aggregate in an epoxy-resin adhesive **OR** As indicated, **as directed**.
 - j. Aluminum Finish: Mill finish **OR** Class I, clear, anodized finish, **as directed**.
7. Removable Grating Sections: Fabricate with banding bars attached by welding to entire perimeter of each section. Include anchors and fasteners of type indicated or, if not indicated, as recommended by manufacturer for attaching to supports.
- a. Provide no fewer than four weld lugs for each heavy-duty grating section, with each lug shop welded to two bearing bars.
 - b. Provide no fewer than four saddle clips for each grating section composed of rectangular bearing bars 3/16 inch (4.8 mm) or less in thickness and spaced 15/16 inch (24 mm) or more o.c., with each clip designed and fabricated to fit over two bearing bars.
 - c. Provide no fewer than four weld lugs for each grating section composed of rectangular bearing bars 3/16 inch (4.8 mm) or less in thickness and spaced less than 15/16 inch (24 mm) o.c., with each lug shop welded to three or more bearing bars. Interrupt intermediate bearing bars as necessary for fasteners securing grating to supports.
 - d. Provide no fewer than four flange blocks for each section of aluminum I-bar grating, with block designed to fit over lower flange of I-shaped bearing bars.
 - e. Furnish threaded bolts with nuts and washers for securing grating to supports.
 - f. Furnish self-drilling fasteners with washers for securing grating to supports.
 - g. Furnish galvanized malleable-iron flange clamp with galvanized bolt for securing grating to supports. Furnish as a system designed to be installed from above grating by one person.
8. Fabricate cutouts in grating sections for penetrations indicated. Arrange cutouts to permit grating removal without disturbing items penetrating gratings.
- a. Edge-band openings in grating that interrupt four or more bearing bars with bars of same size and material as bearing bars.
9. Do not notch bearing bars at supports to maintain elevation.
- G. Expanded-Metal Gratings
1. Provide expanded-metal gratings in material, finish, style, size, thickness, weight, and type indicated or, if not indicated, as recommended by manufacturer for indicated applications and as needed to support indicated loads.
 - a. Material: Steel **OR** Stainless steel **OR** Aluminum, **as directed**.
 - b. Steel Finish: Unfinished, oiled **OR** Shop primed **OR** Galvanized, **as directed**.
 - c. Stainless-Steel Finish: Mill finish, as fabricated.
 - d. Aluminum Finish: Mill finish, as fabricated.
 - e. Style Designation (for steel): 4.27 lb **OR** 3/4 number 9, **as directed**.
 - f. Style Designation (for stainless steel): 1-1/2 number 9 **OR** 3/4 number 9, **as directed**.
 - g. Size (for aluminum): 2 lb **OR** 3/4 0.188 **OR** 1-1/2 0.125, **as directed**.
 - h. Type: I, expanded **OR** II, expanded and flattened, **as directed**.
 2. Fabricate cutouts in grating sections for penetrations of sizes and at locations indicated. Cut openings neatly and accurately to size. Edge-band openings with bars having a thickness not less than overall grating thickness at contact points.
 3. Where gratings are pierced by pipes, ducts, and structural members, cut openings neatly and accurately to size and weld a strap collar not less than 1/8 inch (3 mm) thick to the cut ends. Divide panels into sections only to extent required for installation where grating platforms and runways are to be placed around previously installed pipe, ducts, and structural members.
- H. Formed-Metal Plank Gratings
1. C-shaped channels rolled from heavy sheet metal of thickness indicated, and punched in serrated diamond shape to produce raised slip-resistant surface and drainage holes.



- a. Channel Width: 4-3/4 inches (121 mm) **OR** 7 inches (178 mm) **OR** 9-1/2 inches (241 mm) **OR** 11-3/4 inches (298 mm) **OR** 18-3/4 inches (476 mm) **OR** 24 inches (610 mm) **OR** As indicated **OR** As required to comply with structural performance requirements, **as directed**.
 - b. Channel Depth: 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** 2-1/2 inches (64 mm) **OR** 3 inches (76 mm) **OR** As indicated **OR** As required to comply with structural performance requirements, **as directed**.
 - c. Material: 0.074-inch- (1.9-mm-) thick steel sheet, shop primed **OR** 0.104-inch- (2.65-mm-) thick steel sheet, shop primed **OR** 0.079-inch- (2.0-mm-) thick, hot-dip galvanized-steel sheet **OR** 0.108-inch- (2.8-mm-) thick, hot-dip galvanized-steel sheet **OR** 0.074-inch- (1.9-mm-) thick steel sheet, hot-dip galvanized after fabrication **OR** 0.104-inch- (2.65-mm-) thick steel sheet, hot-dip galvanized after fabrication **OR** 0.062-inch- (1.6-mm-) thick, stainless-steel sheet **OR** 0.078-inch- (2.0-mm-) thick, stainless-steel sheet **OR** 0.080-inch- (2.0-mm-) thick aluminum sheet **OR** 0.100-inch- (2.5-mm-) thick aluminum sheet, **as directed**.
2. Fabricate cutouts in grating sections for penetrations of sizes and at locations indicated. Cut openings neatly and accurately to size. Edge-band openings with metal sheet or bars having a thickness not less than grating material.
 3. Where gratings are pierced by pipes, ducts, and structural members, cut openings neatly and accurately to size and weld a strap collar not less than 1/8 inch (3 mm) thick to the cut ends. Divide panels into sections only to extent required for installation where grating platforms and runways are to be placed around previously installed pipe, ducts, and structural members.
- I. Extruded-Aluminum Plank Gratings
1. Provide extruded-aluminum plank gratings in type, size, and finish indicated or, if not indicated, as recommended by manufacturer for indicated applications and as needed to support indicated loads.
 - a. Type: Extruded-aluminum planks approximately 6 inches (152 mm) wide with multiple flanges approximately 1.2 inches (30 mm) o.c., acting as bearing bars connected by a web that serves as a walking surface. Top surface has raised ribs to increase slip resistance.
 - b. Depth: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** As required to comply with structural performance requirements, **as directed**.
 - c. Perforations: None **OR** Rectangular, 19/32 by 3 inches (15 by 76 mm), with adjacent rows staggered **OR** 19/32 inch (15 mm) square, with adjacent rows aligned, **as directed**.
 - d. Finish: Mill finish, as fabricated.
 2. Fabricate cutouts in grating sections for penetrations indicated. Arrange cutouts to permit grating removal without disturbing items penetrating gratings.
- J. Glass-Fiber-Reinforced Plastic Gratings
1. Molded Glass-Fiber-Reinforced Gratings: Bar gratings made by placing glass-fiber strands that have been saturated with thermosetting plastic resin in molds in alternating directions to form interlocking bars without voids and with a high resin content.
 - a. Configuration: 1-1/2-inch- (38-mm-) square mesh, 1 inch (25 mm) thick **OR** 1-1/2-inch- (38-mm-) square mesh, 1-1/4 inches (32 mm) thick **OR** 1-1/2-inch- (38-mm-) square mesh, 1-1/2 inches (38 mm) thick **OR** 2-inch- (51-mm-) square mesh, 2 inches (51 mm) thick **OR** 1-1/2-inch- (38-mm-) square mesh, thickness as required to comply with structural performance requirements **OR** As required to comply with structural performance requirements, **as directed**.
 - b. Weight: 2.5 lb/sq. ft. (12.2 kg/sq. m) **OR** 2.7 lb/sq. ft. (13.2 kg/sq. m) **OR** 3.2 lb/sq. ft. (15.6 kg/sq. m) **OR** 3.5 lb/sq. ft. (17.1 kg/sq. m) **OR** 3.7 lb/sq. ft. (18.1 kg/sq. m) **OR** 4.1 lb/sq. ft. (20.0 kg/sq. m) **OR** 5.0 lb/sq. ft. (24.4 kg/sq. m), **as directed**.
 - c. Resin: Polyester **OR** Vinylester, **as directed**.
 - 1) Flame-Spread Index: 25 or less when tested according to ASTM E 84.
 - 2) U.S.D.A. Acceptance: Accepted for food-processing applications.
 - d. Color: Beige **OR** Gray **OR** Green **OR** Orange **OR** Yellow **OR** Manufacturer's standard, **as directed**.
 - e. Traffic Surface: Plain, meniscus **OR** Applied abrasive finish **OR** As indicated, **as directed**.



2. Pultruded Glass-Fiber-Reinforced Gratings: Bar gratings assembled from components made by simultaneously pulling glass fibers and extruding thermosetting plastic resin through a heated die under pressure to produce a product without voids and with a high glass-fiber content.
 - a. Configuration: I4010; 1-inch (25-mm) I-bars spaced 1 inch (25 mm) o.c. (40 percent open) **OR** I6010; 1-inch (25-mm) I-bars spaced 1-1/2 inches (38 mm) o.c. (60 percent open) **OR** I4015; 1-1/2-inch (38-mm) I-bars spaced 1 inch (25 mm) o.c. (40 percent open) **OR** I6015; 1-1/2-inch (38-mm) I-bars spaced 1-1/2 inches (38 mm) o.c. (60 percent open) **OR** T3320; 2-inch (51-mm) T-bars spaced 1-1/2 inches (38 mm) o.c. (33 percent open) **OR** T5020; 2-inch (51-mm) T-bars spaced 2 inches (51 mm) o.c. (50 percent open) **OR** As required to comply with structural performance requirements, **as directed**.
 - b. Weight: 2.35 lb/sq. ft. (11.5 kg/sq. m) **OR** 2.83 lb/sq. ft. (13.8 kg/sq. m) **OR** 3.10 lb/sq. ft. (15.1 kg/sq. m) **OR** 3.41 lb/sq. ft. (16.6 kg/sq. m) **OR** 4.10 lb/sq. ft. (20.0 kg/sq. m) **OR** 4.13 lb/sq. ft. (20.2 kg/sq. m), **as directed**.
 - c. Resin Type: Polyester **OR** Vinylester, **as directed**.
 - 1) Flame-Spread Index: 25 or less when tested according to ASTM E 84.
 - 2) U.S.D.A. Acceptance: Accepted for food processing applications.
 - d. Color: Beige **OR** Gray **OR** Green **OR** Orange **OR** Yellow **OR** Manufacturer's standard, **as directed**.
 - e. Traffic Surface: Plain, grooved **OR** Applied abrasive finish **OR** As indicated, **as directed**.
3. Fabricate cutouts in grating sections for penetrations indicated. Arrange cutouts to permit grating removal without disturbing items penetrating gratings.

K. Grating Frames And Supports

1. Frames and Supports for Metal Gratings: Fabricate from metal shapes, plates, and bars of welded construction to sizes, shapes, and profiles indicated and as necessary to receive gratings. Miter and weld connections for perimeter angle frames. Cut, drill, and tap units to receive hardware and similar items.
 - a. Unless otherwise indicated, fabricate from same basic metal as gratings.
 - b. Equip units indicated to be cast into concrete or built into masonry with integrally welded anchors. Unless otherwise indicated, space anchors 24 inches (600 mm) o.c. and provide minimum anchor units in the form of steel straps 1-1/4 inches (32 mm) wide by 1/4 inch (6 mm) thick by 8 inches (200 mm) long.
2. Frames and Supports for Glass-Fiber-Reinforced Plastic Gratings: Fabricate from glass-fiber-reinforced plastic shapes of sizes, shapes, and profiles indicated and as necessary to receive gratings. Miter connections for perimeter angle frames. Cut, drill, and tap units to receive hardware and similar items.
 - a. Unless otherwise indicated, use shapes made from same resin as gratings.
 - b. Equip units indicated to be cast into concrete or built into masonry with integral anchors.
3. Galvanize steel frames and supports in the following locations:
 - a. Exterior.
 - b. Interior, where indicated.

L. Aluminum Finishes

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

M. Steel Finishes

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Finish gratings, frames, and supports after assembly.
3. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.



- a. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
4. Shop prime gratings, frames and supports not indicated to be galvanized unless otherwise indicated.
 - a. Shop prime with universal shop primer **OR** primers specified in Division 07, **as directed**, unless zinc-rich primer is **OR** primers specified in Division 09 Section "High-performance Coatings" are, **as directed**, indicated.
5. Preparation for Shop Priming: Prepare surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" **OR** SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning" **OR** requirements indicated below, **as directed**:
 - a. Exterior Items: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - c. Items Indicated to Receive Primers Specified in Division 9 Section "High-Performance Coatings": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - d. Other Items: SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
6. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

1.3 EXECUTION

A. Installation, General

1. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing gratings to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.
2. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing gratings. Set units accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.
3. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry.
4. Fit exposed connections accurately together to form hairline joints.
 - a. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade the surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
5. Attach toeplates to gratings by welding at locations indicated.
6. Field Welding: Comply with the following requirements:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
7. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.

B. Installing Metal Bar Gratings

1. General: Install gratings to comply with recommendations of referenced metal bar grating standards that apply to grating types and bar sizes indicated, including installation clearances and standard anchoring details.
2. Attach removable units to supporting members with type and size of clips and fasteners indicated or, if not indicated, as recommended by grating manufacturer for type of installation conditions shown.
3. Attach nonremovable units to supporting members by welding where both materials are same; otherwise, fasten by bolting as indicated above.



- C. Installing Expanded-Metal Gratings
1. General: Comply with manufacturer's written instructions for installing gratings.
 2. Place units with straight edge of bond up and with long direction of diamond-shaped openings parallel to direction of span.
 3. Attach removable units to supporting members by bolting at 6-inch (150-mm) intervals.
 4. Attach nonremovable units to supporting members by welding unless otherwise indicated. Space welds at 6-inch (150-mm) intervals.
 5. Attach aluminum units to steel supporting members by bolting at 6-inch (150-mm) intervals.
 6. Butt edges parallel to long direction of diamond-shaped openings and weld at every second bond point. Place individual grating sections so diamonds of one piece are aligned with those of adjacent sections.
- D. Installing Metal Plank Gratings
1. General: Comply with manufacturer's written instructions for installing gratings. Use manufacturer's standard anchor clips and hold-down devices for bolted connections.
 2. Attach removable units to supporting members by bolting at every point of contact.
 3. Attach nonremovable units to supporting members by welding unless otherwise indicated. Comply with manufacturer's written instructions for size and spacing of welds.
 4. Attach aluminum units to steel supporting members by bolting at side channels at every point of contact and by bolting intermediate planks at each end on alternate sides. Bolt adjacent planks together at midspan.
- E. Installing Glass-Fiber-Reinforced Plastic Gratings
1. Comply with manufacturer's written instructions for installing gratings. Use manufacturer's standard stainless-steel anchor clips and hold-down devices for bolted connections.
- F. Adjusting And Cleaning
1. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 requirements for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.

OR

Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 07.
 2. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

END OF SECTION 05 53 13 00



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Task	Specification	Specification Description
05 53 13 00	01 22 16 00	No Specification Required
05 53 13 00	05 50 00 00	Metal Fabrications
05 54 00 00	05 50 00 00	Metal Fabrications
05 55 13 00	05 50 00 00	Metal Fabrications
05 55 13 00	05 51 13 00	Metal Stairs
05 55 13 00	05 51 13 00a	Fabricated Spiral Stairs
05 55 16 00	05 50 00 00	Metal Fabrications
05 55 16 00	05 51 13 00	Metal Stairs
05 55 16 00	05 51 13 00a	Fabricated Spiral Stairs
05 56 00 00	05 50 00 00	Metal Fabrications



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SECTION 05 58 16 00 - ORNAMENTAL METAL

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for ornamental metal. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Decorative window security bars.
 - b. Decorative mechanical grilles and frames.
 - c. Decorative-metal-clad, hollow-metal doors and frames.
 - d. Custom door pulls.
 - e. Combination hall push-button stations.
 - f. Metal reveals at wood paneling.
 - g. Cast-metal rosettes at marble joints.

C. Submittals

1. Product Data: For each type of product indicated, including finishing materials.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Show fabrication and installation details for decorative metal.
 - a. Include plans, elevations, component details, and attachments to other work.
 - b. Indicate materials and profiles of each decorative metal member, fittings, joinery, finishes, fasteners, anchorages, and accessory items.
4. Patterns, Models, or Plaster Castings: Made from proposed patterns for each design of custom casting required.
5. Samples: For each type of exposed finish required.
 - a. Sections of linear shapes.
 - b. Full-size Samples of castings and forgings.
 - 1) For custom castings, submit finished Samples showing ability to reproduce detail, cast-metal color, and quality of finish. Samples may be of similar previous work.
 - c. Samples of welded and brazed joints showing quality of workmanship and color matching of materials.
6. Qualification Data: For qualified fabricator **OR** organic-coating applicator **OR** anodic finisher **OR** powder-coating applicator, **as directed**.
7. Mill Certificates: Signed by manufacturers of stainless-steel certifying that products furnished comply with requirements.
8. Welding certificates.

D. Quality Assurance

1. Fabricator Qualifications: A firm experienced in producing decorative metal similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
2. Installer Qualifications: Fabricator of products.



3. Organic-Coating Applicator Qualifications: A firm experienced in successfully applying organic coatings, of type indicated, to aluminum extrusions and employing competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.
4. Anodic Finisher Qualifications: A firm experienced in successfully applying anodic finishes of type indicated and employing competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.
5. Powder-Coating Applicator Qualifications: A firm experienced in successfully applying powder coatings of type indicated and employing competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.
6. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - d. AWS D1.6, "Structural Welding Code - Stainless Steel."
7. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling

1. Store decorative metal in a well-ventilated area, away from uncured concrete and masonry, and protected from weather, moisture, soiling, abrasion, extreme temperatures, and humidity.
2. Deliver and store cast-metal products in wooden crates surrounded by sufficient packing material to ensure that products will not be cracked or otherwise damaged.

F. Project Conditions

1. Field Measurements: Verify actual locations of walls and other construction contiguous with decorative metal by field measurements before fabrication and indicate measurements on Shop Drawings.

G. Coordination

1. Coordinate installation of anchorages for decorative metal items. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.2 PRODUCTS

A. Metals, General

1. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. Provide materials without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

B. Aluminum

1. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with strength and durability properties for each aluminum form required not less than that of alloy and temper designated below.
 - a. Extruded Bars and Shapes: ASTM B 221 (ASTM B 221M), Alloy 6063-T5/T52.
 - b. Extruded Structural Pipe and Round Tubing: ASTM B 429/B 429M, Alloy 6063-T6.
 - c. Drawn Seamless Tubing: ASTM B 210 (ASTM B 210M) or ASTM B 483/B 483M, Alloy 6063-T832.
 - d. Plate and Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003-H14 **OR** Alloy 5005-H32 **OR** Alloy 6061-T6, **as directed**.
 - e. Die and Hand Forgings: ASTM B 247 (ASTM B 247M), Alloy 6061-T6.
 - f. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

C. Copper Alloys



1. Copper and Copper Alloys, General: Provide alloys indicated and temper to suit application and forming methods but with strength and stiffness not less than H01 (quarter-hard) for plate, sheet, strip, and bars and H55 (light-drawn) for tube and pipe.
 2. Extruded Shapes, Bronze: ASTM B 455, Alloy UNS No. C38500 (architectural bronze).
 3. Extruded Shapes, Brass: ASTM B 249/B 249M, Alloy UNS No. C36000 (free-cutting brass).
 4. Extruded Shapes, Nickel Silver: ASTM B 249/B 249M, Alloy UNS No. C79600.
 5. Seamless Pipe, Bronze: ASTM B 43, Alloy UNS No. C23000 (red brass, 85 percent copper).
 6. Seamless Tube, Bronze: ASTM B 135 (ASTM B 135M), Alloy UNS No. C23000 (red brass, 85 percent copper).
 7. Seamless Tube, Brass: ASTM B 135 (ASTM B 135M), Alloy UNS No. C26000 (cartridge brass, 70 percent copper).
 8. Seamless Tube, Copper: ASTM B 75 (ASTM B 75M), Alloy UNS No. C12200 (phosphorous deoxidized, high residual phosphorous copper).
 9. Castings, Bronze: ASTM B 62, Alloy UNS No. C83600 (85-5-5-5 or No. 1 composition commercial red brass) or ASTM B 584, Alloy UNS No. C86500 (No. 1 manganese bronze).
 10. Castings, Brass: ASTM B 584, Alloy UNS No. C85200 (high-copper yellow brass).
 11. Castings, Copper: ASTM B 824, with a minimum of 99.9 percent copper.
 12. Castings, Nickel Silver: ASTM B 584, Alloy UNS No. C97300 (12 percent leaded nickel silver).
 13. Plate, Sheet, Strip, and Bars; Bronze: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal, 60 percent copper).
 14. Plate, Sheet, Strip, and Bars; Brass: ASTM B 36/B 36M, Alloy UNS No. C26000 (cartridge brass, 70 percent copper).
 15. Plate, Sheet, Strip, and Bars; Copper: ASTM B 152/B 152M, Alloy UNS No. C11000 (electrolytic tough pitch copper) or UNS No. C12200 (phosphorous deoxidized, high-residual phosphorous copper).
- D. Stainless Steel
1. Tubing: ASTM A 554, Grade MT 304 **OR** Grade MT 316 **OR** Grade MT 316L, **as directed**.
 2. Pipe: ASTM A 312/A 312M, Grade TP 304 **OR** Grade TP 316 **OR** Grade TP 316L, **as directed**.
 3. Castings: ASTM A 743/A 743M, Grade CF 8 or CF 20 **OR** Grade CF 8M or CF 3M, **as directed**.
 4. Sheet, Strip, Plate, and Flat Bar: ASTM A 666, Type 304 **OR** Type 316 **OR** Type 316L, **as directed**.
 5. Bars and Shapes: ASTM A 276, Type 304 **OR** Type 316 **OR** Type 316L, **as directed**.
 6. Wire Rope and Fittings:
 - a. Wire Rope: 1-by-19 **OR** 7-by-7 **OR** 7-by-19, **as directed**, wire rope made from wire complying with ASTM A 492, Type 316.
 - b. Wire-Rope Fittings: Connectors of types indicated, fabricated from stainless steel, and with capability to sustain, without failure, a load equal to minimum breaking strength of wire rope with which they are used.
- E. Steel And Iron
1. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
 2. Tubing: ASTM A 500 (cold formed) or ASTM A 513, Type 5 (mandrel drawn).
 3. Bars: Hot-rolled, carbon steel complying with ASTM A 29/A 29M, Grade 1010.
 4. Plates, Shapes, and Bars: ASTM A 36/A 36M.
 5. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M unless otherwise indicated.
 6. Steel Sheet, Cold Rolled: ASTM A 1008/A 1008M, either commercial steel or structural steel, exposed.
- F. Titanium
1. Titanium Strip, Sheet, and Plate: ASTM B 265, Grade 1.
 2. Titanium Bars: ASTM B 348, Grade 1.



G. Fasteners

1. Fastener Materials: Unless otherwise indicated, provide the following:
 - a. Aluminum Items: Aluminum **OR** Type 304 stainless-steel **OR** Type 316 stainless-steel, **as directed**, fasteners.
 - b. Copper-Alloy (Bronze) Items: Silicon bronze (Alloy 651 or Alloy 655) fasteners where concealed, muntz metal (Alloy 280) fasteners where exposed.
 - c. Copper-Alloy (Brass) Items: Silicon bronze (Alloy 651 or Alloy 655) fasteners where concealed, brass (Alloy 260 or 360) fasteners where exposed.
 - d. Stainless-Steel Items: Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners.
 - e. Titanium Items: Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners.
 - f. Uncoated-Steel Items: Plated steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating where concealed, Type 304 stainless-steel fasteners where exposed.
 - g. Galvanized-Steel Items: Plated steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating.
 - h. Dissimilar Metals: Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners.
2. Fasteners for Anchoring to Other Construction: Unless otherwise indicated, select fasteners of type, grade, and class required to produce connections suitable for anchoring indicated items to other types of construction indicated.
3. Provide concealed fasteners for interconnecting components and for attaching decorative metal items to other work unless otherwise indicated **OR** exposed fasteners are unavoidable, **as directed**.
 - a. Provide Phillips **OR** tamper-resistant **OR** square or hex socket, **as directed**, flat-head machine screws for exposed fasteners unless otherwise indicated.
4. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
5. Post-Installed Anchors: Torque-controlled expansion type or chemical type.
 - a. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5 unless otherwise indicated.
 - b. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**, stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

H. Miscellaneous Materials

1. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 - a. For aluminum, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
2. Brazing Rods: For copper alloys, provide type and alloy as recommended by producer of metal to be brazed and as required for color match, strength, and compatibility in fabricated items.
3. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
4. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
5. Lacquer for Copper Alloys: Clear, acrylic lacquer specially developed for coating copper-alloy products.
6. Shop Primers: Provide primers that comply with Division 07 **OR** Division 09 Section(s) "High-performance Coatings", **as directed**.
7. Universal Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - a. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
8. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.



9. Shop Primer for Galvanized Steel: Cementitious galvanized metal primer complying with MPI#26 **OR** Vinyl wash primer complying with MPI#80 **OR** Water-based galvanized metal primer complying with MPI#134, **as directed**.
10. Intermediate Coats and Topcoats for Steel: Provide products that comply with Division 07 **OR** Division 09 Section(s) "High-performance Coatings" **OR** Division 07 **AND** Division 09 Section(s) "High-performance Coatings", **as directed**.
11. Epoxy Intermediate Coat for Steel: Complying with MPI#77 and compatible with primer and topcoat.
12. Polyurethane Topcoat for Steel: Complying with MPI#72 and compatible with undercoat.
13. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

I. Fabrication, General

1. Assemble items in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.
2. Make up wire-rope assemblies in the shop to field-measured dimensions with fittings machine swaged. Minimize amount of turnbuckle take-up used for dimensional adjustment so maximum amount is available for tensioning wire ropes. Tag wire-rope assemblies and fittings to identify installation locations and orientations for coordinated installation.
3. Form decorative metal to required shapes and sizes, true to line and level with true curves and accurate angles and surfaces. Finish exposed surfaces to smooth, sharp, well-defined lines and arris.
4. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.
5. Form simple and compound curves in bars, pipe, tubing, and extruded shapes by bending members in jigs to produce uniform curvature for each configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces.
6. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
7. Mill joints to a tight, hairline fit. Cope or miter corner joints. Fabricate connections that will be exposed to weather in a manner to exclude water.
8. Provide weep holes where water may accumulate. Locate weep holes in inconspicuous locations.
9. Provide necessary rebates, lugs, and brackets to assemble units and to attach to other work. Cut, reinforce, drill, and tap as needed to receive finish hardware, screws, and similar items unless otherwise indicated.
10. Comply with AWS for recommended practices in shop welding and brazing. Weld and braze behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded and brazed joints of flux, and dress exposed and contact surfaces.
 - a. Where welding and brazing cannot be concealed behind finished surfaces, finish joints to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 1 Welds: no evidence of a welded joint **OR** Type 2 Welds: completely sanded joint, some undercutting and pinholes okay **OR** Type 3 Welds: partially dressed weld with spatter removed **OR** Type 4 Welds: good quality, uniform undressed weld with minimal splatter, **as directed**.
11. Provide castings that are sound and free of warp, cracks, blowholes, or other defects that impair strength or appearance. Grind, wire brush, sandblast, and buff castings to remove seams, gate marks, casting flash, and other casting marks.

J. Decorative Window Security Bars

1. General: Fabricate decorative window grilles to designs indicated from steel bars and shapes of sizes and profiles indicated. Form steel bars by bending, forging, coping, mitering, and welding.
2. Welding: Interconnect grille members with full-length, full-penetration welds unless otherwise indicated. Use welding method that is appropriate for metal and finish indicated and that



develops full strength of members joined. Finish exposed welds and surfaces smooth, flush, and blended to match adjoining surfaces.

3. Brackets, Fittings, and Anchors: Provide wall brackets, fittings, and anchors to connect decorative window grilles to other work unless otherwise indicated.
 - a. Furnish inserts and other anchorage devices to connect decorative window grilles to concrete and masonry work. Coordinate anchorage devices with supporting structure.
 - b. Fabricate anchorage devices that are capable of withstanding loads indicated.

K. Decorative Mechanical Grilles

1. Fabricate decorative grilles from perforated aluminum **OR** brass **OR** bronze **OR** stainless-steel **OR** steel, **as directed**, sheet or plate of thickness, size, and pattern indicated. Form perforations by punching, cutting, or drilling to produce openings of sizes and shapes indicated. Roll, press, and grind perforated metal to flatten and to remove burrs and deformations.
 - a. Form perforations to match existing grilles.
OR
Drawings indicate perforated metal patterns required and are based on products of one manufacturer. Perforated metal patterns produced by other manufacturers may be considered, provided deviations are minor and do not change design concept as judged solely by the Owner.
2. Drill and countersink grilles for mounting screws at 2 inches (50 mm) from corners and at 10 inches (250 mm) or less o.c. Provide units with oval-head wood **OR** self-tapping machine, **as directed**, screws.
3. Fabricate grille frames from extruded aluminum **OR** brass **OR** bronze, **as directed**, of profiles, and to sizes and shapes indicated. Miter frame members at corners and connect with concealed splice plates welded **OR** brazed, **as directed**, to back of frames.
 - a. Secure grilles in frames with 0.5-inch- (12-mm-) long welds **OR** brazing, **as directed**, along perimeter of grilles at 4 inches (100 mm) o.c.
 - b. Provide frame profiles to match existing frames.
OR
Drawings indicate frame profiles required and are based on products of one manufacturer. Similar frame profiles produced by other manufacturers may be considered, provided deviations are minor and do not change design concept as judged solely by the Owner.
4. Drill and countersink frames for mounting screws at 4 inches (100 mm) from corners and at 16 inches (400 mm) or less o.c. Provide units with oval-head wood **OR** self-tapping machine, **as directed**, screws.

L. Decorative-Metal-Clad Doors And Frames

1. Laminate 0.0403-inch- (1.0-mm-) thick, muntz-metal **OR** 0.0403-inch- (1.0-mm-) thick, brass **OR** 0.0375-inch- (0.95-mm-) thick, stainless-steel **OR** 0.024-inch- (0.6-mm-) thick, titanium, **as directed**, sheets to outside face of hollow-metal doors and frames at locations and to comply with details indicated. Use adhesive recommended by metal fabricator that will fully bond metal to metal and that will prevent telegraphing and oil canning.
 - a. Hollow-metal doors and frames are specified in Division 8 Section "Steel Doors and Frames."

M. Custom Door Pulls

1. Fabricate custom door pulls from brass **OR** bronze **OR** stainless-steel, **as directed**, bar stock of profile indicated, fabricated to shapes indicated. Form curves by bending to produce uniform curvature of radii indicated; maintain profile of member throughout entire bend without buckling, twisting, or otherwise deforming exposed surfaces. Where radii of bends are too small to avoid buckling, grind bars after bending to restore original profile. Drill and tap door pulls to receive through bolts for attachment to doors.
2. Fabricate backing plates for custom door pulls from 1/8-inch (3.2-mm) brass **OR** bronze **OR** stainless-steel, **as directed**, sheet. Cut to shape indicated and bevel edges at a 45-degree angle for one-half thickness of metal. Drill and countersink holes where indicated for screws and bolts.



3. Provide units with oval-head through bolts for mounting pulls and with oval-head wood screws for mounting backing plates.
- N. Combination Hall Push-Button Stations
1. Fabricate units of brass **OR** bronze **OR** stainless steel, **as directed**, to comply with details indicated. Coordinate with requirements in Division 14 Section "Electric Traction Elevators" to provide integrated, closely fitted assemblies.
 - a. Fabricate faceplates from 1/8-inch- (3.2-mm-) thick sheet with edges beveled at a 45-degree angle for one-half thickness of metal.
 - b. Provide units with rectangular, split-bowl trash receptacle, designed for recess mounting in nominal 4-inch (100-mm) wall depth. Fabricate recessed cabinets, top rings, and split bowls of same metal as face of units; fabricate removable receptacles of drawn aluminum. Nominal dimensions of units are 10 by 10 by 3-1/2 inches (250 by 250 by 90 mm) in depth.
 - c. Provide units with emergency pictorial signs and text, complying with requirements of authorities having jurisdiction, indicating that in fire emergency, elevators should not be used and that stairways should be used instead. Engrave pictorial sign and text into front surface of faceplates to a depth of 1/16 inch (1.6 mm) with engraving painted red. Make signs 5 inches (125 mm) wide by 8 inches (200 mm) high.
 - d. Provide cutouts in faceplates of units for push buttons of elevator hall push-button station, card reader, **as directed**, and elevator key switches. Coordinate locations and sizes of cutouts so additional faceplate is not required and so faces of push buttons are flush with fronts of faceplates and key switches project beyond faceplate only by depth of bezel.
- O. Metal Reveals
1. Fabricate metal reveals for wood paneling from 3/4-by-3/4-by-1/16-inch (19-by-19-by-3-mm) extruded-bronze **OR** 3/4-by-3/4-by-0.025-inch (19-by-19-by-0.6-mm) brake-formed, stainless-steel **OR** 3/4-by-3/4-by-0.015-inch (19-by-19-by-0.4-mm) brake-formed titanium, **as directed**, channels. Drill for mounting screws 6 inches (150 mm) from ends of channels and not more than 24 inches (600 mm) o.c. Locate mounting screws at same heights for all channels. Provide black-finished, **as directed**, hex-socket, wafer-head screws for mounting reveals.
- P. Cast-Metal Rosettes
1. Fabricate cast-metal rosettes to design indicated from aluminum **OR** brass **OR** bronze **OR** nickel silver, **as directed**. Drill and tap castings for threaded mounting studs.
 - a. Provide custom castings to match design indicated.
 - b. Manufacturer's stock castings may be considered, provided deviations are minor and do not change design concept as judged solely by the Owner.
 - c. Drawings indicate cast-metal rosette designs required and are based on products of one manufacturer. Castings produced by other manufacturers may be considered, provided deviations are minor and do not change design concept as judged solely by the Owner.
- Q. Finishes, General
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- R. Aluminum Finishes
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 2. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
 3. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.



- a. Color: Champagne **OR** Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from full range of industry colors and color densities, **as directed**.
4. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
5. Siliconized Polyester Finish: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
6. High-Performance Organic Finish: Two-coat fluoropolymer finish complying with AAMA 2604 **OR** AAMA 2605, **as directed**, and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

OR

High-Performance Organic Finish: Three **OR** Four, **as directed**, -coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

- b. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

S. Copper-Alloy Finishes

1. Finish designations for copper alloys comply with the system established for designating copper-alloy finish systems defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
2. Buffed Finish: M21 (Mechanical Finish: buffed, smooth specular).
3. Hand-Rubbed Finish: M31-M34 (Mechanical Finish: directionally textured, fine satin; Mechanical Finish: directionally textured, hand rubbed).
4. Medium-Satin Finish: M32 (Mechanical Finish: directionally textured, medium satin).
5. Fine-Matte Finish: M42 (Mechanical Finish: nondirectional finish, fine matte).
6. Buffed Finish, Lacquered: M21-O6x (Mechanical Finish: buffed, smooth specular; Coating: clear organic, air drying, as specified below):
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
7. Hand-Rubbed Finish, Lacquered: M31-M34-O6x (Mechanical Finish: directionally textured, fine satin; Mechanical Finish: directionally textured, hand rubbed; Coating: clear organic, air drying, as specified below):
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
8. Medium-Satin Finish, Lacquered: M32-O6x (Mechanical Finish: directionally textured, medium satin; Coating: clear organic, air drying, as specified below):
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
9. Fine-Matte Finish, Lacquered: M42-O6x (Mechanical Finish: nondirectional finish, fine matte; Coating: clear organic, air drying, as specified below):



- a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
 10. Statuary Conversion Coating over Satin Finish: M31-C55 (Mechanical Finish: directionally textured, fine satin; Chemical Finish: conversion coating, sulfide), with color matching the Owner's sample.
 11. Patina Conversion Coating: M36-C12-C52 (Mechanical Finish: directionally textured, uniform; Chemical Finish: nonetched cleaned, degreased; Chemical Finish: conversion coating, ammonium sulfate), with color matching the Owner's sample.
 12. Statuary Conversion Coating, Bright Relieved and Lacquered: M12-C55-M2x-O6x (Mechanical Finish: matte finish, as cast; Chemical Finish: conversion coating, sulfide; Mechanical Finish: buffed, as specified; Coating: clear, organic, air drying, as specified below), with color matching the Owner's sample:
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
 13. Blackened, Bright Relieved, and Lacquered: M33-O60-M2x-O6x (Mechanical Finish: directionally textured, coarse satin; Coating: black, air drying; Mechanical Finish: buffed, as specified; Coating: clear, organic, air drying, as specified below), with blackening and buffing matching the Owner's sample:
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
- T. Stainless-Steel Finishes
1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 3. Bright, Cold-Rolled, Unpolished Finish: No. 2B.
 4. Directional Satin Finish: No. 4.
 5. Dull Satin Finish: No. 6.
 6. Reflective, Directional Polish: No. 7.
 7. Mirrorlike Reflective, Nondirectional Polish: No. 8.
 8. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 9. Sputter-Coated Finish: Titanium nitride coating deposited by magnetic sputter-coating process over indicated mechanical finish.
 10. Colored, Oxide-Film Finish: Clear, oxide interference film produced by degreasing and then immersing in a mixture of chromic and sulfuric acids.
 - a. Product: Subject to compliance with requirements, provide INCO colored stainless-steel finish as developed and licensed by International Nickel Co., Ltd.
 - b. Color: Match the Owner's sample **OR** As selected from finisher's full range, **as directed**.
- U. Steel And Iron Finishes
1. Galvanizing: Hot-dip galvanize products made from rolled, pressed, and forged steel shapes, castings, plates, bars, and strips indicated to be galvanized to comply with ASTM A 123/A 123M.
 - a. Hot-dip galvanize steel and iron hardware indicated to be galvanized to comply with ASTM A 153/A 153M.
 - b. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
 - c. Fill vent and drain holes that will be exposed in finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
 2. Preparing Galvanized Items for Shop Priming: After galvanizing, thoroughly clean decorative metal of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.



3. Preparing Nongalvanized Items for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" **OR** SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning" **OR** requirements indicated below, **as directed**:
 - a. Exteriors (SSPC Zone 1B): SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Interiors (SSPC Zone 1A): SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
4. Primer Application: Apply shop primer to prepared surfaces of items unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.
 - a. Shop prime uncoated ferrous-metal surfaces with universal shop primer **OR** primers specified in Division 07, **as directed**, unless zinc-rich primer is **OR** primers specified in Division 09 Section "High-performance Coatings" are, **as directed**, indicated.
 - b. Do not apply primer to galvanized surfaces.
5. Shop-Painted Finish: Comply with Division 09 Section(s) "Exterior Painting" **OR** "High-performance Coatings", **as directed**.
 - a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
6. High-Performance Coating: Apply epoxy intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.
 - a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
7. Powder-Coat Finish: Prepare, treat, and coat nongalvanized ferrous metal to comply with resin manufacturer's written instructions and as follows:
 - a. Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Treat prepared metal with iron-phosphate pretreatment, rinse, and seal surfaces.
 - c. Apply thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils (0.04 mm).
 - d. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
8. Powder-Coat Finish: Prepare, treat, and coat galvanized metal to comply with resin manufacturer's written instructions and as follows:
 - a. Prepare galvanized metal by thoroughly removing grease, dirt, oil, flux, and other foreign matter.
 - b. Treat prepared metal with zinc-phosphate pretreatment, rinse, and seal surfaces.
 - c. Apply thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils (0.04 mm).
 - d. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

V. Titanium Finishes

1. General: Fabricate items from finished titanium stock, taking care not to damage finish during fabrication. Protect finish as needed during fabrication by applying a strippable, temporary protective covering.
2. Dull Matte Finish: Pickled and annealed.
3. Bright Matte Finish: Vacuum annealed.

1.3 EXECUTION

A. Examination

1. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of decorative metal.



2. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Installation, General
1. Provide anchorage devices and fasteners where needed to secure decorative metal to in-place construction.
 2. Perform cutting, drilling, and fitting required to install decorative metal. Set products accurately in location, alignment, and elevation, measured from established lines and levels. Provide temporary bracing or anchors in formwork for items to be built into concrete, masonry, or similar construction.
 3. Fit exposed connections accurately together to form tight, hairline joints or, where indicated, uniform reveals and spaces for sealants and joint fillers. Where cutting, welding, and grinding are required for proper shop fitting and jointing of decorative metal, restore finishes to eliminate evidence of such corrective work.
 4. Do not cut or abrade finishes that cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing, or provide new units as required.
 5. Install concealed gaskets, joint fillers, insulation, and flashings as work progresses.
 6. Restore protective coverings that have been damaged during shipment or installation. Remove protective coverings only when there is no possibility of damage from other work yet to be performed at same location.
 - a. Retain protective coverings intact; remove coverings simultaneously from similarly finished items to preclude nonuniform oxidation and discoloration.
 7. Field Welding: Comply with applicable AWS specification for procedures of manual shielded metal arc welding and requirements for welding and for finishing welded connections in "Fabrication, General" Article. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.
 8. Field Brazing: Comply with requirements for brazing and for finishing brazed connections in "Fabrication, General" Article. Braze connections that are not to be left as exposed joints but cannot be shop brazed because of shipping size limitations.
 9. Corrosion Protection: Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
- C. Installing Decorative Window Security Bars
1. Fasten security bar frames to concrete and masonry walls with cast-in-place or postinstalled anchors. Peen exposed threads of anchors to prevent removal of security bars.
- D. Installing Decorative Mechanical Grilles
1. Mount decorative grilles at heights and in positions indicated, adjusting ductwork to be centered on grilles if any.
 - a. Secure to framing and blocking with specified fasteners.
 - b. On marble, brick, and other solid surfaces, secure with wood screws in lead plugs.
- E. Installing Decorative-Metal-Clad, Hollow-Metal Doors And Frames
1. Install doors and frames to comply with requirements specified in Division 08 Section "Hollow Metal Doors And Frames".
- F. Installing Custom Door Pulls
1. Install door pulls at heights and locations shown. Install with backing plates on both sides of doors. Fasten backing plates to doors with oval-head wood **OR** self-tapping metal, **as directed**, screws and secure pulls through doors and backing plates with oval-head machine screws.
- G. Installing Combination Hall Push-Button Stations
1. Coordinate installation of combination hall push-button stations with installation of related elevator signal equipment components specified in Division 14 Section "Electric Traction Elevators". Secure units in place with faceplate overlapping surrounding wall finish and drawn into contact with surrounding wall finish at entire perimeter of faceplate.



- H. Installing Metal Reveals At Wood Paneling
1. Install metal reveals between wood panels as paneling is installed. Secure to wood grounds with specified screws.
- I. Installing Cast-Metal Rosettes At Marble Joints
1. Install cast-metal rosettes at intersections of marble joints where indicated. Install only after marble work is complete and joints are grouted. Secure to wall by drilling a 3/4-inch- (19-mm-) round hole at intersection of marble joints and by filling hole with molding plaster into which threaded stud is embedded. Angle drill and rotate so bottom of hole is larger than at surface.
 - a. Secure rosettes in place with masking tape until plaster sets. After plaster has set, remove masking tape and adhesive residue.
- J. Cleaning And Protection
1. Unless otherwise indicated, clean metals by washing thoroughly with clean water and soap, rinsing with clean water, and drying with soft cloths.
 2. Clean copper alloys according to metal finisher's written instructions in a manner that leaves an undamaged and uniform finish matching approved Sample.
 3. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.

OR

Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 07 OR Division 09 Section(s) "High-performance Coatings" **OR** Division 07 AND Division 09 Section(s) "High-performance Coatings", **as directed.**
 4. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.
 5. Protect finishes of decorative metal from damage during construction period with temporary protective coverings approved by decorative metal fabricator. Remove protective covering at time of Final Completion.
 6. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 05 58 16 00



SECTION 05 58 16 00a - ORNAMENTAL FORMED METAL

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for ornamental formed metal. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Beam wraps.
 - b. Closures and trim.
 - c. Column covers.
 - d. Decorative-metal-clad, hollow-metal doors and frames.
 - e. Elevator cab and entrance finishes.
 - f. Escalator enclosures.
 - g. Filler panels at demountable partitions and/or between dissimilar construction.
 - h. Heating-cooling unit enclosures.
 - i. Lighting coves.
 - j. Metal base.
 - k. Mullion cladding.
 - l. Pipe system covers.
 - m. Pockets for window treatment.
 - n. Window stools.
 - o. Exterior fins.
 - p. Exterior formed-metal-shaped panels.
 - q. Exterior sunshades.
 - r. Exterior trellises.
 - s. Exterior window covers.
 - t. Metal shapes as part of roof construction.

C. Performance Requirements

1. Delegated Design: Design exterior decorative formed metal items, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Decorative formed metal items, including anchors and connections, shall withstand the effects of gravity loads and the following loads and stresses without exceeding the allowable design working stress of materials involved and without exhibiting permanent deformation in any components:
 - a. Wind Loads on Exterior Items: As indicated on Drawings **OR** 20 lbf/sq. ft. (957 Pa) **OR** 30 lbf/sq. ft. (1436 Pa) **OR** As required to meet local Project requirements.
 - b. Live Loads on Heating-Cooling Unit Enclosures: 100 lbf/sq. ft. (4.8 kN/sq. m) or a concentrated load of 300 lbf (1.3 kN) on an area of 4 sq. in. (26 sq. cm), whichever produces the greater stress.
3. Seismic Performance: Exterior decorative formed metal items, including anchors and connections, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. Component Importance Factor is 1.0.
4. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.



- a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
5. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

D. Submittals

1. Product Data: For each type of product indicated. Include finishing materials.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: Show fabrication and installation details for decorative formed metal.
 - a. Include plans, elevations, component details, and attachments to other work.
 - b. Indicate materials and profiles of each decorative formed metal member, fittings, joinery, finishes, fasteners, anchorages, and accessory items.
4. Samples: For each type of exposed finish required, prepared on 6-inch- (150-mm-) square Samples of metal of same thickness and material indicated for the Work.
5. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
6. Coordination Drawings: For decorative formed metal elements that house items specified in other Sections. Show dimensions of housed items, including locations of housing penetrations and attachments, and necessary clearances.
7. Qualification Data: For qualified Installer, fabricator, organic-coating applicator, anodic finisher, powder-coating applicator and professional engineer.
8. Mill Certificates: Signed by stainless-steel manufacturers certifying that products furnished comply with requirements.
9. Welding certificates.
10. Maintenance Data: For mirrorlike stainless-steel finish and statuary conversion coating copper-alloy finish to include in maintenance manuals.

E. Quality Assurance

1. Fabricator Qualifications: A firm experienced in producing decorative formed metal similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
2. Organic-Coating Applicator Qualifications: A firm experienced in successfully applying organic coatings of type indicated to metals of types indicated and that employs competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.
3. Anodic Finisher Qualifications: A firm experienced in successfully applying anodic finishes of type indicated and that employs competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.
4. Powder-Coating Applicator Qualifications: A firm experienced in successfully applying powder coatings of type indicated to metals of types indicated and that employs competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.
5. Installer Qualifications: Fabricator of products.
6. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - d. AWS D1.6, "Structural Welding Code - Stainless Steel."



7. Preinstallation Conference: Conduct conference at Project site.
- F. Delivery, Storage, And Handling
1. Deliver decorative formed metal products wrapped in protective coverings and strapped together in suitable packs or in heavy-duty cartons. Remove protective coverings before they stain or bond to finished surfaces.
 2. Store products on elevated platforms in a dry location.
- G. Project Conditions
1. Field Measurements: Verify actual locations of walls, columns, beams, and other construction contiguous with decorative formed metal by field measurements before fabrication and indicate measurements on Shop Drawings.
- H. Coordination
1. Coordinate installation of anchorages for decorative formed metal items. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
 2. Coordinate installation of decorative formed metal with adjacent construction to ensure that wall assemblies, flashings, trim, and joint sealants, are protected against damage from the effects of weather, age, corrosion, and other causes.

1.2 PRODUCTS

- A. Sheet Metal
1. General: Provide sheet metal without pitting, seam marks, roller marks, stains, discolorations, or other imperfections where exposed to view on finished units.
 2. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
 3. Aluminum Sheet: Flat sheet complying with ASTM B 209 (ASTM B 209M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than strength and durability properties of Alloy 5005-H32.
 4. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating, either commercial steel or forming steel.
 5. Steel Sheet: Uncoated, cold-rolled, ASTM A 1008/A 1008M, commercial steel, exposed or electrolytic zinc-coated, ASTM A 879/A 879M, with steel sheet substrate complying with ASTM A 1008/A 1008M, commercial steel, exposed.
 6. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304 **OR** Type 316, **as directed**, stretcher-leveled standard of flatness.
 7. Bronze Sheet: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal, 60 percent copper) or Alloy UNS No. C23000 (red brass, 85 percent copper).
 8. Brass Sheet: ASTM B 36/B 36M, Alloy UNS No. C26000 (cartridge brass, 70 percent copper).
 9. Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 temper.
 10. Titanium Sheet: ASTM B 265, Grade 1.
- B. Miscellaneous Materials
1. Gaskets: As required to seal joints in decorative formed metal and remain airtight **OR** weathertight, **as directed**; as recommended in writing by decorative formed metal manufacturer.
 - a. ASTM D 1056, Type 1, Class A, grade as recommended by gasket manufacturer to obtain seal for application indicated.
 - b. Closed-cell polyurethane foam, adhesive on two sides, release paper protected.
 2. Sealants, Exterior: ASTM C 920; elastomeric silicone **OR** polyurethane **OR** polysulfide, **as directed**, sealant; of type, grade, class, and use classifications required to seal joints in



- decorative formed metal and remain weathertight; and as recommended in writing by decorative formed metal manufacturer.
3. Sealants, Interior: Nonsag, paintable, nonstaining, latex sealant complying with ASTM C 834; of type and grade required to seal joints in decorative formed metal; and as recommended in writing by decorative formed metal manufacturer.
 - a. Use sealant that has a VOC content of not more than 250 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 4. Filler Metal and Electrodes: Provide type and alloy of filler metal and electrodes as recommended by producer of metal to be welded or brazed and as necessary for strength, corrosion resistance, and compatibility in fabricated items.
 - a. Use filler metals that will match the color of metal being joined and will not cause discoloration.
 5. Fasteners: Fabricated from same basic metal and alloy as fastened metal unless otherwise indicated. Do not use metals that are incompatible with materials joined.
 - a. Provide concealed fasteners for interconnecting decorative formed metal items and for attaching them to other work unless otherwise indicated **OR** exposed fasteners are unavoidable or are the standard fastening method, **as directed**.
 - b. Provide Phillips **OR** tamper-resistant **OR** square or hex socket, **as directed**, flat-head machine screws for exposed fasteners unless otherwise indicated.
 6. Structural Anchors: For applications indicated to comply with certain design loads, provide chemical or torque-controlled expansion anchors with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.
 7. Nonstructural Anchors: For applications not indicated to comply with design loads, provide powder-actuated fasteners **OR** metal expansion sleeve anchors **OR** metal-impact expansion anchors, **as directed**, of type, size, and material necessary for type of load and installation indicated, as recommended by manufacturer, unless otherwise indicated.
 8. Anchor Materials:
 - a. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
 - b. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**, stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).
 9. Sound-Deadening Materials:
 - a. Insulation: Unfaced, mineral-fiber blanket insulation complying with ASTM C 665, Type I, and passing ASTM E 136 test.
 - b. Mastic: Cold-applied asphalt emulsion complying with ASTM D 1187.
 10. Backing Materials: Provided or recommended by decorative formed metal manufacturer.
 11. Laminating Adhesive: Adhesive recommended by metal fabricator that will fully bond metal to metal and that will prevent telegraphing and oil canning and is compatible with substrate and noncombustible after curing.
 - a. Contact Adhesive: VOC content of not more than 80 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Metal-to-Metal Adhesive: VOC content of not more than 30 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - c. Multipurpose Construction Adhesive: VOC content of not more than 70 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - d. Special-Purpose Contact Adhesive: (Contact adhesive used to bond melamine-covered board, metal, unsupported vinyl, ultrahigh molecular weight polyethylene, and rubber or wood veneer, 1/16 inch thick or less, to any surface): 250 g/L.
 12. Isolation Coating: Manufacturer's standard alkali-resistant coating **OR** bituminous paint **OR** epoxy coating, **as directed**.



C. Paints And Coatings

1. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
2. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
3. Lacquer for Copper Alloys: Clear, acrylic lacquer specially developed for coating copper-alloy products.
4. Shop Primers: Comply with Division 07 OR Division 09 Section(s) "High-performance Coatings", **as directed**.
5. Universal Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - a. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
6. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
7. Shop Primer for Galvanized Steel: Cementitious galvanized metal primer complying with MPI#26 **OR** Vinyl wash primer complying with MPI#80 **OR** Water-based galvanized metal primer complying with MPI#134, **as directed**.
8. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

D. Fabrication, General

1. Shop Assembly: Preassemble decorative formed metal items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
2. Coordinate dimensions and attachment methods of decorative formed metal items with those of adjoining construction to produce integrated assemblies with closely fitting joints and with edges and surfaces aligned unless otherwise indicated.
3. Form metal to profiles indicated, in maximum lengths to minimize joints. Produce flat, flush surfaces without cracking or grain separation at bends. Fold back exposed edges of unsupported sheet metal to form a 1/2-inch- (12-mm-) wide hem on the concealed side, or ease edges to a radius of approximately 1/32 inch (1 mm) and support with concealed stiffeners.
4. Increase metal thickness or reinforce with concealed stiffeners, backing materials, or both, as needed to provide surface flatness equivalent to stretcher-leveled standard of flatness and sufficient strength for indicated use.
 - a. Support joints with concealed stiffeners as needed to hold exposed faces of adjoining sheets in flush alignment.
5. Build in straps, plates, and brackets as needed to support and anchor fabricated items to adjoining construction. Reinforce decorative formed metal items as needed to attach and support other construction.
6. Provide support framing, mounting and attachment clips, splice sleeves, fasteners, and accessories needed to install decorative formed metal items.
7. Where welding or brazing is indicated, weld or braze joints and seams continuously. Grind, fill, and dress to produce smooth, flush, exposed surfaces in which joints are not visible after finishing is completed.
 - a. Use welding and brazing procedures that will blend with and not cause discoloration of metal being joined.

E. Beam Wraps

1. Form beam wraps from metal of type and thickness indicated below. Fabricate to fit tightly to adjoining construction.
 - a. Aluminum Sheet: 0.063 inch (1.60 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Baked enamel or powder coat **OR** Siliconized polyester **OR** High-performance organic coating **OR** Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - b. Steel Sheet: 0.060 inch (1.52 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Powder coat, **as directed**.



- c. Stainless-Steel Sheet: 0.050 inch (1.27 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.
2. Fabricate with calk stop angle to retain backer rod and sealant.

F. Closures And Trim

1. Form closures and trim from metal of type and thickness indicated below. Fabricate to fit tightly to adjoining construction, with weathertight joints at exterior installations.
 - a. Aluminum Sheet: 0.063 inch (1.60 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Baked enamel or powder coat **OR** Siliconized polyester **OR** High-performance organic coating **OR** Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - b. Galvanized-Steel Sheet: 0.052 inch (1.32 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Siliconized polyester **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - c. Steel Sheet: 0.048 inch (1.21 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Powder coat, **as directed**.
 - d. Closures and trim may be fabricated from prefinished metal sheet in lieu of finishing after fabrication provided unfinished edges are concealed from view and not exposed to weather.
2. Conceal fasteners where possible; otherwise, locate where they are as inconspicuous as possible. Size fasteners to support closures and trim, with fasteners spaced to prevent buckling or waviness in finished surfaces.
3. Drill and tap holes needed for securing closures and trim to other surfaces.
4. Incorporate gaskets where indicated or needed for concealed, continuous seal at abutting surfaces.
5. Miter or cope trim members at corners and reinforce with bent metal splice plates to form tight joints.

G. Column Covers

1. Spackled-Seam Type: Form column covers from 0.125-inch (3.2-mm) aluminum, rolled to radii indicated. Taper edges of adjoining pieces of column covers, for taping and spackling, to 0.094-inch (2.4-mm) thickness in approximately 1 inch (25 mm) of width. Punch tapered edges for gypsum board screws at 1/2 inch (12 mm) o.c., and mill grooves in tapered edge to improve bond with joint compound.
 - a. Support Framing: At vertical joints, provide 1-1/2-by-3-5/8-inch (38-by-89-mm) steel channel support posts formed from 0.040-inch (1.0-mm) galvanized steel.
 - b. Joint Treatment Materials: Provide joint treatment compounds and reinforcing tape complying with requirements in Division 9 Section "Gypsum Board."
2. Snap-Together Type: Form column covers to shapes indicated from metal of type and minimum thickness indicated below. Return vertical edges and bend to form hook that will engage continuous mounting clips.
 - a. Aluminum Sheet: 0.063 inch (1.60 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Baked enamel or powder coat **OR** Siliconized polyester **OR** High-performance organic coating **OR** Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - b. Steel Sheet: 0.060 inch (1.52 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Powder coat, **as directed**.
 - c. Stainless-Steel Sheet: 0.050 inch (1.27 mm) **OR** Thickness required to comply with performance requirements, **as directed**.



- d. 1) Finish: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.
Bronze Sheet: 0.051 inch (1.29 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Buffed finish, lacquered **OR** Hand-rubbed finish, lacquered **OR** Statuary conversion coating over satin finish, **as directed**.
 - e. Brass Sheet: 0.051 inch (1.29 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: Buffed **OR** Hand-rubbed, **as directed**, finish, lacquered.
 - f. Column covers may be fabricated from prefinished metal sheet in lieu of finishing after fabrication provided unfinished edges are concealed from view.
 - g. Form returns at vertical joints to provide hairline V-joints.
OR
Form returns at vertical joints to provide 1/2-inch- (12-mm-) **OR** 3/4-inch- (18-mm-), **as directed**, wide reveal at joints. Provide snap-in metal filler strips at reveals that leave reveals 1/2 inch (12 mm) deep **OR** flush, **as directed**.
OR
Form returns at vertical joints to accommodate backer rod and sealant.
 - h. Fabricate column covers with hairline horizontal V-joints produced by forming returns on mating ends of column cover sections. Locate horizontal joints as indicated.
OR
Fabricate column covers without horizontal joints.
OR
Fabricate column covers with horizontal butt joints, tightly fitted and backed with a sleeve for field splicing with adhesive.
OR
Fabricate column covers with 1/2-inch- (12-mm-) wide, **as directed**, reveals at horizontal joints produced by forming returns on mating ends of column cover sections. Provide snap-in metal filler strips at reveals matching reveals at vertical joints. Locate horizontal joints as indicated.
 - i. Fabricate base **OR** ceiling, **as directed**, ring to match **OR** contrast with, **as directed**, column covers.
 - j. Fabricate with calk stop/stiffener ring.
 - k. Apply manufacturer's recommended sound-deadening insulation **OR** mastic, **as directed**, to backs of column covers.
- H. Decorative-Metal-Clad Doors And Frames
- 1. Laminate metal sheets, of type and thickness indicated below, to faces of hollow-metal doors and frames and elevator entrances where indicated:
 - a. Bronze Sheet: 0.040 inch (1.02 mm).
 - 1) Finish: Buffed finish, lacquered **OR** Hand-rubbed finish, lacquered **OR** Statuary conversion coating over satin finish, lacquered, **as directed**.
 - b. Brass Sheet: 0.040 inch (1.02 mm).
 - 1) Finish: Buffed **OR** Hand-rubbed, **as directed**, finish lacquered.
 - c. Stainless-Steel Sheet: 0.038 inch (0.95 mm).
 - 1) Finish: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.
 - d. Titanium Sheet: 0.025 inch (0.64 mm).
 - 1) Finish: Dull **OR** Bright, **as directed**, matte.
- I. Escalator Enclosures
- 1. Form escalator enclosures from metal of type and thickness indicated below. Coordinate size of enclosures, location of cutouts, and method of attachment to adjoining construction.
 - a. Stainless-Steel Sheet: 0.062 inch (1.59 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 1) Finish: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.
 - b. Bronze Sheet: 0.081 inch (2.05 mm) **OR** Thickness required to comply with performance requirements, **as directed**.



- 1) Finish: Buffed finish, lacquered **OR** Hand-rubbed finish, lacquered **OR** Statuary conversion coating over satin finish, **as directed**.

J. Filler Panels

1. Form filler panels for closing ends of partition systems and for other applications indicated. Form from two sheets of metal of type and thickness indicated below, separated by channels formed from the same material, producing a panel of same thickness as partitions **OR** mullions, **as directed**, unless otherwise indicated. Incorporate reveals, trim, and concealed anchorages for attaching to adjacent surfaces.
 - a. Galvanized-Steel Sheet: 0.064 inch (1.63 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Siliconized polyester **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - b. Steel Sheet: 0.060 inch (1.52 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Powder coat, **as directed**.
 - c. Filler panels may be fabricated from prefinished metal sheet in lieu of finishing after fabrication provided unfinished edges are concealed from view.
2. Fill interior of panel with sound-deadening insulation permanently attached to inside panel faces.
3. Adhesively attach gaskets to filler panel edges where they abut mullions or glazing. Use 1-inch- (25-mm-) square material, unless otherwise indicated, set approximately 1/4 inch (6 mm) into channeled edge of filler panel.

OR

Attach gaskets to all edges of panels that abut adjacent surfaces to form a continuous seal. Use compressible gaskets or mastic sealing tape, applied to center of panel edges to be concealed from view, unless otherwise indicated.
4. Do not mechanically fasten filler panels to mullions.

K. Heating-Cooling Unit Enclosures

1. Fabricate heating-cooling unit enclosures from metal of type and thickness indicated below:
 - a. Galvanized-Steel Sheet:
 - 1) Framing: 0.108 inch (2.74 mm) **OR** Thickness required to comply with performance requirements.
 - 2) Sills and Stools: 0.079 inch (2.01 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 3) Front Panels and Bases: 0.064 inch (1.63 mm).
 - 4) Concealed Panels and Trim: 0.040 inch (1.02 mm).
 - 5) Finish: Factory primed **OR** Baked enamel **OR** Siliconized polyester **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - b. Steel Sheet:
 - 1) Framing: 0.105 inch (2.66 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 2) Sills and Stools: 0.075 inch (1.90 mm) **OR** Thickness required to comply with performance requirements, **as directed**.
 - 3) Front Panels and Bases: 0.060 inch (1.52 mm).
 - 4) Concealed Panels and Trim: 0.036 inch (0.91 mm).
 - 5) Finish: Factory primed **OR** Baked enamel **OR** Powder coat, **as directed**.
2. Weld seams and connections unless otherwise indicated or unless other methods are necessary for access to heating and cooling equipment.
3. Incorporate stiffeners or laminated backing using noncombustible materials as needed for strength and rigidity.
 - a. Fill space between stiffeners with sound-deadening insulation attached to face sheet with insulation adhesive unless otherwise indicated.

OR

Coat concealed faces of metal panels more than 6 inches (150 mm) wide with a heavy coating of sound-deadening mastic applied at the minimum rate of 20 sq. ft./gal. (0.5 sq. m/L).



4. Provide louvers and grilles of size, type, and materials indicated.
 - a. For removable grilles, use modular units with recessed openings formed into surfaces of enclosures and without blank filler panels between grilles, so face panels and stools are continuous. Fabricate removable grilles and openings to precise tolerances to produce well-fitted assemblies free of warp or rattle, with grilles supported continuously along parallel edges and with tops flush with top of enclosure.
 5. Incorporate removable tops and fronts where indicated or needed for access to heating-cooling units and to piping, ductwork, controls, and electrical service, with panels and openings as follows:
 - a. Fabricate with a fitting tolerance of not less than 1/32 inch (0.8 mm) and not more than 1/16 inch (1.6 mm) at each edge, with face of panels flush with adjoining fixed surfaces of enclosure.
 - b. Form panels for easy removal without interfering with adjoining construction or furniture. Hold panels in place with concealed clips and hardware that prevent warp and rattle.
 6. Incorporate hinged access panels in enclosures for access to heating-cooling unit controls, as either separate elements or integrated with grille openings, as indicated or needed.
 7. Coordinate construction, configuration, and dimensions of enclosures with those of heating-cooling units. Provide support for heating-cooling units and controls where indicated. Provide blind knockouts and supports for piping, ductwork, control lines, electrical conduit, and wiring where indicated or needed.
 8. Locate fixed surfaces of enclosure to coincide precisely with window mullions and partition system terminations. Provide closures at ends of units, at recessed openings in base of units, and at other locations where needed to conceal unfinished wall or floor surfaces, piping, conduit, ductwork, or heating-cooling units.
 - a. Provide built-in partitions (bulkheads) within enclosures between heating-cooling units, located to coincide with mullions and partition system terminations. Seal partitions to faces of enclosures with compressible gaskets or mastic sealing tape, and cover both sides of partitions with sound-deadening insulation attached to partitions with insulation adhesive.
- L. Lighting Coves
1. Form lighting coves from metal of type and thickness indicated below. Coordinate size of coves, location of cutouts for electrical wiring, and method of attachment to adjoining construction.
 - a. Aluminum Sheet: 0.063 inch (1.60 mm).
 - 1) Finish: Baked enamel or powder coat **OR** Siliconized polyester **OR** High-performance organic coating **OR** Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - b. Galvanized-Steel Sheet: 0.052 inch (1.32 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Siliconized polyester **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - c. Steel Sheet: 0.048 inch (1.21 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Powder coat, **as directed**.
 - d. Fabricate light coves with hairline butt joints **OR** tapered edges for taping and spackling, **as directed**.
 - e. Provide mitered corners, factory welded with backplates **OR** factory endcaps, **as directed**.
 - f. Lighting coves may be fabricated from prefinished metal sheet in lieu of finishing after fabrication provided unfinished edges are concealed from view.
- M. Metal Base
1. Form metal base from metal of type and thickness indicated below:
 - a. Aluminum Sheet: 0.063 inch (1.60 mm).
 - 1) Finish: Baked enamel or powder coat **OR** Siliconized polyester **OR** High-performance organic coating **OR** Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - b. Stainless-Steel Sheet: 0.050 inch (1.27 mm).
 - 1) Finish: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.

**N. Mullion Cladding**

1. Form mullion cladding from metal of type and thickness indicated below. Fabricate to fit tightly to adjoining construction.
 - a. Aluminum Sheet: 0.063 inch (1.60 mm).
 - 1) Finish: Baked enamel or powder coat **OR** Siliconized polyester **OR** High-performance organic coating **OR** Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - b. Galvanized-Steel Sheet: 0.052 inch (1.32 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Siliconized polyester **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - c. Stainless-Steel Sheet: 0.050 inch (1.27 mm).
 - 1) Finish: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.

O. Pipe System Covers

1. Form pipe system covers from metal of type and thickness indicated below. Coordinate size of covers, location of cutouts for piping, and method of attachment to adjoining construction.
 - a. Galvanized-Steel Sheet: 0.052 inch (1.32 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Siliconized polyester **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - b. Steel Sheet: 0.048 inch (1.21 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Powder coat, **as directed**.

P. Pockets For Window Treatment

1. Form pockets from metal of type and thickness indicated below, with end closures. Coordinate dimensions and attachment methods with window treatment equipment, window frames, ceiling suspension system, and other related construction to produce a coordinated, closely fitting assembly.
 - a. Aluminum Sheet: 0.063 inch (1.60 mm).
 - 1) Finish: Baked enamel or powder coat **OR** Siliconized polyester **OR** High-performance organic coating **OR** Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - b. Galvanized-Steel Sheet: 0.052 inch (1.32 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Siliconized polyester **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - c. Steel Sheet: 0.048 inch (1.21 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Powder coat, **as directed**.
 - d. Pockets for window treatment may be fabricated from prefinished metal sheet in lieu of finishing after fabrication provided unfinished edges are concealed from view.
2. Reinforce pockets for attaching window treatment equipment and hardware, or increase metal thickness.
3. Divide continuous pockets with built-in partitions located to separate adjoining drapery and blind units, to coincide with window mullions, and to receive filler panels at ends of partitions.

Q. Window Stools

1. Form window stools from metal of type and thickness indicated below, with end closures:
 - a. Aluminum Sheet: 0.063 inch (1.60 mm).
 - 1) Finish: Baked enamel or powder coat **OR** Siliconized polyester **OR** High-performance organic coating **OR** Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - b. Galvanized-Steel Sheet: 0.052 inch (1.32 mm).
 - 1) Finish: Factory primed **OR** Baked enamel **OR** Siliconized polyester **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - c. Stainless-Steel Sheet: 0.050 inch (1.27 mm) **OR** 1.3 mm, **as directed**.
 - 1) Finish: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.
 - d. Bronze Sheet: 0.051 inch (1.29 mm).



- 1) Finish: Buffed finish, lacquered **OR** Hand-rubbed finish, lacquered **OR** Statuary conversion coating over satin finish, **as directed**.
2. Weld seams at end closures.
OR
Braze seams at end closures.
3. Apply sound-deadening insulation **OR** mastic, **as directed**, to underside of window stools.

R. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Complete mechanical finishes of flat sheet metal surfaces before fabrication where possible. After fabrication, finish all joints, bends, abrasions, and other surface blemishes to match sheet finish.
3. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
4. Apply organic and anodic finishes to formed metal after fabrication unless otherwise indicated.
5. Finish items indicated on Drawings after assembly.
6. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

S. Aluminum Finishes

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
3. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - a. Color: Champagne **OR** Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from full range of industry colors and color densities, **as directed**.
4. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
5. Siliconized Polyester Finish: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
6. High-Performance Organic Finish: Two-coat fluoropolymer finish complying with AAMA 2604 **OR** AAMA 2605, **as directed**, and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

OR

High-Performance Organic Finish: Three **OR** Four, **as directed**, -coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
- b. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.



T. Galvanized-Steel Sheet Finishes

1. Preparing Galvanized Items for Factory Priming: Thoroughly clean galvanized decorative formed metal of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.
2. Preparing Galvanized Items for Factory Finishing: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it.
3. Repairing Galvanized Surfaces: Clean welds and abraded areas and repair galvanizing to comply with ASTM A 780.
4. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply shop primer to prepared surfaces of items unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
5. Factory-Painted Finish: Comply with Division 09 Section(s) "Exterior Painting" OR "High-performance Coatings", **as directed**.
 - a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
6. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
7. Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils (0.04 mm). Prepare, treat, and coat metal to comply with resin manufacturer's written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
8. Siliconized-Polyester Coating: Immediately after cleaning and pretreating, apply manufacturer's standard epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
9. High-Performance Organic Finish: Two-coat fluoropolymer finish complying with AAMA 2604 **OR** AAMA 2605, **as directed**, and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

OR

High-Performance Organic Finish: Three **OR** Four, **as directed**, -coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

- a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

U. Steel Sheet Finishes

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, or other contaminants that could impair paint bond. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
2. Pretreatment: Immediately after cleaning, apply a conversion coating of type suited to organic coating applied over it.



3. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply shop primer to prepared surfaces of items unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
4. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
5. Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils (0.04 mm). Prepare, treat, and coat metal to comply with resin manufacturer's written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

V. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
3. Bright, Cold-Rolled, Unpolished Finish: No. 2B.
4. Directional Satin Finish: No. 4.
5. Dull Satin Finish: No. 6.
6. Satin, Reflective, Directional Polish: No. 7.
7. Mirrorlike Reflective, Nondirectional Polish: No. 8 finish.
8. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

W. Copper-Alloy Finishes

1. Finish designations for copper alloys comply with the system established for designating copper-alloy finish systems defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
2. Buffed Finish: M21 (Mechanical Finish: buffed, smooth specular).
3. Hand-Rubbed Finish: M31-M34 (Mechanical Finish: directionally textured, fine satin; Mechanical Finish: directionally textured, hand rubbed).
4. Medium-Satin Finish: M32 (Mechanical Finish: directionally textured, medium satin).
5. Fine-Matte Finish: M42 (Mechanical Finish: nondirectional finish, fine matte).
6. Buffed Finish, Lacquered: M21-O6x (Mechanical Finish: buffed, smooth specular; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
7. Hand-Rubbed Finish, Lacquered: M31-M34-O6x (Mechanical Finish: directionally textured, fine satin; Mechanical Finish: directionally textured, hand rubbed; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
8. Medium-Satin Finish, Lacquered: M32-O6x (Mechanical Finish: directionally textured, medium satin; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
9. Fine-Matte Finish, Lacquered: M42-O6x (Mechanical Finish: nondirectional finish, fine matte; Coating: clear organic, air drying, as specified below).



- a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
10. Statuary Conversion Coating over Satin Finish: M31-C55 (Mechanical Finish: directionally textured, fine satin; Chemical Finish: conversion coating, sulfide), with color matching the Owner's sample.
11. Statuary Conversion Coating over Satin Finish, Lacquered: M31-C55-O6x (Mechanical Finish: directionally textured, fine satin; Chemical Finish: conversion coating, sulfide; Coating: clear, organic, air drying, as specified below) , with color matching the Owner's sample:
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).

X. Titanium Finishes

1. General: Fabricate items from finished titanium sheet, taking care not to damage finish during fabrication. Protect finish as needed during fabrication by applying a strippable, temporary protective covering.
2. Dull Matte Finish: Pickled and annealed.
3. Bright Matte Finish: Vacuum annealed.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of decorative formed metal.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Locate and place decorative formed metal items level and plumb and in alignment with adjacent construction. Perform cutting, drilling, and fitting required to install decorative formed metal.
 - a. Do not cut or abrade finishes that cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing, or provide new units as required.
2. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where needed to protect metal surfaces and to make a weathertight connection.
3. Form tight joints with exposed connections accurately fitted together. Provide reveals and openings for sealants and joint fillers as indicated.
4. Install concealed gaskets, joint fillers, insulation, sealants, and flashings, as the Work progresses, to make exterior decorative formed metal items weatherproof.
5. Install concealed gaskets, joint fillers, sealants, and insulation, as the Work progresses, to make interior decorative formed metal items soundproof or lightproof as applicable to type of fabrication indicated.
6. Corrosion Protection: Apply bituminous paint or other permanent separation materials on concealed surfaces where metals would otherwise be in direct contact with substrate materials that are incompatible or could result in corrosion or deterioration of either material or finish.
7. Install decorative-formed-metal-clad doors and frames to comply with requirements specified in Division 08 Section "Hollow Metal Doors And Frames".
8. Apply joint treatment at joints of spackled-seam-type metal column covers. Comply with requirements in Division 09 Section "Gypsum Board".

C. Adjusting And Cleaning

1. Unless otherwise indicated, clean metals by washing thoroughly with clean water and soap, rinsing with clean water, and drying with soft cloths.



2. Clean copper alloys according to metal finisher's written instructions in a manner that leaves an undamaged and uniform finish matching approved Sample.
 3. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
 4. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 07 OR Division 09 Section(s) "High-performance Coatings" **OR** Division 07 AND Division 09 Section(s) "High-performance Coatings", **as directed**.
 5. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit or provide new units.
- D. Protection
1. Protect finishes of decorative formed metal items from damage during construction period. Remove temporary protective coverings at time of Final Completion.

END OF SECTION 05 58 16 00a



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Task	Specification	Specification Description
05 59 65 00	01 22 16 00	No Specification Required
05 59 65 00	05 58 16 00	Ornamental Metal



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**SECTION 05 73 00 00 - MISCELLANEOUS ORNAMENTAL METALS****1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of Trap Pit Doors; Access to Pipe Trenches; Subway Type Gratings; Manhole, Catch and Retention Basins, Hoods; Iron Fences and Railways, Wicket Guard and Fence; Pipe Railings; Chimney Caps; Cast Iron Sills; Expansion Joints; Chimney Cleanout Doors; Ladders; Ladder Rungs; Retractable Ladders and Balconies, Staircases and Counter-Balanced Stairs; Vent Back Frames in Exhaust Opening of Toilet Rooms; Grilles in Exhaust Openings in Toilet Rooms; Access Doors, Dressing Compartment Seat Frames; Stainless Steel; Lumber Rack; Ganging Rods; Auditorium Loudspeaker Grilles; Bronze Saddles (Exterior), Bronze Expansion Saddles (Interior); Bronze Pipe and Tubes; Aluminum Hat and Coat Racks and Hook Strips; Aluminum Angles for Showers; Aluminum Railings; Miscellaneous Ornamental Metal Work; Hardware.

B. Submittals/Shop Drawings

1. Show all locations, markings, quantities, materials, sizes and shapes.
2. Indicate all methods of connecting, anchoring, fastening, bracing and attaching work of other trades.
3. Do not fabricate until approval of Shop Drawing.
4. Product Design Data: For each type of product indicated in 1.2.

C. Quality Assurance

1. Retractable Ladders, Balconies, and Staircases: For use as a supplemental escape device up to 30 feet (9144 mm), comply with requirements of:
 - a. Underwriters Laboratories Inc. for use as a supplementary means of egress; provide UL listing data.
 - b. ICC International Building Code.
 - c. ICC International Fire Code.
2. For use as a mechanical equipment ladder, comply with requirements of ICC International Mechanical Code.
3. Provide Evaluation Reports showing compliance.

D. Product Handling

1. Before shipment to the job, all finished shall be adequately protected for transporting and erecting periods.
2. Replace damaged items with the approval of the Owner and at no additional cost to the Owner.

1.2 PRODUCTS**A. Frame and Covers**

1. Aluminum: ASTM B 221, 6063-T6.
2. Bronze: ASTM B 455, Alloy C 38500.
3. Stainless Steel: ASTM A 167, Type 304.

B. Gratings

1. Aluminum Grating, Banding, and Kick Plate: Rectangular, pressure-locked bearing bars, ASTM B 221, 6063-T6, mill finish.
2. Steel Grating:
3. Grating: Rectangular, welded, ASTM A 569.
4. Bands and Kick Plate: ASTM A 36.
5. Finish: Galvanized, ASTM A 386, or painted with fabricator's standard shop primer.



- C. Castings (Frames, Covers, Steps, and Sills)
1. Gray Iron: ASTM A 48, Class 30. Malleable Iron, ASTM A 47.
 2. Steel: ASTM A 36; Galvanized, ASTM A 386.
 3. Aluminum: ASTM B 26, 356-T6.
 4. Stainless Steel: ASTM A 743, Grade CF8 or CF20
 5. Bronze: ASTM B 455, Alloy C38500 and ASTM B 135, Alloy C2800.
 6. Corner Protection: Steel angles with anchors, ASTM A 36; Galvanized, ASTM A 386.
 7. Ventilation Boxes: Extruded Aluminum, ASTM B 221, 6063-T6.
- D. Pipe and Tube Railings and Ladders
1. Post and rails: Steel pipe, ASTM A 53, Type E or S, Grade B, Schedule 40.
 2. Bars and Rungs: ASTM A 36.
 3. Finish: Galvanized, ASTM A 386 or shop primer, Fed. Spec. TT-P-86, Type I or II; TT-P-615, Type I, II, or V; TT-P-645.
 4. Aluminum: ASTM B 221, 6063-T6, T-52.
 5. Steel: ASTM A 36, A 500, A 501.
 6. Stainless Steel: ASTM A 544, Grade MT304; ASTM A 312, Grade TP304; ASTM A 167, Type 304.
- E. Retractable Ladders and Balconies
1. Ladders
 - a. Maintenance-free, aluminum and stainless steel construction.
 - b. Rungs: Extruded aluminum, 6005-T5 and 6005-T6 alloy.
 - c. Stiles: Extruded aluminum, 6063-T6 alloy.
 - d. Support 1,000 pounds (454 kg) per rung individually and 200 pounds per 6 feet (90 kg per 1.83 m) of length simultaneously.
 - e. Ground support of gravity loads; building wall support for lateral stability.
 - f. Provide deployment handle at each access level.
 - g. Provide removable deployment handle at lower access point; provide locking hub and padlock.
 - h. Provide dual safety rails at ladders with access from both sides.
 - i. Provide reinforcement channel where ladders extend beyond wall support, such as at parapets and roof tops, or where ladder spans open areas in excess of 5 feet (1524 mm) between attachment points.
 - j. Height: As directed.
 2. Balconies
 - a. Aluminum, 6063-T6 alloy.
 - b. Provide aluminum access balconies at locations as directed.
 - c. Size: As directed.
 - d. Railing: 42-inch (1,067 mm) rail 2 sides, restraining chain 1 side.
 - e. Platform Capacity: 100 pounds per square foot (488 kg/square m), unless directed otherwise.
 - f. Railing Capacity: Uniform load of not less than 50 pounds per lineal foot (74.5 kg per lineal m), unless directed otherwise.
 - g. Balustrade: Not less than 36 inches (914 mm) high.
 - h. Pickets and Rails: Configured not to pass a sphere 4 inches (100 mm) in diameter. Exception; triangular openings formed by riser, tread, and rail, configured not to pass a sphere 6 inches (150 mm) in diameter.
 3. Factory Finish: Clear anodized **OR** Manufacturer's standard shop-applied enamel **OR** As selected from manufacturer's standard colors **OR** Match paint sample supplied by the Owner, **as directed**.
- F. Staircases and Counter-Balanced Stairs
1. Provide aluminum staircases, platforms, and counter-balanced stairs at locations indicated on the drawings.
 2. Platform Capacity: 100 pounds per square foot (488 kg/square m), unless directed otherwise.



3. Railing Capacity: Uniform load of not less than 50 pounds per lineal foot (74.5 kg per lineal m), unless directed otherwise.
4. Required Width: Minimum 36 inches (914 mm).
5. Stair Rise: 4 inches (102 mm) minimum, 10 inches (254 mm) maximum.
6. Treads: 10 inches (254 mm) in depth.
7. Balustrade: Not less than 36 inches (914 mm) high.
8. Pickets and Rails: Configured not to pass a sphere 4 inches (101.6 mm) in diameter.
 - a. Exception: Triangular openings formed by riser, tread, and rail configured not to pass a sphere 6 inches (152.4 mm) in diameter.
 - b. Rail Projection: 3-1/2 inches (89 mm) maximum from each side of stairway into required width.

1.3 EXECUTION

A. Trap Pit Doors

1. Furnish and set trap pit doors and frames flush with the finish floors, pavement, grade or as otherwise required. Doors for interior pits shall be of 1/4 inch checkered steel plate set in angle frames having mitered and welded corners and angle seat for covers, provided with bronze lifting handles. Doors and frames for exterior pits shall be of cast iron and hinged with 3-1/2 x 5 inch extra heavy bronze hinges. All doors shall be provided with locking devices.

B. Access to Pipe Trenches

1. Checkered or flat steel plate access doors to pipe trenches below cellar floors shall be made in accordance with detail. Include angle iron frame, anchors, hardware, etc., complete. The steel plate access doors shall be flush with the adjoining floors. Hinges shall be approved bronze flush type. Provide bronze lift handle and approved locking device for each access door.
2. Doors shall be covered with resilient tile where required. Where cement floors occur, top of steel cover shall be flush, but depressed for other finishes as required by the thickness of floor finish.
See other Sections of Specifications for Finish.
3. All doors under this section unless otherwise specified, shall be secured in place with bronze square shank locking device and brass deck plate with slot and socket holes. Furnish six (6) wrenches for brass deck plates for each different size of locking device.

C. Manhole, Catch and Retention Basins, Hoods

1. Furnish cast iron manhole covers, catch basin covers and cast iron hoods for masonry, manholes, catch basins and retention basins furnished and installed under Division 22 OR Division 28.
2. Manhole covers and frames for catch basins shall be of cast iron, with locking device and key, equal to Flockhart Company No. 35-139.
3. Covers and frames for catch basins shall be of cast iron, with locking device and key, equal to Flockhart Company No. 35-328.
4. Covers and frames for catch basins shall be of cast iron, with locking device and key, equal to Flockhart Company No. 18-919.
5. Cast iron hoods for catch basins and manhole shall be equal to Flockhart Company pattern number indicated.

D. Iron Fences and Railings

1. Furnish and erect iron railings, fences, and gates. Materials of fences and railings shall be medium steel, shapes as required.
2. Posts and braces shall be leaded into cast-iron shoes, which shall be embedded in the concrete pavements or blocks. Center picket of each panel of 6 foot fence shall be leaded 2 inches into curb or pavement. Fences and railings on stone copings, platforms, steps or check blocks shall be leaded into sockets cut in same. Gates shall be hung with hinges. Provide all hasps required for locking gates in both open and closed positions. Double and quadruple gates shall also be furnished with sliding lever bolts and galvanized, malleable iron catches having pipe anchor and



drain embedded in concrete. Gates shall be locked open or closed with Type C Padlocks. Rivet the padlocks to the gates as required. Single gates require 1 padlock; double gates, 2 padlocks; quadruple gates, 4 padlocks.

3. Furnish cast-iron shoes for fence posts and set them at the proper time so that they may be cast into the concrete footing and pavements with top flush with finished surfaces.
4. Folding swing gates shall have fast pin to hold in closed position.
5. Unless otherwise required center rails and side rails on outside steps shall be made of 1-1/4 inch solid posts with 2-1/2 inch by 1/2 inch horizontal flats spaced as required, with top rail of two bronze, aluminum or steel channels and steel stiffener. Post at upper level of center railings shall be of malleable cast iron of height required, tapering from 1-3/4 inches at bottom to 1-1/4 inches at top, with finial. All posts shall be leaded-in 4 inches in cheeks and steps.

E. Wicket Guard and Fence

1. Furnish and install wicket guard fence 12 inches high constructed of 1/2 inch round bent steel rods welded together, to form a continuous wicket fence around the concrete curbing at seeded and planted areas. This guard fence shall be set in concrete footing specified under Division 03 Section "Cast-in-place Concrete".

F. Pipe Railings

1. Furnish and erect wrought iron or steel pipe railings and hand rails together with all fittings, flanges, collars, brackets, bolts, etc. of sizes required, all put together and secured in place in a thorough manner. All pipe railings shall be welded assembly, with continuous "V" joints, full thickness of pipe wall, welds filled solid and ground smooth. All radii, curves, sweeps, bends, etc., as indicated on details for pipe fitting assembly shall be maintained in the welded assembly. For pipe handrails in connection with stairs, see Division 05 Section "Pipe And Tube Railings".
2. Center pipe rails and free standing end pipe railings on outside concrete steps shall be made of 1-1/2 inch nominal diameter pipe and have pipe uprights with cast-iron collar and cap fittings secured in place with tap screws. The uprights shall be leaded-in pipe sleeves. Upright at upper level of center radii shall be of 2 inch nominal diameter pipe with approved cap.
3. Handrails at side of outside steps against walls shall be 1 inch nominal diameter pipes, with returns against wall at ends, and supported on galvanized cast-iron brackets and wall plates same as specified for egress stair.
4. Handrails at side of outside steps against iron fences shall be 1 inch nominal diameter, with returns at ends and supported on wrought iron brackets and plates. Handrails at area walls shall be 1-1/4 inch nominal diameter.
5. All outside pipe railings and handrails including fittings, etc., shall be galvanized after fabrication.
6. Furnish the combined pipe sleeve and base plate and turn over same for setting in concrete work.
7. Exterior barrier rails (at areaways, etc.) shall be of 1-1/2 inch nominal diameter pipe; interior barrier rails (at pits, changes in floor levels, etc.) shall be 1-1/4 inch nominal diameter.

G. Chimney Caps

1. Chimneys shall be provided with cast-iron caps.

H. Cast-Iron Sills

1. Furnish cast-iron sills for exterior doors of bulkheads, etc. The sills shall be set in a bed of cement and be substantially secured with bolts or expansion bolts.

I. Expansion Joints

1. Furnish and install all rolled steel members with required anchors at structural expansion joints through slabs. Items cast in concrete shall be furnished when required for setting. Provide bronze plates as required; top surfaces of plates shall be "BRONZOGRIT" or approved equal.

J. Chimney Cleanout Doors



1. Furnish to the mason proper cleanout doors of sizes indicated for chimneys, of 10 gauge steel plate and steel flats. The doors shall have angle-iron frames with strap anchors. Hang door with two 4 x 4 inch steel hinges and secure door with a latch.
- K. Ladders
1. Furnish and set ladders 18 inches wide, constructed with steel plate stringers, 3/4 inch diameter single rung treads let in and welded to stringers, angle and flat braces, and when required shall have pipe hand rails all riveted together. Secure ladders with angle clip and expansion bolts at top, bottom and elsewhere as required.
- L. Ladder Rungs
1. When ladder rungs are indicated built into mason work, furnish to the mason 5/8 inch galvanized wrought-iron ladder rungs.
 2. Ladder rungs in concrete shall be 15 inches wide and shall be built into concrete every 14 inches in height projecting into walls 4 inches on each side.
 3. Ladder rungs in brickwork of chimney shall be 18 inches wide, and shall be built into brickwork every 5 courses in height, project 8 inches beyond face of wall and continue 8 inches into wall with a 2 inch return. First rung shall start 10 feet above roof level at chimney.
- M. Retractable Ladders, Staircases and Counter-Balanced Stairs
1. Fabrication: Shop fabricate and assemble to maximum extent practicable for installation on-site with minimal labor.
 2. Accessories
 - a. Provide brackets, spacers, etc, necessary for a complete installation.
 - 1) Brackets: 6063-T6 aluminum alloy.
 - 2) Pivot Pins, Springs, Masonry Bolts, Fasteners, and Base Plates: Stainless steel.
 - b. Provide removable deployment handle at lower access point of retractable ladders.
OR
Provide removable deployment handle at lower access point of retractable ladders and locking hub and padlock.
 - c. Fasteners for securement to wood construction: Stainless steel lag bolts; 3/8-inch (9.5 mm) diameter, 4-inches (100 mm) minimum embedment.
 - d. Fasteners for securement to steel construction: Stainless steel bolts, nuts, and washers; 3/8-inch (9.5 mm) diameter.
 3. Footing: Install concrete footing in accordance with manufacturer's requirements, and in compliance with Division 03 Section "Cast-in-place Concrete".
 4. Install components in strict compliance with manufacturer's instructions.
 5. Adjust And Clean
 - a. Adjust operating parts for smooth deployment and storage.
 - b. Remove scraps and debris; leave project site in clean and orderly condition.
 - c. Instruct Owner's representative in proper operation.
- N. Vent Back Frames in Exhaust Opening of Toilet Rooms
1. Furnish and install 12 gauge bent steel frames in exhaust openings in partitions of toilet rooms. Frames shall be set plumb in partitions to receive the vent grilles. Baffle plates are not required.
- O. Grilles in Exhaust Openings
1. Furnish and set in frames at exhaust openings in toilet partitions, approved pressed steel bar type grilles with baked on primer, as manufactured by Tuttle and Bailey, Catalog No. T-80, or approved equal. Grilles shall be secured with tap screws to the frame. The bars of grilles shall be fixed and of rigid construction and shall be set at the angle required. Submit sample of grille for approval.
 2. Furnish and install individually adjustable shutters attached to grille frames, in certain toilets where required. Grilles shall be bar type, equal to Register and Grille Mfg. Co. No. 3311 or Tuttle and Bailey No. A-77.



3. In general, vent openings are provided in partitions of all toilet rooms back of water closets; however, certain smaller toilets, are mechanically vented by means of vent openings in ceiling or in partitions close to ceilings.

P. Access Doors

1. Access doors and frames that are to be furnished and installed as part of the work of this Contract shall be furnished and installed under Division 08 Section "Access Doors And Frames".
2. Access doors and frames that are to be furnished and installed in metal lath and plaster walls and ceilings as part of the work of this Contract shall be constructed of high grade sheet steel with 16 gauge frames and 14 gauge doors. Doors shall be equipped with concealed hinges and cylinder locks all keyed alike (furnish six (6) keys); doors in ceilings may have screwdriver operated type of lock. Doors shall have one piece plain trim set flush with finish surface. Stock doors manufactured by Columbia Metal Product Co., Karp Metal Products Co., or approved equal complying with the specifications, may be accepted. Submit sample for approval if not already approved.

Q. Dressing Compartment Seat Frames

1. Where seats are indicated in dressing compartments, furnish and set 1/4 x 1-1/2 inch flat galvanized bent steel brackets.

R. Stainless Steel

1. Stainless Steel and Cabinet Top Supports: Furnish and install adjustable, stainless steel tubing forming legs to support the tops of sinks and cabinets together with the stainless steel screens, collars, plates, etc., of sizes required. The screens shall be wrapped around and tap screwed to the legs of sink tubing.
2. Stainless Steel Jambs at Dressing Compartments: Furnish and install 14 gauge stainless steel tube jambs at doors to dressing compartments adjoining shower stalls. These jambs shall be anchored to the structural facing tile partition with 14 gauge stainless steel straps.
3. Package Slide: Furnish and install stainless steel half round strips and anchors (type 304 (18-8)) for package slide to Receiving Room. Strips shall be plug welded to anchors.
4. Angle and Channel Guards: Furnish and install angle and channel guards in the kitchen and auxiliary areas. Guards shall be 12 gauge stainless steel satin finish of length and dimensions required, secured in place with oval head stainless steel bolts in expansion shields.
5. Stainless Steel Shelf: Furnish and install stainless steel shelves complete with brackets, of gauges required, generally in helps' locker room, over sinks in locker rooms, in eraser cleaning closets, art room and medical office.
Note: All stainless steel shall be chrome nickel cold rolled alloy designated by trade name Stainless Steel 18-8, No. 4 Finish; it shall contain a minimum of 18% chromium, 8% nickel, and not more than 0.12% carbon, non-magnetic (straight chrome iron not accepted).

S. Lumber Rack

1. Furnish a lumber rack for the woodworking room and general crafts shop, constructed with angles and provided with chains and hoods as required.

T. Hanging Rods

1. Furnish and erect hanging rods of diameters required of wrought-iron or steel pipe supported on approved hangers, brackets or flanges cabinets, closets and elsewhere throughout the building where required.

U. Auditorium Loudspeaker Grilles

1. Furnish and install complete, two (2) loudspeaker grilles in Auditorium. Grilles shall be equal to Blumcraft Deluxe-Line. Grille facets shall have a bronze anodized finish on faces and brushed finish on backs. Supporting bars #258 to have dull black anodized finish.
2. Frame of grilles shall be equal to Blumcraft's trim section WF-4, anodized black, and be secured to masonry with stainless steel screws (slack painted heads) in expansion shields.



3. Sub-frame shall be formed from 1/4" thick aluminum bar with corners mitered, continuously welded and ground smooth and firmly secured in place. Provide continuous piano hinge with 3/16" stop angle.
 4. The inside surface of grille shall be entirely covered with black grille cloth equal to "Acousticloth", as manufactured by Merlang or "Lumite", as manufactured by Chicopee. Grille cloth shall be fastened in place. Submit samples for approval.
 5. Include continuous angles and all other angles, plates, bars and reinforcing channels, all as required.
 6. Contractor is to verify all dimensions at job before fabricating any of the work.
 7. Loudspeaker enclosure and sound absorbing blanket will be furnished and installed as part of the work of Division 27 Section "Public Address And Mass Notification Systems".
- V. Bronze Saddles (Exterior)
1. All exterior door saddles shall be of bronze unless otherwise indicated. White bronze shall be provided for aluminum doors. Finish shall be "Bronzogrit" or an approved equal.
- W. Bronze Expansion Saddles (Interior)
1. Furnish and install bronze expansion saddles generally in the following areas: doors opening off auditorium platform or stage; gymnasium; dance room. None required in store room. Saddles shall consist of bronze flats, plates, and angle clips. Installation shall allow for 3/4 inch expansion. Exposed surfaces of plates and flats shall be "Bronzogrit" or approved equal.
- X. Bronze Pipe and Tubes
1. Furnish 1 inch square bronze tubes in toilet rooms and pipe spaces. Tubes shall be turned over to mason for installation. Tubes shall be of proper length (not less than full thickness of wall) and provided with bronze wire bars at one end.
- Y. Aluminum Hat and Coat Racks and Hook Strips
1. Furnish and install hat and coat racks and hook strips in locations required. Racks and hook strips shall be constructed of aluminum channels, flats and tubing of sizes required, toggle or expansion bolted to walls to suit conditions. Aluminum shall have alumilite finish.
 2. Submit shop drawings for approval.
- Z. Aluminum Angles for Showers
1. Furnish and install aluminum angle bracing as required. Angles shall have alumilite finish. Submit shop drawings for approval prior to fabrication.
- AA. Aluminum Railings
1. Center and side rails and wall handrails shall be of aluminum when required. Posts and horizontal members shall be solid. Posts shall be 1-1/2 inches square, extend through intermediate rails, secured to top rail with 3/8 inch stud bolts; posts at upper level shall be of height indicated, tapering from 1-3/4 inches at bottom to 1-1/4 inches at top, with finial. Posts shall be solidly set with molten sulphur or other approved non-electrolytic material into a combination 1/4 inch pipe sleeve and base plate welded to same, sleeve shall be welded to stair stringer or tread to suit condition, or set in concrete sub-stair.
 2. Exterior Aluminum Railings shall be constructed required. Aluminum posts shall be solid 1-1/2 inches square, extend through bottom rail, let into top rail and continuously welded. Center railing shall have tapered aluminum post of size and taper as required for "center rail". Rails shall be formed to shape indicated from, 3" x 1" solid aluminum flats with rounded edges.
 3. Roof railing shall be as required.
 4. Grab bars in toilets where indicated.
 5. All aluminum railings shall have finish equal to 204-C2 Aluminum Co. of America.
- BB. Miscellaneous Ornamental Metal Work
1. Include all other ornamental metal work. Submit shop drawings for approval.



CC. Hardware

1. All hardware specified under Ornamental Metal Work shall match the approved samples in the office of the Owner. One sample of each item shall be submitted for approval of the Owner.
2. The key to all locks furnished under Ornamental Metal Work shall be provided with brass tags attached to the key with a strong metal ring or link and be similar to the tags specified under Hardware. The tags shall have stamped upon them the letters the Owner and the name or number of the room, closets, etc., for which the keys are intended.
3. All type C padlocks mentioned in this Section will be furnished as specified under Hardware. The Contractor for Ornamental Metal Work shall rivet padlock chains referred to in this Section in place.

DD. Painting

1. All Ornamental Metal Work and cast-iron work excepting cast-iron work to be set in concrete and galvanized items shall be thoroughly cleaned and painted one shop coat specified in Division 07.
2. After installation, all damaged surfaces of shop coat and all rough surfaces shall be scraped or sanded smooth and then touched up.

END OF SECTION 05 73 00 00



SECTION 05 73 00 00a - ORNAMENTAL RAILINGS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for ornamental railings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Aluminum decorative railings with stainless-steel, wire-rope guard infill, **as directed**.
 - b. Copper-alloy decorative railings.
 - c. Stainless-steel decorative railings with stainless-steel, wire-rope guard infill, **as directed**.
 - d. Steel and iron decorative railings with stainless-steel, wire-rope guard infill, **as directed**.
 - e. Glass- and plastic-supported railings.
 - f. Post-supported railings with glass infill.
 - g. Illuminated decorative railings.

C. Definitions

1. Railings: Guards, handrails, and similar devices used for protection of occupants at open-sided floor areas, pedestrian guidance and support, visual separation, or wall protection.

D. Performance Requirements

1. Delegated Design: Design railings, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. General: In engineering railings to withstand structural loads indicated, determine allowable design working stresses of railing materials based on the following:
 - a. Aluminum: The lesser of minimum yield strength divided by 1.65 or minimum ultimate tensile strength divided by 1.95.
 - b. Copper Alloys: 60 percent of minimum yield strength.
 - c. Stainless Steel: 60 percent of minimum yield strength.
 - d. Steel: 72 percent of minimum yield strength.
 - e. Glass: 25 percent of mean modulus of rupture (50 percent probability of breakage), as listed in "Mechanical Properties" in AAMA's Aluminum Curtain Wall Series No. 12, "Structural Properties of Glass."
 - 1) Requirement above is based on the 2006 International Building Code (IBC) for safety factor of 4.
3. Structural Performance: Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - a. Loads below are based on the 2006 International Building Code (IBC).
 - 1) Handrails and Top Rails of Guards:
 - a) Uniform load of 50 lbf/ft. (0.73 kN/m) applied in any direction.
 - b) Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c) Uniform and concentrated loads need not be assumed to act concurrently.
 - 2) Infill of Guards:
 - a) Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b) Infill load and other loads need not be assumed to act concurrently.
 - 3) Glass-Supported Railings: Support each section of top rail by a minimum of three glass panels or by other means so top rail will remain in place if any one panel fails.



4. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.
 - a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
5. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

E. Submittals

1. Product Data: For the following:
 - a. Manufacturer's product lines of railings assembled from standard components.
 - b. Grout, anchoring cement, and paint products.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. For illuminated railings, include wiring diagrams and roughing-in details.
4. Samples: For each type of exposed finish required.
 - a. Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters.
 - b. Each type of glass required.
 - c. Fittings and brackets.
 - d. Welded connections.
 - e. Brazed connections.
 - f. Assembled Samples of railing systems, made from full-size components, including top rail, post, handrail, and infill. Show method of finishing members at intersections. Samples need not be full height.
5. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
6. Qualification Data: For qualified professional engineer **OR** testing agency, **as directed**.
7. Mill Certificates: Signed by manufacturers of stainless-steel products certifying that products furnished comply with requirements.
8. Welding certificates.
9. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

F. Quality Assurance

1. Source Limitations: Obtain each type of railing from single source from single manufacturer.
2. Product Options: Information on Drawings and in Specifications establishes requirements for system's aesthetic effects and performance characteristics. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction. Performance characteristics are indicated by criteria subject to verification by one or more methods including structural analysis, preconstruction testing, field testing, and in-service performance.
 - a. Do not modify intended aesthetic effects, as judged solely by the Owner, except with the Owner's approval. If modifications are proposed, submit comprehensive explanatory data to the Owner for review.
3. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.6, "Structural Welding Code - Stainless Steel."



4. Safety Glazing Labeling: Permanently mark glass with certification label of the SGCC **OR** the SGCC or another certification agency acceptable to authorities having jurisdiction **OR** manufacturer, **as directed**. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Preinstallation Conference: Conduct conference at Project site.

G. Project Conditions

1. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication and indicate measurements on Shop Drawings.

H. Coordination And Scheduling

1. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
2. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
3. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not suit structural performance requirements.

1.2 PRODUCTS

A. Metals, General

1. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
2. Brackets, Flanges, and Anchors: Same metal and finish as supported rails unless otherwise indicated.
 - a. Provide cast-metal brackets with flange tapped for concealed anchorage to threaded hanger bolt.
 - b. Provide either formed- or cast-metal brackets with predrilled hole for exposed bolt anchorage.
 - c. Provide formed-steel brackets with predrilled hole for bolted anchorage and with snap-on cover that matches rail finish and conceals bracket base and bolt head.
 - d. Provide extruded-aluminum brackets with interlocking pieces that conceal anchorage. Locate set screws on bottom of bracket.

B. Aluminum

1. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with strength and durability properties for each aluminum form required not less than that of alloy and temper designated below.
2. Extruded Bars and Shapes, Including Extruded Tubing: ASTM B 221 (ASTM B 221M), Alloy 6063-T5/T52.
3. Extruded Structural Pipe and Round Tubing: ASTM B 429/B 429M, Alloy 6063-T6.
 - a. Provide Standard Weight (Schedule 40) pipe unless otherwise indicated.
4. Drawn Seamless Tubing: ASTM B 210 (ASTM B 210M), Alloy 6063-T832.
5. Plate and Sheet: ASTM B 209 (ASTM B 209M), Alloy 5005-H32 **OR** Alloy 6061-T6, **as directed**.
6. Die and Hand Forgings: ASTM B 247 (ASTM B 247M), Alloy 6061-T6.
7. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.
8. Perforated Metal: Aluminum sheet, ASTM B 209 (ASTM B 209M), Alloy 6061-T6, 0.063 inch (1.60 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.



9. Woven-Wire Mesh: Intermediate-crimp, diamond **OR** square, **as directed**, pattern, 2-inch (50-mm) woven-wire mesh, made from 0.162-inch (4.1-mm) nominal diameter wire complying with ASTM B 211 (ASTM B 211M), Alloy 6061-T94.

C. Copper Alloys

1. Copper and Copper Alloys, General: Provide alloys indicated and with temper to suit application and forming methods, but with strength and stiffness not less than Temper H01 (quarter hard) for plate, sheet, strip, and bars and Temper H55 (light drawn) for tube and pipe.
2. Extruded Shapes, Bronze: ASTM B 455, Alloy UNS No. C38500 (architectural bronze).
3. Extruded Shapes, Brass: ASTM B 249/B 249M, Alloy UNS No. C36000 (free-cutting brass).
4. Extruded Shapes, Nickel Silver: ASTM B 249/B 249M, Alloy UNS No. C79600.
5. Seamless Pipe, Bronze: ASTM B 43, Alloy UNS No. C23000 (red brass, 85 percent copper).
6. Seamless Tube, Bronze: ASTM B 135 (ASTM B 135M), Alloy UNS No. C23000 (red brass, 85 percent copper).
7. Seamless Tube, Brass: ASTM B 135 (ASTM B 135M), Alloy UNS No. C26000 (cartridge brass, 70 percent copper).
8. Seamless Tube, Copper: ASTM B 75 (ASTM B 75M), Alloy UNS No. C12200 (phosphorous deoxidized, high residual phosphorous copper).
9. Castings, Bronze: Composition bronze castings complying with ASTM B 62, Alloy UNS No. C83600 (85-5-5-5 or No. 1 composition commercial red brass) or sand castings complying with ASTM B 584, Alloy UNS No. C86500 (No. 1 manganese bronze).
10. Castings, Brass: Sand castings complying with ASTM B 584, Alloy UNS No. C85200 (high-copper yellow brass).
11. Castings, Copper: ASTM B 824, with a minimum of 99.9 percent copper.
12. Castings, Nickel Silver: ASTM B 584, Alloy UNS No. C97300 (12 percent leaded nickel silver).
13. Plate, Sheet, Strip, and Bars; Bronze: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal, 60 percent copper).
14. Plate, Sheet, Strip, and Bars; Brass: ASTM B 36/B 36M, Alloy UNS No. C26000 (cartridge brass, 70 percent copper).
15. Plate, Sheet, Strip, and Bars; Copper: ASTM B 152/B 152M, Alloy UNS No. C11000 (electrolytic tough pitch copper) or Alloy UNS No. C12200 (phosphorous deoxidized, high-residual phosphorous copper).

D. Stainless Steel

1. Tubing: ASTM A 554, Grade MT 304 **OR** Grade MT 316 **OR** Grade MT 316L, **as directed**.
2. Pipe: ASTM A 312/A 312M, Grade TP 304 **OR** Grade TP 316 **OR** Grade TP 316L, **as directed**.
3. Castings: ASTM A 743/A 743M, Grade CF 8 or CF 20 **OR** Grade CF 8M or CF 3M, **as directed**.
4. Sheet, Strip, Plate, and Flat Bar: ASTM A 666, Type 304 **OR** Type 316 **OR** Type 316L, **as directed**.
5. Bars and Shapes: ASTM A 276, Type 304 **OR** Type 316 **OR** Type 316L, **as directed**.
6. Wire Rope and Fittings:
 - a. Wire Rope: 1-by-19 **OR** 7-by-7 **OR** 7-by-19, **as directed**, wire rope made from wire complying with ASTM A 492, Type 316.
 - b. Wire-Rope Fittings: Connectors of types indicated, fabricated from stainless steel, and with capability to sustain, without failure, a load equal to minimum breaking strength of wire rope with which they are used.
7. Expanded Metal: ASTM F 1267, Type I (expanded) **OR** Type II (expanded and flattened), **as directed**, Class 3 (corrosion-resisting steel), made from stainless-steel sheet complying with ASTM A 666, Type 304 **OR** Type 316, **as directed**.
 - a. Style Designation: 3/4 number 13 **OR** 1-1/2 number 10, **as directed**.
8. Perforated Metal: Stainless-steel sheet, ASTM A 240/A 240M or ASTM A 666, Type 304 **OR** Type 316L, **as directed**, 0.062 inch (1.59 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.



9. Woven-Wire Mesh: Intermediate-crimp, diamond **OR** square, **as directed**, pattern, 2-inch (50-mm) woven-wire mesh, made from 0.135-inch (3.5-mm) nominal diameter wire complying with ASTM A 580/A 580M, Type 304 **OR** Type 316, **as directed**.
- E. Steel And Iron
1. Recycled Content of Steel Products: Provide products with average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
 2. Tubing: ASTM A 500 (cold formed) or ASTM A 513.
 3. Bars: Hot-rolled, carbon steel complying with ASTM A 29/A 29M, Grade 1010.
 4. Plates, Shapes, and Bars: ASTM A 36/A 36M.
 5. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.
 6. Expanded Metal: ASTM F 1267, Type I (expanded) **OR** Type II (expanded and flattened), **as directed**, Class 1 (uncoated).
 - a. Style Designation: 3/4 number 13 **OR** 1-1/2 number 10, **as directed**.
 7. Perforated Metal: Cold-rolled steel sheet, ASTM A 1008/A 1008M, or hot-rolled steel sheet, ASTM A 1011/A 1011M, commercial steel Type B, 0.060 inch (1.52 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.

OR

Perforated Metal: Galvanized-steel sheet, ASTM A 653/A 653M, G90 (Z275) coating, commercial steel Type B, 0.064 inch (1.63 mm) thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows **OR** with 1/8-by-1-inch (3.2-by-25.4-mm) round end slotted holes in staggered rows, **as directed**.
 8. Woven-Wire Mesh: Intermediate-crimp, diamond **OR** square, **as directed**, pattern, 2-inch (50-mm) woven-wire mesh, made from 0.135-inch (3.5-mm) nominal diameter wire complying with ASTM A 510 (ASTM A 510M).
- F. Glass And Glazing Materials
1. Tempered Glass: ASTM C 1048, Kind FT (fully tempered), Condition A (uncoated), Type 1 (transparent flat glass), Quality-Q3. Provide products that have been tested for surface and edge compression according to ASTM C 1048 and for impact strength according to 16 CFR 1201 for Category II materials.
 - a. Glass Color: Clear **OR** Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 - b. Thickness for Structural Glass Balusters: As required by structural loads, but not less than 12.0 **OR** 19.0, **as directed**, mm.
 - c. Thickness for Glass Infill Panels: As required by structural loads, but not less than 6.0 **OR** 10.0, **as directed**, mm.

OR

Thickness: As indicated on Drawings.
 2. Laminated Glass: ASTM C 1172, Condition A (uncoated), Type I (transparent flat glass), Quality-Q3 with two plies of glass and polyvinyl butyral interlayer not less than 0.060 inch (1.52 mm) thick.
 - a. Kind: LA (laminated annealed) **OR** LHS (laminated heat strengthened) **OR** LT (laminated tempered) **OR** As indicated, **as directed**.
 - b. Glass Color: Clear **OR** Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 - c. Interlayer Color: Clear **OR** Blue-green **OR** Bronze light **OR** Gray **OR** As selected from manufacturer's full range, **as directed**.
 - d. Glass Plies for Structural Glass Balusters: Thickness required by structural loads, but not less than 6.0 **OR** 8.0, **as directed**, mm thick, each.
 - e. Glass Plies for Glass Infill Panels: Thickness required by structural loads, but not less than 3.0 **OR** 4.0 **OR** 5.0, **as directed**, mm, each.
 3. Ceramic-Coated Glass: Heat-treated float glass, Condition C; with ceramic enamel applied by silk-screened process; complying with Specification No. 95-1-31 in GANA's "Engineering Standards Manual" and with other requirements specified.



- a. Glass Color: Clear **OR** Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray **OR** As selected from manufacturer's full range, **as directed**.
4. Plastic Structural Glazing: Uncoated, transparent, monolithic acrylic sheet complying with ASTM D 4802, Category A-1 or A-2 (cell cast or continuous cast), Finish 1 (smooth or polished), and as follows:
 - a. Color: Colorless (clear) **OR** Blue **OR** Blue-green **OR** Bronze **OR** Gray **OR** Green **OR** Match glass, **as directed**.
 - b. Thickness: 12.0 mm **OR** Match glass thickness, **as directed**.
5. Glazing Cement and Accessories for Structural Glazing: Glazing cement, setting blocks, shims, and related accessories as recommended or supplied by railing manufacturer for installing structural glazing in metal subrails.
 - a. Glazing Cement: Nonshrinking organic cement designed for curing by passing an electric current through metal subrail holding glass panel, as standard with manufacturer.
6. Glazing Gaskets for Glass Infill Panels: Glazing gaskets and related accessories recommended or supplied by railing manufacturer for installing glass infill panels in post-supported railings.

G. Fasteners

1. Fastener Materials: Unless otherwise indicated, provide the following:
 - a. Aluminum Components: Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners.
 - b. Copper-Alloy (Bronze) Components: Silicon bronze (Alloy 651 or Alloy 655) fasteners where concealed; muntz metal (Alloy 280) fasteners where exposed.
 - c. Copper-Alloy (Brass) Components: Silicon bronze (Alloy 651 or Alloy 655) fasteners where concealed; brass (Alloy 260 or Alloy 360) fasteners where exposed.
 - d. Stainless-Steel Components: Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners.
 - e. Uncoated Steel Components: Plated-steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating where concealed; Type 304 stainless-steel fasteners where exposed.
 - f. Galvanized-Steel Components: Plated-steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating.
 - g. Dissimilar Metals: Type 304 **OR** Type 316, **as directed**, stainless-steel fasteners.
2. Fasteners for Anchoring to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads, **as directed**.
3. Provide concealed fasteners for interconnecting railing components and for attaching railings to other work unless otherwise indicated **OR** exposed fasteners are unavoidable **OR** exposed fasteners are the standard fastening method for railings indicated, **as directed**.
 - a. Provide Phillips **OR** tamper-resistant **OR** square or hex socket, **as directed**, flat-head machine screws for exposed fasteners unless otherwise indicated.
4. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
5. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
 - a. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
 - b. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) **OR** Group 2 (A4), **as directed**, stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

H. Miscellaneous Materials

1. Wood Rails: Clear, straight-grained hardwood rails secured to recessed **OR** exposed, **as directed**, metal subrail.
 - a. Species: Ash **OR** Cherry **OR** Red oak **OR** Walnut **OR** White oak, **as directed**.



- b. Finish: Manufacturer's standard **OR** Transparent polyurethane **OR** Penetrating oil **OR** Acrylic impregnated, **as directed**.
- c. Staining: None **OR** Match the Owner's sample **OR** As selected from manufacturer's full range, **as directed**.
- d. Profile: Square, 1-3/4 by 1-3/4 inches (45 by 45 mm) with edges eased to 1/4-inch (6-mm) radius **OR** Rectangular, 1-3/4 by 5 inches (45 by 127 mm) with edges eased to 1/4-inch (6-mm) radius **OR** Round, 2-inch (50-mm) diameter **OR** As indicated, **as directed**.

OR

Wood Rails: Hardwood rails complying with Division 06 Section "Interior Architectural Woodwork"

- 2. Electrical Components: Provide internal, fluorescent light fixtures and electrical components, required as part of illuminated railings, that comply with NFPA 70 and that are listed and labeled by UL.
- 3. Plastic Handrail Caps: Thermoplastic rail covering, color as indicated or, if not indicated, as selected by the Owner from manufacturer's standard colors.
- 4. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 - a. For aluminum railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
- 5. Brazing Rods: For copper-alloy railings, provide type and alloy as recommended by producer of metal to be brazed and as required for color match, strength, and compatibility in fabricated items.
- 6. Lacquer for Copper Alloys: Clear acrylic lacquer specially developed for coating copper-alloy products.
- 7. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
- 8. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- 9. Shop Primers: Provide primers that comply with Division 07 **OR** Division 09 Section(s) "High-performance Coatings" **OR** Division 07 **AND** Division 09 Section(s) "High-performance Coatings", **as directed**.
- 10. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - a. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
- 11. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
- 12. Shop Primer for Galvanized Steel: Cementitious galvanized metal primer complying with MPI#26 **OR** Vinyl wash primer complying with MPI#80 **OR** Water-based galvanized metal primer complying with MPI#134, **as directed**.
- 13. Intermediate Coats and Topcoats: Provide products that comply with Division 07 **OR** Division 09 Section(s) "High-performance Coatings" **OR** Division 07 **AND** Division 09 Section(s) "High-performance Coatings", **as directed**.
- 14. Epoxy Intermediate Coat: Complying with MPI#77 and compatible with primer and topcoat.
- 15. Polyurethane Topcoat: Complying with MPI#72 and compatible with undercoat.
- 16. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
- 17. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- 18. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.
 - a. Water-Resistant Product: At exterior locations and where indicated provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

I. Fabrication

- 1. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.



2. Assemble railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.
3. Make up wire-rope assemblies in the shop to field-measured dimensions with fittings machine swaged. Minimize amount of turnbuckle take-up used for dimensional adjustment so maximum amount is available for tensioning wire ropes. Tag wire-rope assemblies and fittings to identify installation locations and orientations for coordinated installation.
4. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
5. Form work true to line and level with accurate angles and surfaces.
6. Fabricate connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate. Locate weep holes in inconspicuous locations.
7. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
8. Connections: Fabricate railings with welded or nonwelded connections unless otherwise indicated.
9. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove flux immediately.
 - d. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 1 welds: no evidence of a welded joint.
10. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.
11. Brazed Connections: Connect copper-alloy railings by brazing. Cope components at connections to provide close fit, or use fittings designed for this purpose. Braze corners and seams continuously.
 - a. Use materials and methods that match color of base metal, minimize distortion, and develop maximum strength and corrosion resistance.
 - b. Remove flux immediately.
 - c. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and brazed surface matches contours of adjoining surfaces.
12. Mechanical Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
 - a. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.
13. Form changes in direction as follows:
 - a. As detailed.
OR
By bending or by inserting prefabricated elbow fittings.
OR
By flush bends or by inserting prefabricated flush-elbow fittings.
OR
By radius bends of radius indicated or by inserting prefabricated elbow fittings of radius indicated.
OR
By bending to smallest radius that will not result in distortion of railing member.
14. Bend members in jigs to produce uniform curvature for each configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
15. Close exposed ends of hollow railing members with prefabricated end fittings.



16. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns, unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
 17. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
 - a. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers, or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.
 18. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.
 19. For railing posts set in concrete, provide steel **OR** stainless-steel, **as directed**, sleeves not less than 6 inches (150 mm) long with inside dimensions not less than 1/2 inch (13 mm) greater than outside dimensions of post, with metal plate forming bottom closure.
 20. For removable railing posts, fabricate slip-fit sockets from steel **OR** stainless-steel, **as directed**, tube or pipe whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height. Provide socket covers designed and fabricated to resist being dislodged.
 - a. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.
 21. Expanded-Metal Infill Panels: Fabricate infill panels from stainless-steel **OR** steel, **as directed**, expanded metal unless otherwise indicated.
 - a. Edge panels with U-shaped channels made from same metal as infill; not less than 0.043 inch (1.1 mm) thick.
 - b. Orient expanded metal with long dimension of diamonds parallel to top rail **OR** perpendicular to top rail **OR** horizontal **OR** vertical, **as directed**.
 22. Perforated-Metal Infill Panels: Fabricate infill panels from perforated metal made from steel **OR** galvanized steel **OR** aluminum **OR** stainless steel **OR** same metal as railings in which they are installed, **as directed**.
 - a. Edge panels with U-shaped channels made from metal sheet, of same metal as perforated metal and not less than 0.043 inch (1.1 mm) thick.
 - b. Orient perforated metal with pattern parallel to top rail **OR** perpendicular to top rail **OR** horizontal **OR** vertical **OR** as indicated on Drawings, **as directed**.
 23. Woven-Wire Mesh Infill Panels: Fabricate infill panels from woven-wire mesh crimped into 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) metal channel frames.
 - a. Make wire mesh and frames from aluminum **OR** stainless steel **OR** steel, **as directed**, unless otherwise indicated.
 - b. Orient wire mesh with diamonds vertical **OR** wires perpendicular and parallel to top rail **OR** wires horizontal and vertical, **as directed**.
 24. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.
- J. Glazing Panel Fabrication
1. General: Fabricate to sizes and shapes required; provide for proper edge clearance and bite on glazing panels.
 - a. Clean-cut or flat-grind edges at butt-glazed sealant joints to produce square edges with slight chamfers at junctions of edges and faces
 - b. Grind smooth exposed edges, including those at open joints, to produce square edges with slight chamfers at junctions of edges and faces.
 2. Structural Glass Balusters: Factory-bond glass to aluminum base and top-rail channels in railing manufacturer's plant using glazing cement to comply with manufacturer's written specifications, unless field glazing is standard with manufacturer.
 3. Structural Balusters: Provide tempered **OR** laminated, heat-strengthened **OR** laminated, tempered, **as directed**, glass panels for both straight and curved sections, **as directed**.
OR



Structural Balusters: Provide thermoformed, curved, plastic glazing panels for curved sections and tempered **OR** laminated, heat-strengthened **OR** laminated, tempered, **as directed**, glass panels for straight sections.

OR

Infill Panels: Provide tempered **OR** laminated, annealed **OR** laminated, heat-strengthened **OR** laminated, tempered, **as directed**, glass panels for both straight and curved sections, **as directed**.

K. Illuminated Railings

1. General: Comply with requirements in this Section for aluminum railings with welded connections.
2. Illuminated Units: Provide internal illumination using concealed, internally wired, fluorescent-strip fixture system to illuminate walking surfaces adjacent to railings without light leaks. Make provisions for servicing and for concealed connection to electric service. Coordinate electrical characteristics with those of the power supply provided.
 - a. Fluorescent Tubes: Provide number of tubes indicated or required by railing length.
 - b. Diffusers: UV-stabilized acrylic diffusers matching profile of railings.
 - c. Ballasts: Energy-saving, high power factor, Class P, electromagnetic type; designed for use with high-output lamps, and with automatic-reset thermal protection. Ballasts comply with ANSI C82.1, bear Certified Ballast Manufacturer Certification labels, and are rated for 0 deg F (minus 17 deg C) **OR** minus 20 deg F (minus 29 deg C), **as directed**, starting temperature.

L. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipment.
3. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
4. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

M. Aluminum Finishes

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Mechanical Finish: AA-M3x (Mechanical Finish: as specified); sand top rails, handrails, and intermediate rails in one direction only, parallel to length of railing, with 120- and 320-grit abrasive. After installation, polish railings with No. 0 steel wool immersed in paste wax, then rub to a luster with a soft dry cloth.
3. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
4. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - a. Color: Champagne **OR** Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from full range of industry colors and color densities, **as directed**.
5. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.



6. Siliconized Polyester Finish: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
7. High-Performance Organic Finish: Two-coat fluoropolymer finish complying with AAMA 2604 **OR** AAMA 2605, **as directed**, and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

OR

- High-Performance Organic Finish: Three **OR** Four, **as directed**,-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
- b. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

N. Copper-Alloy Finishes

1. Finish designations for copper alloys comply with the system for designating copper-alloy finish systems defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
2. Buffed Finish: M21 (Mechanical Finish: buffed, smooth specular).
3. Hand-Rubbed Finish: M31-M34 (Mechanical Finish: directionally textured, fine satin; Mechanical Finish: directionally textured, hand rubbed).
4. Medium-Satin Finish: M32 (Mechanical Finish: directionally textured, medium satin).
5. Fine-Matte Finish: M42 (Mechanical Finish: nondirectional finish, fine matte).
6. Buffed Finish, Lacquered: M21-O6x (Mechanical Finish: buffed, smooth specular; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
7. Hand-Rubbed Finish, Lacquered: M31-M34-O6x (Mechanical Finish: directionally textured, fine satin; Mechanical Finish: directionally textured, hand rubbed; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
8. Medium-Satin Finish, Lacquered: M32-O6x (Mechanical Finish: directionally textured, medium satin; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
9. Fine-Matte Finish, Lacquered: M42-O6x (Mechanical Finish: nondirectional finish, fine matte; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
10. Statuary Conversion Coating over Satin Finish: M31-C55 (Mechanical Finish: directionally textured, fine satin; Chemical Finish: conversion coating, sulfide), with color matching the Owner's sample.
11. Patina Conversion Coating: M36-C12-C52 (Mechanical Finish: directionally textured, uniform; Chemical Finish: nonetched cleaned, degreased; Chemical Finish: conversion coating, ammonium sulfate), with color matching the Owner's sample.

O. Stainless-Steel Finishes



1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
3. Directional Satin Finish: No. 4.
4. Dull Satin Finish: No. 6.
5. Satin, Reflective, Directional Polish: No. 7.
6. Mirrorlike Reflective, Nondirectional Polish: No. 8.
7. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
8. Sputter-Coated Finish: Titanium nitride coating deposited by magnetic sputter-coating process over indicated mechanical finish.

P. Steel And Iron Finishes

1. Galvanized Railings:
 - a. Hot-dip galvanize steel **OR** exterior steel, **as directed**, and iron railings, including hardware, after fabrication.
 - b. Hot-dip galvanize indicated steel and iron railings, including hardware, after fabrication.
 - c. Comply with ASTM A 123/A 123M for hot-dip galvanized railings.
 - d. Comply with ASTM A 153/A 153M for hot-dip galvanized hardware.
 - e. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
 - f. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
2. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.
3. Preparing Galvanized Railings for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.
4. For nongalvanized-steel railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors to be embedded in exterior concrete or masonry.
5. Preparing Nongalvanized Items for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" **OR** SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning" **OR** requirements indicated below, **as directed**:
 - a. Exterior Railings: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Railings Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - c. Railings Indicated to Receive Primers Specified in Division 9 Section "High-Performance Coatings": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - d. Other Railings: SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
6. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.
 - a. Shop prime uncoated railings with universal shop primer **OR** primers specified in Division 07, **as directed**, unless zinc-rich primer is **OR** primers specified in Division 09 Section "High-performance Coatings" are, **as directed**, indicated.
 - b. Do not apply primer to galvanized surfaces.
7. Shop-Painted Finish: Comply with Division 09 Section(s) "Exterior Painting" **OR** "High-performance Coatings", **as directed**.
 - a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
8. High-Performance Coating: Apply epoxy intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.



- a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
9. Powder-Coat Finish: Prepare, treat, and coat nongalvanized ferrous metal to comply with resin manufacturer's written instructions and as follows:
 - a. Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Treat prepared metal with iron-phosphate pretreatment, rinse, and seal surfaces.
 - c. Apply thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils (0.04 mm).
 - d. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
10. Powder-Coat Finish: Prepare, treat, and coat galvanized metal to comply with resin manufacturer's written instructions and as follows:
 - a. Prepare galvanized metal by thoroughly removing grease, dirt, oil, flux, and other foreign matter.
 - b. Treat prepared metal with zinc-phosphate pretreatment, rinse, and seal surfaces.
 - c. Apply thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils (0.04 mm).
 - d. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

1.3 EXECUTION

A. Examination

1. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements have been clearly marked for Installer. Locate reinforcements and mark locations if not already done.

B. Installation, General

1. Fit exposed connections together to form tight, hairline joints.
2. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.
 - a. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 - b. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
 - c. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (5 mm in 3 m).
3. Corrosion Protection: Coat concealed surfaces of aluminum and copper alloys that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
4. Adjust railings before anchoring to ensure matching alignment at abutting joints.
5. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

C. Railing Connections

1. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to railing members and fittings. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of railings.
2. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.



3. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches (50 mm) beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches (150 mm) of post.

D. Anchoring Posts

1. Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.
2. Form or core-drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.
3. Cover anchorage joint with flange of same metal as post, welded to post after placing anchoring material **OR** attached to post with set screws, **as directed**.
OR
Leave anchorage joint exposed with 1/8-inch (3-mm) buildup, sloped away from post **OR** anchoring material flush with adjacent surface, **as directed**.
4. Anchor posts to metal surfaces with flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:
 - a. For aluminum railings, attach posts as indicated using fittings designed and engineered for this purpose.
 - b. For copper-alloy railings, attach posts as indicated using fittings designed and engineered for this purpose.
 - c. For stainless-steel railings, weld flanges to posts and bolt to metal-supporting surfaces.
 - d. For steel railings, weld flanges to posts and bolt to metal-supporting surfaces.
5. Install removable railing sections, where indicated, in slip-fit metal sockets cast in concrete.

E. Attaching Railings

1. Anchor railing ends to concrete and masonry with sleeves concealed within **OR** flanges connected to **OR** brackets on underside of rails connected to, **as directed**, railing ends and anchored to wall construction with anchors and bolts.
2. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends or connected to railing ends using nonwelded connections.
3. Attach handrails to walls with wall brackets except where end flanges are used. Provide brackets with 1-1/2-inch (38-mm) clearance from inside face of handrail and finished wall surface. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
 - a. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt **OR** predrilled hole for exposed bolt anchorage, **as directed**.
 - b. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
4. Secure wall brackets and railing end flanges to building construction as follows:
 - a. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
 - b. For hollow masonry anchorage, use toggle bolts.
 - c. For wood stud partitions, use hanger or lag bolts set into wood backing between studs. Coordinate with carpentry work to locate backing members.
 - d. For steel-framed partitions, use hanger or lag bolts set into fire-retardant-treated, **as directed**, wood backing between studs. Coordinate with stud installation to locate backing members.
OR
For steel-framed partitions, fasten brackets directly to steel framing or concealed steel reinforcements using self-tapping screws of size and type required to support structural loads.

**OR**

For steel-framed partitions, fasten brackets with toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

F. Installing Glass Panels

1. Glass-Supported Railings: Install assembly to comply with railing manufacturer's written instructions.
 - a. Attach base channel to building structure, then insert and connect factory-fabricated and -assembled glass panels if glass was bonded to base and top rail channels in factory.
 - b. Attach base channel to building structure, then insert glass into base channel and bond with glazing cement unless glass was bonded to base and top rail channels in factory.
 - 1) Support glass panels in base channel at quarter points with channel-shaped setting blocks that also act as shims to maintain uniform space for glazing cement. Fill remaining space in base channel with glazing cement for uniform support of glass.
 - c. Adjust spacing of glass panels so gaps between panels are equal before securing in position.
 - d. Erect glass railings under direct supervision of manufacturer's authorized technical personnel.
2. Post-Supported Glass Railings: Install assembly to comply with railing manufacturer's written instructions and with requirements in other Part 1.3 articles. Erect posts and other metal railing components, then set factory-cut glass panels. Do not cut, drill, or alter glass panels in field. Protect edges from damage.

G. Installing Plastic Handrail Caps

1. Apply plastic handrail caps to top rails and handrails, where indicated, complying with manufacturer's written instructions for cutting, mounting, forming, welding, cleaning, applying end caps, and finishing.
2. Minimize number of joints in plastic caps by installing in lengths as long as possible. Allow for shortening of plastic cap caused by welding and splicing process; butt ends together to produce hairline joint.
 - a. Continuously weld, splice, miter, and end-cap joints using cap manufacturer's electric welding iron designed for this purpose. Remove welding flash while material is still soft.
 - b. Weld only prongs on underside of plastic cap at splice, miter, and end-cap joints. After cutting plastic cap, dress ends with file to produce a hairline fit between abutting sections. After mounting cap, polish top surface with cap manufacturer's solvent designed for this purpose until joint becomes almost invisible.

H. Field Quality Control

1. Testing Agency: Perform field tests and inspections and prepare test reports.
2. Extent and Testing Methodology: Randomly select completed railing assemblies for testing that are representative of different railing designs and conditions in the completed Work. Railings will be tested according to ASTM E 894 and ASTM E 935 for compliance with performance requirements.
3. Remove and replace railings where test results indicate that they do not comply with specified requirements unless they can be repaired in a manner satisfactory to the Owner and will comply with specified requirements.
4. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Cleaning

1. Clean aluminum and stainless steel by washing thoroughly with clean water and soap, rinsing with clean water, and wiping dry.
2. Clean copper alloys according to metal finisher's written instructions in a manner that leaves an undamaged and uniform finish matching approved Sample.



3. Clean and polish glass and plastic glazing as recommended in writing by manufacturer. Wash both exposed surfaces in each area of Project not more than four days before date scheduled for inspections that establish date of Final Completion.
4. Clean wood rails and plastic handrail caps by wiping with a damp cloth and then wiping dry.
5. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.

OR

Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 07 OR Division 09 Section(s) "High-performance Coatings" **OR** Division 07 AND Division 09 Section(s) "High-performance Coatings", **as directed**.
6. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

J. Protection

1. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Final Completion.
2. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 05 73 00 00a



Task	Specification	Specification Description
05 73 00 00	05 58 16 00	Ornamental Metal
05 75 00 00	05 58 16 00	Ornamental Metal
05 75 00 00	05 73 00 00	Miscellaneous Ornamental Metals
05 75 00 00	05 58 16 00a	Ornamental Formed Metal



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**SECTION 07 05 13 00 - BUILT-UP COAL-TAR ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for built-up coal-tar roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Built-up coal-tar roofing.
 - b. Vapor retarder.
 - c. Roof insulation.
2. Section includes the installation of insulation strips in ribs of acoustical roof deck. Insulation strips are furnished under Division 05 Section "Steel Decking".

C. Definitions

1. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to built-up roofing.
2. Bitumen: A generic term for either asphalt or coal-tar pitch.
3. Hot Coal-Tar Pitch: Coal-tar pitch heated to its equiviscous temperature, the temperature at which its viscosity is 25 centipoise for either mopping or mechanical application, within a range of plus or minus 25 deg F (14 deg C), measured at the mop cart or mechanical spreader immediately before application.
4. Hot Roofing Asphalt: Roofing asphalt heated to its equiviscous temperature, the temperature at which its viscosity is 125 centipoise for mop-applied roofing asphalt and 75 centipoise for mechanical spreader-applied roofing asphalt, within a range of plus or minus 25 deg F (14 deg C), measured at the mop cart or mechanical spreader immediately before application.

D. Performance Requirements

1. General Performance: Installed built-up roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Built-up roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by built-up roofing manufacturer based on testing and field experience.
3. Roofing System Design (if built-up roofing system is to be designed to withstand uplift pressure established by ASCE/SEI 7): Provide built-up roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
 - a. Corner Uplift Pressure: as directed by the Owner.
 - b. Perimeter Uplift Pressure: as directed by the Owner.
 - c. Field-of-Roof Uplift Pressure: as directed by the Owner.
4. FM Approvals Listing (if Project is FM Global insured or if FM Approvals requirements will set a minimum quality standard): Provide built-up roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a built-up roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120, **as directed**.
 - b. Hail Resistance Rating: MH **OR** SH, **as directed**.



5. Energy Performance (if required for LEED-NC Credit SS 7.2): Provide roofing system with initial Solar Reflectance Index not less than 78 when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.
6. Energy Performance (for roofs that must comply with the DOE's ENERGY STAR requirements): Provide roofing system that is listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low-slope roof products.
7. Energy Performance (for roofs that must comply with California Energy Commission's CEC-Title 24): Provide roofing system with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRR-1.

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Test Reports for Credit SS 7.2: For roof materials, indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For built-up roofing. Include plans, elevations, sections, details, and attachments to other work.
 - a. Base flashings and built-up terminations.
 - b. Tapered insulation, including slopes.
 - c. Crickets, saddles, and tapered edge strips, including slopes.
 - d. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.
4. Samples: For the following products:
 - a. Built-up roofing materials, including base sheet, ply sheet and flashing sheet, of color specified.
 - b. Roof insulation.
 - c. 3 lb (1.5 kg) of aggregate surfacing material in gradation and color indicated.
 - d. Walkway pads.
 - e. Six insulation fasteners of each type, length, and finish.
5. Qualification Data: For qualified Installer and manufacturer.
6. Manufacturer Certificates: Signed by roofing manufacturer certifying that built-up roofing complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of compliance with performance requirements.
7. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for components of built-up roofing.
8. Research/Evaluation Reports: For components of built-up roofing, from the ICC-ES **OR** other applicable model code organization, **as directed**.
9. Maintenance Data: For built-up roofing to include in maintenance manuals.
10. Warranties: Sample of special warranties.

F. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer that is UL listed **OR** FM Approvals approved, **as directed**, for built-up roofing identical to that used for this Project.
2. Installer Qualifications (if Project is FM Global insured and if a certified roofing installer is required): A qualified firm that is approved, authorized, or licensed by built-up roofing manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
3. Source Limitations (if required to comply with FM Approvals, UL, or another building code, or to comply with provisions of manufacturer's special warranty): Obtain components including roof insulation and fasteners for built-up roofing from same manufacturer as built-up roofing or approved by built-up roofing manufacturer.
4. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical built-up roofing materials



- by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
5. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 6. Preinstallation Roofing Conference: Conduct conference at Project site.
- G. Delivery, Storage, And Handling
1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
 2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing manufacturer. Protect stored liquid material from direct sunlight.
 - a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
 3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
 4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.
- H. Project Conditions
1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing to be installed according to manufacturer's written instructions and warranty requirements.
- I. Warranty
1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of built-up roofing that fail in materials or workmanship within specified warranty period.
 - a. Special warranty includes built-up roofing membrane, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, roof pavers, and other components of built-up roofing.
 - b. Warranty Period: 10 **OR** 15 **OR** 20 **OR** 25 **OR** 30, **as directed**, years from date of Final Completion.
- 1.2 PRODUCTS
- A. Base-Sheet Materials
1. Sheathing Paper: Red-rosin type, minimum 3 lb/100 sq. ft. (0.16 kg/sq. m).
 2. Base Sheet: ASTM D 4601, Type I **OR** II, **as directed**, nonperforated, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.
OR
Base Sheet: ASTM D 4897, Type II, venting, nonperforated, heavyweight, asphalt-impregnated and -coated, glass-fiber base sheet with coarse granular surfacing or embossed venting channels on bottom surface.
OR
Base Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.
- B. Roofing Membrane Plies
1. Ply Sheet: ASTM D 227, coal-tar-saturated organic felt.
OR



Ply Sheet: ASTM D 4990, Type I, coal-tar-impregnated, glass-fiber felt and the physical properties of ASTM D 2178, Type IV **OR** VI, **as directed**.

C. Base Flashing Sheet Materials

1. Backer Sheet: ASTM D 2178, Type IV, asphalt-impregnated, glass-fiber felt.
OR
Backer Sheet: Roofing manufacturer's standard spun-bonded, nonwoven, polyester-reinforced fabric, of standard color and weight, suitable for application method specified.
2. Granule-Surfaced Flashing Sheet: ASTM D 6164, Grade G, Type I or II, polyester-reinforced, SBS-modified asphalt sheet; granular surfaced base flashing; suitable for application method specified, and as follows:
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.
3. Polyester Flashing Sheet: Roofing manufacturer's standard asphalt-coated, polyester-reinforced fabric, base flashing, suitable for application method specified.
4. Fabric Termination: Roofing manufacturer's standard polyester cloth, suitable for application and for reinforcing top seal of base flashing.

D. Bitumen Materials

1. Asphalt Primer: ASTM D 41.
OR
Coal-Tar Primer: ASTM D 43.
2. Coal-Tar Pitch: ASTM D 450, Type I.
3. Roofing Asphalt: ASTM D 312, Type III **OR** IV **OR** III or IV as recommended by built-up roofing manufacturer for application, **as directed**.
OR
Roofing Asphalt: ASTM D 6152, SEBS modified.

E. Auxiliary Built-Up Roofing Materials

1. General: Auxiliary materials recommended by built-up roofing manufacturer for intended use and compatible with built-up roofing.
 - a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
 - b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Gypsum Board and Panel Adhesives: 50 g/L.
 - 3) Multipurpose Construction Adhesives: 70 g/L.
 - 4) Fiberglass Adhesives: 80 g/L.
 - 5) Contact Adhesives: 80 g/L.
 - 6) Other Adhesives: 250 g/L.
 - 7) Nonmembrane Roof Sealants: 300 g/L.
 - 8) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 9) Sealant Primers for Porous Substrates: 775 g/L.
2. Cold-Applied Adhesive: Roofing manufacturer's standard asphalt-based, one- or two-part, asbestos-free, cold-applied adhesive specially formulated for compatibility and use with built-up base flashings.
3. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required by roofing manufacturer for application.
4. SBS-Modified Asphalt Flashing Cement: Roofing manufacturer's standard, asbestos free, of consistency required for application.
5. Coal-Tar Roofing Cement: ASTM D 5643, coal-tar-based roofing cement, asbestos free.
6. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening built-up roofing components



to substrate, tested by manufacturer for required pullout strength, and acceptable to roofing manufacturer.

7. Metal Flashing Sheet: Metal flashing sheet is specified in Division 07 Section "Sheet Metal Flashing And Trim".
8. Metal Termination Bars: Roofing manufacturer's standard predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.
9. Roof Coatings: ASTM D 2824, Type I, nonfibered **OR** III, fibered, asbestos-free, **as directed**, aluminum-pigmented asphaltic coating.
OR
Roof Coatings: ASTM D 6083, acrylic elastomer emulsion coating, formulated for use on bituminous roof surfaces.
 - a. Color: White **OR** Gray **OR** Buff, **as directed**.
10. Aggregate Surfacing: ASTM D 1863, No. 6 or No. 67, clean, dry, opaque, water-worn gravel or crushed stone, free of sharp edges **OR** crushed slag, free of sharp edges, **as directed**.
11. Walkway Pads: Mineral-granule-surfaced, reinforced asphaltic composition **OR** Polymer-modified, reconstituted solid-rubber, surface-textured, **as directed**, slip-resisting pads, manufactured as a traffic pad for foot traffic and acceptable to built-up roofing manufacturer, 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, thick, minimum.
12. Miscellaneous Accessories: Provide miscellaneous accessories recommended by built-up roofing manufacturer.

F. Substrate Boards

1. Substrate Board: ASTM C 1396/C 1396M, Type X gypsum board, 5/8 inch (16 mm) thick.
OR
Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Substrate Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 728, perlite board, 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick, seal coated.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate board to roof deck.

G. Vapor Retarder

1. Polyethylene Film: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
 - a. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
OR
Adhesive: Manufacturer's standard lap adhesive, FM Approvals approved for vapor-retarder application.
2. Laminated Sheet: Kraft paper/polyethylene laminate, two layers, reinforced with woven fiberglass yarn, laminated and edge reinforced, with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and with manufacturer's standard adhesive, **as directed**.
3. Self-Adhering Sheet Vapor Retarder: ASTM D 1970, minimum of 40-mil- (1.0-mm-) thick, polyethylene film laminated to layer of rubberized asphalt adhesive; maximum permeance rating of 0.1 perm (6 ng/Pa x s x sq. m); cold-applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.
OR
Self-Adhering Sheet Vapor Retarder: 30- to 40-mil- (0.76- to 1.0-mm-) thick, polyethylene film laminated to layer of butyl rubber adhesive; maximum permeance rating of 0.1 perm (6 ng/Pa x s



x sq. m); cold-applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.

4. Glass-Fiber Felts: ASTM D 2178, Type IV, asphalt impregnated.

H. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 **OR** Type II, Class I, Grade 3, **as directed**, felt or glass-fiber mat facer on both major surfaces.
3. Composite Polyisocyanurate Board Insulation: ASTM C 1289, with factory-applied facing board on one major surface, as indicated below by type, and felt or glass-fiber mat facer on the other surface.
 - a. Type IV, cellulosic-fiber-insulating-board facer, Grade 2, 1/2 inch (13 mm) thick.
 - b. Type V, OSB facer, 7/16 inch (11 mm) thick.
 - c. Type VII, glass mat faced gypsum board facer, 1/4 inch (6 mm) thick.
4. Perlite Board Insulation: ASTM C 728, rigid, mineral-aggregate thermal insulation board composed of expanded perlite, cellulosic fibers, binders, and waterproofing agents with top surface seal coated.
5. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 1, fibrous-felted, rigid insulation boards of wood fiber or other cellulosic-fiber and water-resistant binders, asphalt impregnated, chemically treated for deterioration.
6. Cellular-Glass Board Insulation: ASTM C 552, Type IV, rigid, cellular-glass thermal board insulation faced with manufacturer's standard kraft-paper sheets.
7. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/8 inch per 12 inches (1:96) **OR** 1/4 inch per 12 inches (1:48), **as directed**, unless otherwise indicated.
8. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

I. Insulation Accessories

1. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatible with built-up roofing.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation to substrate and acceptable to roofing manufacturer.
3. Modified Asphaltic Insulation Adhesive: Insulation manufacturer's recommended modified asphaltic, asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.
4. Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one- or multicomponent urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
5. Full-Spread Applied Insulation Adhesive: Insulation manufacturer's recommended spray-applied, low-rise, two-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
6. Insulation Cant Strips: ASTM C 728, perlite insulation board.
OR
Insulation Cant Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.
7. Wood Nailer Strips: Comply with requirements in Division 6 Section "Rough Carpentry" **OR** "Miscellaneous Carpentry", **as directed**.
8. Tapered Edge Strips: ASTM C 728, perlite insulation board.
OR
Tapered Edge Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.
9. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, 1/2 inch (13 mm) thick.
OR



Cover Board: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.

OR

Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.

OR

Cover Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.

10. Substrate Joint Tape: 6- or 8-inch- (150- or 200-mm-) wide, coated, glass fiber.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with the following requirements and other conditions affecting performance of roofing system:
 - a. Verify that roof openings and penetrations are in place and curbs are set and braced and that roof drain bodies are securely clamped in place.
 - b. Verify that wood cants, blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
 - c. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Division 5 Section "Steel Deck."
 - d. Verify that deck is securely fastened with no projecting fasteners and with no adjacent units in excess of 1/16 inch (1.6 mm) out of plane relative to adjoining deck.
 - e. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
 - f. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
 - 1) Test for moisture by pouring 1 pint (0.5 L) of hot roofing asphalt on deck at start of each day's work and at start of each roof area or plane. Do not proceed with roofing work if test sample foams or can be easily and cleanly stripped after cooling.
 - g. Verify that concrete curing compounds that will impair adhesion of roofing components to roof deck have been removed.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Prime surface of concrete deck with asphalt **OR** coal-tar, **as directed**, primer at a rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
4. Install insulation strips in ribs of acoustical roof decks according to acoustical roof deck manufacturer's written instructions.

C. Substrate Board Installation

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - a. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.

OR

Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to built-up roofing manufacturers' written instructions.



D. Vapor-Retarder Installation

1. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 - a. Continuously seal side and end laps with tape **OR** adhesive, **as directed**.
2. Laminate Sheet: Install laminate-sheet vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively. Bond vapor retarder to substrate as follows:
 - a. Apply adhesive at rate recommended by vapor-retarder manufacturer. Seal laps with adhesive.
OR
Apply ribbons of hot roofing asphalt at spacing, temperature, and rate recommended by vapor-retarder manufacturer. Seal laps with hot roofing asphalt.
3. Self-Adhering Sheet Vapor Retarder: Prime substrate if required by manufacturer. Install self-adhering sheet vapor retarder over area to receive vapor retarder, side and end lapping each sheet a minimum of 3-1/2 inches (90 mm) and 6 inches (150 mm), respectively. Seal laps by rolling.
4. Built-up Vapor Retarder: Install two glass-fiber felt plies lapping each felt 19 inches (483 mm) over preceding felt. Embed each felt in a solid mopping of hot roofing asphalt. Glaze-coat completed surface with hot roofing asphalt. Apply hot roofing asphalt within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
5. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into built-up roofing system.

E. Insulation Installation

1. Comply with built-up roofing manufacturer's written instructions for installing roof insulation.
2. Install one lapped base sheet course and mechanically fasten to substrate according to built-up roofing manufacturer's written instructions.
3. Nailer Strips: Mechanically fasten 4-inch nominal- (89-mm actual-) width wood nailer strips of same thickness as insulation perpendicular to sloped roof deck, spaced 16 feet (4.88 m) apart for roof slopes greater than 1/4 inch per 12 inches (1:48) **OR** 1/2 inch per 12 inches (1:24), **as directed**.
4. Insulation Cant Strips: Install and secure preformed 45-degree insulation cant strips at junctures of built-up roofing with vertical surfaces or angle changes greater than 45 degrees.
5. Install tapered insulation under area of roofing to conform to slopes indicated.
6. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - a. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
7. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.
 - a. Where installing composite and noncomposite board insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
8. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
9. Install tapered edge strips at perimeter edges of roof that do not terminate at vertical surfaces.
10. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
 - a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
 - b. Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
OR



- Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
- OR**
- Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
11. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
- a. If Project is FM Global insured or if FM Approvals requirements are proposed as a performance standard, fasten insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
- b. If number of fasteners will be based on ASCE/SEI 7's uplift pressure, fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.
12. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
- a. If Project is FM Global insured or if FM Approvals requirements are proposed as a performance standard, fasten first layer of insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
- b. If fastening is calculated from ASCE/SEI 7's uplift pressure, fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
- c. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
- OR**
- Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
- OR**
- Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
13. If cover boards will be field installed over roof insulation and immediately below built-up roofing, install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together and fasten to roof deck, **as directed**. Tape joints if required by roofing manufacturer.
- a. Fasten cover boards according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
- OR**
- Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.
- b. Apply hot roofing asphalt to underside and immediately bond cover board to substrate.
- F. Built-Up Roofing Installation, General
1. If referencing NRCA's roof assembly identification matrix system, install roofing membrane according to roofing manufacturer's written instructions and applicable recommendations of ARMA/NRCA's "Quality Control Guidelines for the Application of Built-up Roofing."
- a. Install roofing system BU-3 **OR** 4 **OR** 5, **as directed**, -N **OR** I **OR** C, **as directed**, -A-A, according to roof assembly identification matrix and roof assembly layout illustrations in NRCA's "The NRCA Roofing and Waterproofing Manual" and requirements in this Section.
2. For roofing that exceeds requirements of NRCA's roof assemblies, install built-up roofing membrane according to roofing manufacturer's written instructions and applicable recommendations of ARMA/NRCA's "Quality Control Guidelines for the Application of Built-up Roofing" and as follows:
- a. Deck Type: N (nailable) **OR** I (insulated) **OR** C (concrete or nonnailable), **as directed**.
- b. Base Sheet: 1 **OR** 1, installed over sheathing paper, **as directed**.
- c. Number of Organic Felt Ply Sheets: 2 **OR** 3 **OR** 4, **as directed**.
- d. Number of Glass Fiber Ply Sheets: 1, top ply **OR** 2 **OR** 3 **OR** 4, **as directed**.
- e. Surfacing Type: A (aggregate).



3. Start installation of built-up roofing in presence of manufacturer's technical personnel.
 4. Where roof slope exceeds 1/4 inch per 12 inches (1:48) **OR** 1/2 inch per 12 inches (1:24), **as directed**, install built-up roofing sheets parallel with slope.
 - a. Backnail built-up roofing sheets to nailer strips **OR** substrate, **as directed**, according to roofing manufacturer's written instructions.
 5. Cooperate with testing agencies engaged or required to perform services for installing roofing system.
 6. Coordinate installation of built-up roofing so insulation and other components of built-up roofing not permanently exposed are not subjected to precipitation or left uncovered at the end of the workday or when rain is forecast.
 - a. Provide tie-offs at end of each day's work to cover exposed built-up roofing sheets and insulation with a course of coated felt set in roofing cement or hot roofing asphalt with joints and edges sealed.
 - b. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system.
 - c. Remove and discard temporary seals before beginning work on adjoining roofing.
 7. Bitumen Heating: Do not raise bitumen temperature above equiviscous temperature range more than one hour before time of application. Do not exceed bitumen manufacturer's recommended temperature limits during bitumen heating. Do not heat bitumen within 25 deg F (14 deg C) of flash point. Discard bitumen maintained for more than 4 hours at a temperature exceeding 325 deg F (163 deg C) for coal-tar pitch or finished blowing temperature for roofing asphalt, **as directed**.
 - a. Mopping Weights: For interply and other moppings, unless otherwise indicated, apply solid moppings of hot coal-tar pitch between ply sheets at a minimum rate of 20 lb/100 sq. ft. (1 kg/sq. m).
 8. SEBS-Asphalt Heating: Heat and apply SEBS-modified roofing asphalt according to roofing manufacturer's written instructions.
 9. Substrate-Joint Penetrations: Prevent bitumen and adhesives from penetrating substrate joints, entering building, or damaging built-up roofing components or adjacent building construction.
- G. Roofing Membrane Installation
1. If sheathing paper is required over wood decks by built-up roofing manufacturer, loosely lay one course of sheathing paper, lapping edges and ends a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 2. Install lapped base sheet course, extending sheet over and terminating beyond cants. Attach base sheet as follows:
 - a. Mechanically fasten to substrate, for nailable substrate.
OR
Spot- or strip-mop to substrate with hot roofing asphalt.
OR
Adhere to substrate in a solid mopping of hot roofing asphalt **OR** uniform coating of cold-applied adhesive, **as directed**, for nonnailable or insulated substrates.
 3. Monolithic Membrane: Install two **OR** three **OR** four, **as directed**, ply sheets starting at low point of roofing system. Align ply sheets without stretching. Shingle side laps of ply sheets uniformly to achieve required number of plies throughout thickness of roofing membrane. Shingle in direction to shed water. Extend ply sheets over and terminate beyond cants. Embed each ply sheet in a solid mopping of hot coal-tar pitch to form a uniform membrane without ply sheets touching.
OR
Composite Membrane: Install two **OR** three **OR** four, **as directed**, organic felt ply sheets starting at low point of roofing system. Align organic felt ply sheets without stretching. Shingle side laps of organic felt ply sheets uniformly to achieve required number of plies throughout thickness of roofing membrane. Shingle in direction to shed water.
 - a. Install finish layer of one lapped coal-tar, glass-fiber ply sheet course over shingled organic felt ply sheets, starting at low point of built-up roofing. Offset laps from laps of preceding



- ply sheets and align coal-tar, glass-fiber ply sheet without stretching. Lap in direction to shed water.
- b. Extend ply sheets over and terminate beyond cants.
 - c. Embed each ply sheet in a solid mopping of hot coal-tar pitch applied at rate required by built-up roofing manufacturer, to form a uniform membrane without ply sheets touching.
4. If delayed flood coating and aggregate surfacing of coal-tar, glass-fiber membrane or finish layer are permitted, glaze-coat roofing membrane surface with hot coal-tar pitch applied at a rate of 10 to 15 lb/100 sq. ft. (0.5 to 0.75 kg/sq. m) if aggregate surfacing is not applied immediately.
 5. Aggregate Surfacing: If surfacing roofing membrane with aggregate, promptly after installing and testing roofing membrane, base flashing, and stripping, flood-coat roof surface with 70 lb/100 sq. ft. (3.5 kg/sq. m) of hot coal-tar pitch. While flood coat is hot and fluid, cast the following average weight of aggregate in a uniform course:
 - a. Aggregate Weight: 400 lb/100 sq. ft. (20 kg/sq. m) for gravel or crushed stone or 300 lb/100 sq. ft. (15 kg/sq. m) for slag.
 - b. Sweep loose aggregate from roof surface and apply another flood coat of not less than 85 lb/100 sq. ft. (4.15 kg/sq. m) of hot coal-tar pitch. While flood coat is hot and fluid, apply a uniform course of aggregate at the following rate. Sweep away loose aggregate and fully embed aggregate by lightly rolling into finished roof surface.
 - 1) Aggregate Weight: 300 lb/100 sq. ft. (15 kg/sq. m) for gravel or crushed stone 200 lb/100 sq. ft. (10 kg/sq. m) for slag, average.
 6. Walkway Pads: Install walkway pads using units of size indicated or, if not indicated, of manufacturer's standard size according to walkway pad manufacturer's written instructions.
 - a. Sweep away loose aggregate surfacing and set walkway pads in additional flood coat of hot coal-tar pitch.

H. Flashing And Stripping Installation

1. Install base flashing over cant strips and other sloping and vertical surfaces, at roof edges, and at penetrations through roof, and secure to substrates according to built-up roofing manufacturer's written instructions and as follows:
 - a. Prime substrates with asphalt primer if required by built-up roofing manufacturer.
 - b. Backer Sheet Application: Install single backer sheet and adhere to substrate in a solid mopping of hot roofing asphalt **OR** asphalt roofing cement **OR** SBS-modified asphalt roofing cement **OR** cold-applied adhesive, **as directed**.
OR
Backer Sheet Application: Install two **OR** three, **as directed**, backer sheets and adhere to substrate in a solid mopping of hot roofing asphalt **OR** asphalt roofing cement, **as directed**.
 - c. Flashing Sheet Application: Adhere flashing sheet to substrate in a solid mopping of hot roofing asphalt applied at not less than 425 deg F (218 deg C). Apply hot roofing asphalt to back of flashing sheet if recommended by roofing manufacturer.
OR
Flashing Sheet Application: Adhere flashing sheet to substrate in SBS-modified asphalt roofing cement **OR** asphalt roofing cement, **as directed**.
2. Extend base flashing up walls or parapets a minimum of 8 inches (200 mm) above built-up roofing and 4 inches (100 mm) onto field of built-up roofing.
3. Mechanically fasten top of base flashing securely at terminations and perimeter of roofing.
 - a. Securely fasten top termination of base flashing with continuous metal termination bar anchored into substrate.
 - b. Seal top termination of base flashing with a strip of glass-fiber fabric set in asphalt roofing cement, **as directed**.
4. Apply roof coatings to smooth base flashings according to manufacturer's written instructions, by spray, roller, or other suitable application method.
5. Install stripping, according to roofing system manufacturer's written instructions, where metal flanges and edgings are set on built-up roofing.
 - a. Flashing-Sheet Stripping: Install flashing-sheet stripping in a cold-applied adhesive or in a solid mopping of hot coal-tar pitch and extend onto roofing membrane.

**OR**

Built-up Stripping: Install stripping of not less than two roofing membrane ply sheets, setting each ply in a continuous coal-tar roofing cement or in a solid mopping of hot coal-tar pitch, and extend onto roofing membrane 4 inches (100 mm) and 6 inches (150 mm), respectively.

6. Roof Drains: Set 30-by-30-inch (760-by-760-mm) metal flashing in bed of asphalt roofing cement on completed built-up roofing. Cover metal flashing with built-up roofing cap-sheet stripping and extend a minimum of 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, beyond edge of metal flashing onto field of built-up roofing. Clamp built-up roofing, metal flashing, and stripping into roof-drain clamping ring.

- a. Flashing-Sheet Stripping: Install flashing-sheet stripping in cold-applied adhesive or in a solid mopping of hot coal-tar pitch and extend onto roofing membrane.

OR

Built-up Stripping: Install stripping of not less than 2 roofing membrane ply sheets, setting each ply in a continuous coating of coal-tar roofing cement or in a solid mopping of hot coal-tar pitch, and extend onto roofing membrane 4 inches (100 mm) and 6 inches (150 mm), respectively.

I. Field Quality Control

1. Testing Agency: Perform roof tests and inspections, observe flood tests, and prepare test reports.
2. Test Cuts: Test specimens will be removed to evaluate problems observed during quality-assurance inspections of built-up roofing as follows:
 - a. Approximate quantities of components within built-up roofing will be determined according to ASTM D 3617.
 - b. Test specimens will be examined for interply voids according to ASTM D 3617 and to comply with criteria established in Appendix 3 of ARMA/NRCA's "Quality Control Guidelines for the Application of Built-up Roofing."
 - c. Repair areas where test cuts were made according to built-up roofing manufacturer's written instructions.
3. Flood Testing: Flood test each roofing membrane area for leaks, according to recommendations in ASTM D 5957, after completing roofing and flashing but before overlying construction is placed. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
 - a. Flood to an average depth of 2-1/2 inches (65 mm) with a minimum depth of 1 inch (25 mm) and not exceeding a depth of 4 inches (100 mm). Maintain 2 inches (50 mm) of clearance from top of base flashing.
 - b. Flood each area for 24 **OR** 48 **OR** 72, **as directed**, hours.
 - c. After flood testing, repair leaks, repeat flood tests, and make further repairs until roofing and flashing installations are watertight.
4. Repair or remove and replace components of roofing system where test results or inspections indicate that they do not comply with specified requirements.
 - a. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

J. Protecting And Cleaning

1. Protect built-up roofing from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to the Owner.
2. Correct deficiencies in or remove built-up roofing that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.



END OF SECTION 07 05 13 00



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**SECTION 07 05 13 00a - CSPE MEMBRANE ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for chlorosulfonate-polyethylene (CSPE) roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Adhered CSPE membrane roofing system.
 - b. Mechanically fastened CSPE membrane roofing system.
 - c. Loosely laid and ballasted CSPE membrane roofing system.
 - d. Vapor retarder.
 - e. Roof insulation.
2. Section includes the installation of acoustical roof deck rib insulation strips furnished under Division 05 Section "Steel Decking".

C. Definitions

1. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.

D. Performance Requirements

1. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.
3. Roofing System Design: Provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
4. FM Approvals Listing, **as directed**: Provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120 **OR** Class 1A-135 **OR** Class 1A-150 **OR** Class 1A-165, **as directed**.
 - b. Hail Resistance: MH **OR** SH, **as directed**.
5. Energy Performance: Provide roofing system with initial Solar Reflectance Index not less than 78 **OR** 29, **as directed**, when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.
6. Energy Performance: Provide roofing system that is listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low **OR** steep, **as directed**, -slope roof products.
7. Energy Performance (for roofs that must comply with California Energy Commission's CEC-Title 24): Provide roofing system with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC-1.

E. Submittals

1. Product Data: For each type of product indicated.



2. LEED Submittals:
 - a. Product Test Reports for Credit SS 7.2: For roof materials, documentation indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
 3. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.
 4. Samples: For each product included in the roofing system.
 5. Research/evaluation reports.
 6. Field quality-control reports.
 7. Maintenance data.
 8. Warranties: Sample of special warranties.
- F. Quality Assurance
1. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
 2. Source Limitations: Obtain components for membrane roofing system from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.
 3. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
 4. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 5. Preinstallation Roofing Conference: Conduct conference at Project site.
- G. Delivery, Storage, And Handling
1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
 2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
 - a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
 3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
 4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.
- H. Project Conditions
1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.
- I. Warranty
1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within 10 **OR** 15, **as directed**, years from date of Final Completion.



1.2 PRODUCTS

- A. CSPE Membrane Roofing
1. CSPE: ASTM D 5019, Type 1, Grade 2, 45-mil- (1.1-mm-) thick, reinforced, flexible uncured sheet formed from CSPE, and as follows:
 - a. Exposed Face Color: White **OR** Blue **OR** Light gray **OR** Tan, **as directed**.
- B. Auxiliary Membrane Roofing Materials
1. General: Auxiliary membrane roofing materials recommended by roofing system manufacturer for intended use, and compatible with membrane roofing.
 - a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
 - b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Gypsum Board and Panel Adhesives: 50 g/L.
 - 3) Multipurpose Construction Adhesives: 70 g/L.
 - 4) Fiberglass Adhesives: 80 g/L.
 - 5) Contact Adhesive: 80 g/L.
 - 6) Single-Ply Roof Membrane Sealants: 450 g/L.
 - 7) Nonmembrane Roof Sealants: 300 g/L.
 - 8) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 9) Sealant Primers for Porous Substrates: 775 g/L.
 - 10) Other Adhesives and Sealants: 250 g/L.
 2. Sheet Flashing: 45-mil- (1.1-mm-) thick, reinforced and 55-mil- (1.4-mm-) thick, non-reinforced CSPE as recommended by roofing system manufacturer for intended use.
 3. Bonding Adhesive: Manufacturer's standard, water based, **as directed**.
 4. Slip Sheet: Manufacturer's standard, of thickness required for application.
 5. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.
 6. Metal Battens: Manufacturer's standard, aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1 inch wide by 0.05 inch thick (25 mm wide by 1.3 mm thick), prepunched.
 7. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening membrane to substrate, and acceptable to membrane roofing system manufacturer.
 8. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, lap sealants, termination reglets, and other accessories.
- C. Substrate Boards
1. Substrate Board: ASTM C 1396/C 1396M, Type X gypsum board, 5/8 inch (16 mm) thick.
OR
Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 728, perlite board, 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick, seal coated.
 2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate board to roof deck.
- D. Vapor Retarder



1. Polyethylene Film: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
 - a. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
 - b. Adhesive: Manufacturer's standard lap adhesive, FM Approvals approved for vapor-retarder application.
2. Laminated Sheet: Kraft paper, two layers, laminated with asphalt and edge reinforced with woven fiberglass yarn with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and with manufacturer's standard adhesive, **as directed**.
3. Glass-Fiber Felts: ASTM D 2178, Type IV, asphalt impregnated.

E. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by CSPE membrane roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) **OR** Type X, 1.3-lb/cu. ft. (21-kg/cu. m), **as directed**, minimum density, square edged.
3. Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density.
4. Composite Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density, with factory-applied facings, as follows:
 - a. Facer: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, asphalt coated, 1/2 inch (13 mm) thick.
OR
Facer: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
5. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 **OR** Type II, Class I, Grade 3, **as directed**, felt or glass-fiber mat facer on both major surfaces.
6. Composite Polyisocyanurate Board Insulation: ASTM C 1289, with factory-applied facing board on one major surface, as indicated below by type, and felt or glass-fiber mat facer on the other.
 - a. Type IV, cellulosic-fiber-insulating-board facer, Grade 2, 1/2 inch (13 mm) thick.
 - b. Type V, OSB facer, 7/16 inch (11 mm) thick.
 - c. Type VII, glass mat faced gypsum board facer, 1/4 inch (6 mm) thick.
7. Perlite Board Insulation: ASTM C 728, rigid, mineral-aggregate thermal insulation board composed of expanded perlite, cellulosic fibers, binders, and waterproofing agents with top surface seal coated.
8. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 2, fibrous-felted, rigid insulation boards of wood fiber or other cellulosic-fiber and water-resistant binders, asphalt impregnated, chemically treated for deterioration.
9. Cellular-Glass Board Insulation: ASTM C 552, Type IV, rigid, cellular-glass thermal board insulation faced with manufacturer's standard kraft-paper sheets.
10. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches (1:48) unless otherwise indicated.
11. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

F. Insulation Accessories

1. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards, **as directed**, to substrate, and acceptable to roofing system manufacturer.



3. Modified Asphaltic Insulation Adhesive: Insulation manufacturer's recommended modified asphalt, asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 4. Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one- or multicomponent urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 5. Full-Spread Applied Insulation Adhesive: Insulation manufacturer's recommended spray-applied, low-rise, two-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 6. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, 1/2 inch (13 mm) thick.
OR
Cover Board: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
OR
Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Cover Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
 7. Protection Mat: Woven or nonwoven polypropylene, polyolefin, or polyester fabric, water permeable and resistant to UV degradation, type and weight as recommended by roofing system manufacturer for application.
- G. Asphalt Materials
1. Roofing Asphalt: ASTM D 312, Type III or Type IV **OR** ASTM D 6152, SEBS modified, **as directed**.
 2. Asphalt Primer: ASTM D 41.
- H. Aggregate Ballast (for loosely laid and aggregate-ballasted installations)
1. Aggregate Ballast: Provide aggregate ballast that will withstand weather exposure without significant deterioration and will not contribute to membrane degradation, of the following type and size:
 - a. Aggregate Type: Smooth, washed, riverbed gravel or other acceptable smooth-faced stone **OR** Crushed gravel or crushed stone, **as directed**.
 - b. Size: ASTM D 448, Size 4, ranging in size from 3/4 to 1-1/2 inches (19 to 38 mm).
OR
Size: ASTM D 448, Size 2, ranging in size from 1-1/2 to 2-1/2 inches (38 to 63 mm).
OR
Size: ASTM D 448, Size 3, ranging in size from 1 to 2 inches (25 to 50 mm).
- I. Roof Pavers
1. Lightweight Roof Pavers: Interlocking, lightweight concrete units, specially factory cast for use as roof ballast; grooved back, with four-way drainage capability; beveled, doweled, or otherwise profiled; and as follows:
 - a. Size: 8 by 16 inches (200 by 400 mm) **OR** 12 by 12 inches (300 by 300 mm) **OR** 12 by 16-1/2 inches (300 by 420 mm) **OR** 12 by 18 inches (300 by 450 mm), **as directed**.
 - b. Weight: At least 10 lb/sq. ft. (50 kg/sq. m) but not exceeding 18 lb/sq. ft. (90 kg/sq. m).
 - c. Compressive Strength: 2500 psi (17 MPa) **OR** 5000 psi (34 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.
 2. Heavyweight Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:



- a. Size: 12 by 12 inches (300 by 300 mm) **OR** 18 by 18 inches (450 by 450 mm) **OR** 24 by 24 inches (600 by 600 mm), **as directed**. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
- b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m), **as directed**.
- c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum.
- d. Colors and Textures: As selected from manufacturer's full range.

J. Walkways

1. Flexible Walkways: Factory-formed, nonporous, heavy-duty, solid-rubber, slip-resisting, surface-textured walkway pads **OR** rolls, **as directed**, approximately 3/16 inch (5 mm) thick, and acceptable to membrane roofing system manufacturer.
2. Walkway Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 12 by 12 inches (300 by 300 mm) **OR** 18 by 18 inches (450 by 450 mm) **OR** 24 by 24 inches (600 by 600 mm), **as directed**. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m), **as directed**.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.

1.3 EXECUTION

A. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.
4. Install acoustical roof deck rib insulation strips, specified in Division 05 Section "Steel Decking", according to acoustical roof deck manufacturer's written instructions, immediately before installation of overlying construction and to remain dry.

B. Substrate Board

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - a. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.
OR
Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to membrane roofing system manufacturers' written instructions.

C. Vapor-Retarder Installation

1. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 - a. Continuously seal side and end laps with tape **OR** adhesive, **as directed**.



2. Laminate Sheet: Install laminate-sheet vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively. Bond vapor retarder to substrate as follows:
 - a. Apply adhesive at rate recommended by vapor-retarder manufacturer. Seal laps with adhesive.
OR
Apply ribbons of hot roofing asphalt at spacing, temperature, and rate recommended by vapor-retarder manufacturer. Seal laps with hot roofing asphalt.
3. Built-Up Vapor Retarder: Install two glass-fiber felt plies lapping each felt 19 inches (483 mm) over preceding felt. Embed each felt in a solid mopping of hot roofing asphalt. Glaze-coat completed surface with hot roofing asphalt. Apply hot roofing asphalt within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
4. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.

D. Insulation Installation

1. Coordinate installing membrane roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.
2. Comply with membrane roofing system and insulation manufacturer's written instructions for installing roof insulation.
3. Install tapered insulation under area of roofing to conform to slopes indicated.
4. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.
 - a. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
5. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
6. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - a. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
7. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
 - a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
 - b. Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
 - c. Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
OR
Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
8. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. Fasten insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.
9. Mechanically Fastened and Adhered Insulation: Install each layer of insulation and secure first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. Fasten first layer of insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.

**OR**

Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.

- b. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.

OR

Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.

OR

Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

10. Loosely Laid Insulation: Loosely lay insulation units over substrate.
11. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together and fasten to roof deck, **as directed**.
- a. Fasten cover boards according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
- OR**
- Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.
12. Install slip sheet over insulation **OR** cover board, **as directed**, and immediately beneath membrane roofing.

E. Adhered Membrane Roofing Installation

1. Adhere membrane **OR** fabric-backed membrane, **as directed**, roofing over area to receive roofing according to membrane roofing system manufacturer's written instructions. Unroll membrane roofing and allow to relax before installing.
2. Start installation of membrane roofing in presence of membrane roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Bonding Adhesive: Apply to substrate and underside of membrane roofing at rate required by manufacturer and allow to partially dry before installing membrane roofing. Do not apply to splice area of membrane roofing.
5. In addition to adhering, mechanically fasten membrane roofing securely at terminations, penetrations, and perimeter of roofing.
6. Apply membrane roofing with side laps shingled with slope of roof deck where possible.
7. Seams: Clean seam areas, overlap membrane roofing, and weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation. Complete welding of seams within 24 hours of exposing CSPE sheet or before curing of CSPE sheet has begun. Weld seams as follows:
 - a. Weld Method: Hot air **OR** Solvent, **as directed**.
 - b. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - c. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
 - d. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
8. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
9. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing membrane roofing system.

F. Mechanically Fastened Membrane Roofing Installation

1. Mechanically fasten membrane roofing over area to receive roofing and install according to roofing system manufacturer's written instructions.
 - a. For in-splice attachment, install membranes roofing with long dimension perpendicular to steel roof deck flutes.



2. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Mechanically fasten or adhere membrane roofing securely at terminations, penetrations, and perimeter of roofing.
5. Apply membrane roofing with side laps shingled with slope of roof deck where possible.
6. In-Seam Attachment: Secure one edge of CSPE sheet using fastening plates or metal battens centered within membrane seam and mechanically fasten CSPE sheet to roof deck.
7. Seams: Clean seam areas, overlap membrane roofing, and weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation. Complete welding of seams within 24 hours of exposing CSPE sheet or before curing of CSPE sheet has begun. Weld seams as follows:
 - a. Weld Method: Hot air **OR** Solvent, **as directed**.
 - b. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - c. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
 - d. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
8. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
9. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing membrane roofing system.

G. Loosely Laid And Ballasted Membrane Roofing Installation

1. Loosely lay membrane roofing over area to receive roofing and install according to roofing system manufacturer's written instructions.
 - a. Comply with requirements in SPRI RP-4 for System 1 **OR** System 2 **OR** System 3, **as directed**.
2. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing, without stretching, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Mechanically fasten or adhere perimeter of membrane roofing according to requirements in SPRI RP-4.
OR
Mechanically fasten **OR** adhere, **as directed**, membrane roofing at corners, perimeters, and transitions according to requirements in SPRI RP-4.
 - a. At corners and perimeters, omit aggregate ballast leaving membrane roofing exposed.
 - b. At corners and perimeters, adhere a second layer of membrane roofing.
5. Apply membrane roofing with side laps shingled with slope of deck where possible.
6. Seams: Clean seam areas, overlap membrane roofing, and weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation. Complete welding of seams within 24 hours of exposing CSPE sheet or before curing of CSPE sheet has begun. Weld seams as follows:
 - a. Weld Method: Hot air **OR** Solvent, **as directed**.
 - b. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - c. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
 - d. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
7. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
8. Install membrane roofing and auxiliary materials to tie in to existing roofing.
9. Install protection mat over membrane roofing, overlapping a minimum of 6 inches (150 mm). Install an additional protection mat layer at projections, pipes, vents, and drains, overlapping a minimum of 12 inches (300 mm).



10. Aggregate Ballast: Apply uniformly over membrane roofing at the rate required by membrane roofing system manufacturer, but not less than the following, spreading with care to minimize possibility of damage to membrane roofing system. Lay ballast as membrane roofing is installed, leaving membrane roofing ballasted at the end of the workday.
- a. Ballast Weight: Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m).
OR
 Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m), at corners and perimeter; Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m), elsewhere.
OR
 Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m).
11. Roof-Paver Ballast: Install lightweight **OR** heavyweight, **as directed**, roof-paver ballast according to manufacturer's written instructions.
OR
 Roof-Paver and Aggregate Ballast: Install heavyweight roof pavers according to manufacturer's written instructions on roof corners and perimeter.
- a. Install Size 4 aggregate ballast elsewhere on roofing at a minimum rate of 10 lb/sq. ft. (50 kg/sq. m).
OR
 Install Size 2 aggregate ballast elsewhere on roofing at a minimum rate of 13 lb/sq. ft. (65 kg/sq. m).
- H. Base Flashing Installation
1. Install sheet flashings and preformed flashing accessories and adhere to substrates according to membrane roofing system manufacturer's written instructions.
 2. Apply bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply to seam area of flashing.
 3. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.
 4. Clean seam areas, overlap, and firmly roll sheet flashings into the adhesive. Weld side and end laps to ensure a watertight seam installation. Complete welding of seams within 24 hours of exposing CSPE sheet or before curing of CSPE sheet has begun.
 5. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars, **as directed**.
- I. Walkway Installation
1. Flexible Walkways: Install walkway products in locations indicated. Heat weld to substrate or adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.
 2. Roof-Paver Walkways: Install walkway roof pavers according to manufacturer's written instructions in locations indicated, to form walkways. Leave 3 inches (75 mm) of space between adjacent roof pavers.
- J. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform inspections.
 2. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.
 3. Repair or remove and replace components of membrane roofing system where inspections indicate that they do not comply with specified requirements.
 4. Additional inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- K. Protecting And Cleaning
1. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for



- deterioration and damage, describing its nature and extent in a written report, with copies to Owner.
2. Correct deficiencies in or remove membrane roofing system that does not comply with requirements, repair substrates and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
 3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 05 13 00a



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**SECTION 07 05 13 00b - APP-MODIFIED BITUMINOUS MEMBRANE ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for atactic-polypropylene (APP) modified bituminous membrane roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Atactic-polypropylene (APP) modified bituminous membrane roofing.
 - b. Hybrid roofing system that combines built-up ply sheets with APP-modified bituminous membrane.
 - c. Vapor retarder.
 - d. Roof insulation.
2. Section includes the installation of insulation strips in ribs of acoustical roof deck. Insulation strips are furnished under Division 05 Section "Steel Decking".

C. Definitions

1. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.
2. Hot Roofing Asphalt: Roofing asphalt heated to its equiviscous temperature, the temperature at which its viscosity is 125 centipoise for mop-applied roofing asphalt and 75 centipoise for mechanical spreader-applied roofing asphalt, within a range of plus or minus 25 deg F (14 deg C), measured at the mop cart or mechanical spreader immediately before application.

D. Performance Requirements

1. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.
3. Roofing System Design: If membrane roofing system is to be designed to withstand uplift pressure established by ASCE/SEI 7, provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
 - a. Corner Uplift Pressure: as directed by the Owner.
 - b. Perimeter Uplift Pressure: as directed by the Owner.
 - c. Field-of-Roof Uplift Pressure: as directed by the Owner.
4. FM Approvals Listing: If Project is FM Global insured or if FM Approvals requirements will set a minimum quality standard, provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120, **as directed**.
 - b. Hail Resistance Rating: MH **OR** SH, **as directed**.
5. Energy Performance (if required for LEED-NC Credit SS 7.2): Provide roofing system with initial Solar Reflectance Index not less than 78 when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.

**OR**

Energy Performance(for roofs that must comply with DOE's ENERGY STAR requirements): Provide roofing system that is listed on DOE's ENERGY STAR "Roof Products Qualified Product List" for low-slope roof products.

OR

Energy Performance(for roofs that must comply with California Energy Commission's CEC-Title 24): Provide roofing system with initial Solar Reflectance not less than 0.70 and Thermal Emittance not less than 0.75 when tested according to Cool Roof Rating Council's CRRC-1.

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Test Reports for Credit SS 7.2: For roof materials, indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.
 - a. Base flashings and membrane terminations.
 - b. Tapered insulation, including slopes.
 - c. Crickets, saddles, and tapered edge strips, including slopes.
 - d. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.
4. Samples: For the following products:
 - a. Sheet roofing materials, including base sheet, base-ply sheet, roofing membrane sheet, flashing backer sheet, membrane cap sheet and flashing sheet, of color specified.
 - b. Roof insulation.
 - c. Walkway pads or rolls.
 - d. Six insulation fasteners of each type, length, and finish.
5. Qualification Data: For qualified Installer, manufacturer and testing agency.
6. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of complying with performance requirements.
7. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for components of membrane roofing system.
8. Research/Evaluation Reports: For components of membrane roofing system, from the ICC-ES **OR** applicable model code organization, **as directed**.
9. Maintenance Data: For roofing system to include in maintenance manuals.
10. Warranties: Sample of special warranties.

F. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer that is UL listed **OR** FM Approvals approved, **as directed**, for membrane roofing system identical to that used for this Project.
2. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
3. Source Limitations: Obtain components including roof insulation and fasteners for membrane roofing system from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.
4. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
5. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.



6. Preinstallation Roofing Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
 - a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.

H. Project Conditions

1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

I. Warranty

1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within specified warranty period.
 - a. Special warranty includes membrane roofing, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, and other components of membrane roofing system.
 - b. Warranty Period: 10 **OR** 15 **OR** 20 **OR** 25 **OR** 30, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. APP-Modified Asphalt-Sheet Materials

1. Roofing Membrane Sheet: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
2. Smooth-Surfaced Roofing Membrane Cap Sheet: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
OR
Granule-Surfaced Roofing Membrane Cap Sheet: ASTM D 6222, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified, and as follows:
 - a. Granule Material: Mineral ceramic coated **OR** slate, **as directed**.
 - b. Granule Color: White **OR** Gray **OR** Tan, **as directed**.

B. Base-Sheet Materials

1. Sheathing Paper: Red-rosin type, minimum 3 lb/100 sq. ft. (0.16 kg/sq. m).
2. Base Sheet: ASTM D 4601, Type II, SBS-modified, asphalt-impregnated and -coated sheet, with glass-fiber-reinforcing mat, dusted with fine mineral surfacing on both sides.



- a. Weight: 25 lb/100 sq. ft. (1.2 kg/sq. m) **OR** 40 lb/100 sq. ft. (1.95 kg/sq. m) **OR** 50 lb/100 sq. ft. (2.4 kg/sq. m) **OR** 60 lb/100 sq. ft. (2.9 kg/sq. m) **OR** 75 lb/100 sq. ft. (3.7 kg/sq. m), **as directed**, minimum.

OR

Base Sheet: ASTM D 4601, Type I **OR** Type II, **as directed**, nonperforated, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.

OR

Base Sheet: ASTM D 4897, Type II, venting, nonperforated, heavyweight, asphalt-impregnated and -coated, glass-fiber base sheet with coarse granular surfacing or embossed venting channels on bottom surface.

OR

Base Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.

C. Base-Ply Sheet Materials

1. Glass-Fiber Base-Ply Sheet: ASTM D 2178, Type IV **OR** Type VI, **as directed**, asphalt-impregnated, glass-fiber felt.

D. Base Flashing Sheet Materials

1. Backer Sheet: ASTM D 4601, Type I **OR** Type II, **a directed**, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.

OR

Backer Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.

OR

Backer Sheet: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.

2. Smooth-Surfaced Flashing Sheet: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.

OR

Granule-Surfaced Flashing Sheet: ASTM D 6222, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified, and as follows:

- a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.
3. Glass-Fiber Fabric: Woven glass-fiber cloth, treated with asphalt, complying with ASTM D 1668, Type I.

E. Auxiliary Roofing Membrane Materials

1. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with roofing membrane.
- a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
- b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
- 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Gypsum Board and Panel Adhesives: 50 g/L.
 - 3) Multipurpose Construction Adhesives: 70 g/L.
 - 4) Fiberglass Adhesives: 80 g/L.
 - 5) Contact Adhesive: 80 g/L.



- 6) Other Adhesives: 250 g/L.
 - 7) Nonmembrane Roof Sealants: 300 g/L.
 - 8) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 9) Sealant Primers for Porous Substrates: 775 g/L.
2. Asphalt Primer: ASTM D 41.
 3. Roofing Asphalt: ASTM D 312, Type III **OR** Type IV **OR** Type III or IV as recommended by roofing system manufacturer for application, **as directed**.
OR
Roofing Asphalt: ASTM D 6152, SEBS modified.
 4. Cold-Applied Adhesive: Roofing system manufacturer's standard asphalt-based, one- or two-part, asbestos-free, cold-applied adhesive specially formulated for compatibility and use with roofing membrane and base flashings.
 5. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required by roofing system manufacturer for application.
 6. Mastic Sealant: Polyisobutylene, plain or modified bitumen; nonhardening, nonmigrating, nonskinning, and nondrying.
 7. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roofing membrane components to substrate; tested by manufacturer for required pullout strength, and acceptable to roofing system manufacturer.
 8. Metal Flashing Sheet: As specified in Division 07 Section "Sheet Metal Flashing And Trim".
 9. Roofing Granules: Ceramic-coated **OR** Slate, **as directed**, roofing granules, No. 11 screen size with 100 percent passing No. 8 (2.36-mm) sieve and 98 percent of mass retained on No. 40 (0.425-mm) sieve, color to match roofing membrane.
 10. Miscellaneous Accessories: Provide those recommended by roofing system manufacturer.
- F. Substrate Boards
1. Substrate Board: ASTM C 1396/C 1396M, Type X gypsum board, 5/8 inch (16 mm) thick.
OR
Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Substrate Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 728, perlite board, 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick, seal coated.
 2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate board to roof deck.
- G. Vapor Retarder
1. Polyethylene Film: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
 - a. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
OR
Adhesive: Manufacturer's standard lap adhesive, FM Approvals approved for vapor-retarder application.
 2. Laminated Sheet: Kraft paper, two layers, laminated with asphalt and edge reinforced with woven fiberglass yarn, with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and with manufacturer's standard adhesive, **as directed**.
 3. Self-Adhering Sheet Vapor Retarder: ASTM D 1970, minimum of 40-mil- (1.0-mm-) thick, polyethylene film laminated to layer of rubberized asphalt adhesive; maximum permeance rating



of 0.1 perm (6 ng/Pa x s x sq. m); cold applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.

OR

Self-Adhering Sheet Vapor Retarder: 30- to 40-mil- (0.76- to 1.0-mm-) thick, polyethylene film laminated to layer of butyl rubber adhesive; maximum permeance rating of 0.1 perm (6 ng/Pa x s x sq. m); cold applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.

4. Glass-Fiber Felt: ASTM D 2178, Type IV, asphalt impregnated.

H. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) **OR** Type X, 1.3-lb/cu. ft. (21-kg/cu. m), **as directed**, minimum density, square edged.
3. Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density.
4. Composite Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density, with factory-applied facings, as follows:
 - a. Facer: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, asphalt coated, 1/2 inch (13 mm) thick.

OR

Facer: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
5. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 **OR** Type II, Class I, Grade 3, **as directed**, felt or glass-fiber mat facer on both major surfaces.
6. Composite Polyisocyanurate Board Insulation: ASTM C 1289, with factory-applied facing board, as indicated below by type, on one major surface and felt or glass-fiber mat facer on the other surface.
 - a. Type IV, cellulosic-fiber-insulating-board facer, Grade 2, 1/2 inch (13 mm) thick.
 - b. Type V, OSB facer, 7/16 inch (11 mm) thick.
 - c. Type VII, glass-mat-faced gypsum board facer, 1/4 inch (6 mm) thick.
7. Perlite Board Insulation: ASTM C 728, rigid, mineral-aggregate thermal insulation board composed of expanded perlite, cellulosic fibers, binders, and waterproofing agents with top surface seal coated.
8. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 2, fibrous-felted, rigid insulation boards of wood fiber or other cellulosic-fiber and water-resistant binders, asphalt impregnated, chemically treated for deterioration.
9. Cellular-Glass Board Insulation: ASTM C 552, Type IV, rigid, cellular-glass thermal board insulation faced with manufacturer's standard kraft-paper sheets.
10. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches (1:48) unless otherwise indicated.
11. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

I. Insulation Accessories

1. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards, **as directed**, to substrate, and acceptable to roofing system manufacturer.
3. Modified Asphaltic Insulation Adhesive: Insulation manufacturer's recommended modified asphaltic, asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.

**OR**

Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one-component or multicomponent urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.

OR

Full-Spread Applied Insulation Adhesive: Insulation manufacturer's recommended spray-applied, low-rise, two-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.

4. Insulation Cant Strips: ASTM C 728, perlite insulation board.

OR

Insulation Cant Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.

5. Wood Nailer Strips: Comply with requirements in Division 06 Section(s) "Rough Carpentry" OR "Miscellaneous Rough Carpentry", **as directed**.
6. Tapered Edge Strips: ASTM C 728, perlite insulation board.

OR

Tapered Edge Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.

7. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, 1/2 inch (13 mm) thick.

OR

Cover Board: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.

OR

Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.

OR

Cover Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.

8. Substrate Joint Tape: 6- or 8-inch- (150- or 200-mm-) wide, coated, glass-fiber joint tape.

J. Coating Materials

1. Roof Coating: ASTM D 1227, Type II, Class 1, mineral-colloid-emulsified, fibered **OR** Class 2, chemically emulsified, filled or fibered, **as directed**, asphalt emulsion, asbestos free.
2. Roof Coating: ASTM D 1227, Type III, Class 1, mineral-colloid-emulsified **OR** Class 2, chemically emulsified, **as directed**, asphalt emulsion, nonfibered.
3. Roof Coating: ASTM D 2824, Type I, nonfibered **OR** Type III, fibered, asbestos-free, **as directed**, aluminum-pigmented asphaltic coating.
4. Roof Coating: Acrylic elastomer emulsion coating, formulated for use on bituminous roof surfaces and complying with ASTM D 6083.
- a. Color: White **OR** Gray **OR** Buff, **as directed**.

K. Walkways

1. Walkway Pads: Reinforced asphaltic composition pads with slip-resisting mineral-granule surface **OR** Polymer-modified, reconstituted rubber pads with slip-resisting textured surface, **as directed**, manufactured as a traffic pad for foot traffic and acceptable to roofing system manufacturer, 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, thick, minimum.
2. Walkway Backer Strips: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
3. Walkway Cap Sheet Strips: ASTM D 6222, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified, and as follows:
- a. Granule Material: Mineral ceramic coated **OR** slate, **as directed**.
- b. Granule Color: White **OR** Gray **OR** Tan, **as directed**.



1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with the following requirements and other conditions affecting performance of roofing system:
 - a. Verify that roof openings and penetrations are in place and curbs are set and braced and that roof drain bodies are securely clamped in place.
 - b. Verify that wood cants, blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
 - c. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Division 05 Section "Steel Decking".
 - d. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
 - e. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
 - 1) Test for moisture by pouring 1 pint (0.5 L) of hot roofing asphalt on deck at start of each day's work and at start of each roof area or plane. Do not proceed with roofing work if test sample foams or can be easily and cleanly stripped after cooling.
 - f. Verify that concrete-curing compounds that will impair adhesion of roofing components to roof deck have been removed.
 - g. Verify that deck is securely fastened with no projecting fasteners and with no adjacent units in excess of 1/16 inch (1.6 mm) out of plane relative to adjoining deck.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Prime surface of concrete deck with asphalt primer at a rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
4. Install insulation strips in ribs of acoustical roof deck according to acoustical roof deck manufacturer's written instructions.

C. Substrate Board Installation

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - a. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.
OR
Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to membrane roofing system manufacturers' written instructions.

D. Vapor-Retarder Installation

1. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 - a. Continuously seal side and end laps with tape **OR** adhesive, **as directed**.
2. Laminate Sheet: Install laminate-sheet vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively. Bond vapor retarder to substrate as follows:



- a. Apply adhesive at rate recommended by vapor-retarder manufacturer. Seal laps with adhesive.
OR
Apply ribbons of hot roofing asphalt at spacing, temperature, and rate recommended by vapor-retarder manufacturer. Seal laps with hot roofing asphalt.
 3. Self-Adhering Sheet Vapor Retarder: Prime substrate if required by manufacturer. Install self-adhering sheet vapor retarder over area to receive vapor retarder, side and end lapping each sheet a minimum of 3-1/2 inches (90 mm) and 6 inches (150 mm), respectively. Seal laps by rolling.
 4. Built-up Vapor Retarder: Install two glass-fiber felt plies lapping each felt 19 inches (483 mm) over preceding felt. Embed each felt in a solid mopping of hot roofing asphalt. Glaze-coat completed surface with hot roofing asphalt. Apply hot roofing asphalt within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
 5. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.
- E. Insulation Installation
1. Comply with roofing system manufacturer's written instructions for installing roof insulation.
 2. If mechanically fastening base sheet to substrate before adhering first layer of insulation, install one lapped base-sheet course and mechanically fasten to substrate according to roofing system manufacturer's written instructions.
 3. Nailer Strips: Mechanically fasten 4-inch nominal- (89-mm actual-) width wood nailer strips of same thickness as insulation perpendicular to sloped roof deck at the following spacing:
 - a. 16 feet (4.88 m) apart for roof slopes steeper than 1 inch per 12 inches (1:12) but less than 3 inches per 12 inches (3:12).
 - b. 48 inches (1220 mm) apart for roof slopes steeper than 3 inches per 12 inches (3:12).
 4. Insulation Cant Strips: Install and secure preformed 45-degree insulation cant strips at junctures of roofing membrane system with vertical surfaces or angle changes more than 45 degrees.
 5. Install tapered insulation under area of roofing to conform to slopes indicated.
 6. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - a. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
 7. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or more, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.
 - a. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
 8. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
 9. Install tapered edge strips at perimeter edges of roof that do not terminate at vertical surfaces.
 10. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
 - a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
 - b. Set each layer of insulation in a solid mopping of hot roofing asphalt applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
OR
Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
OR
Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
 11. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.



- a. If Project is FM Global insured or if FM Approvals requirements are proposed as a performance standard, fasten insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
 - b. If number of fasteners will be based on ASCE/SEI 7's uplift pressure or SPRI's factored-design uplift pressure, fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.
12. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
- a. If Project is FM Global insured or if FM Approvals requirements are proposed as a performance standard, fasten first layer of insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
 - b. If fastening is calculated from ASCE/SEI 7's uplift pressure or SPRI's factored-design uplift pressure, fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
 - 1) Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
OR
Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
OR
Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
 - c. If cover boards will be field installed over roof insulation and immediately below roofing membrane, install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints a minimum of 6 inches (150 mm) in each direction from joints of insulation below. Loosely butt cover boards together and fasten to roof deck, **as directed**. Tape joints if required by roofing system manufacturer.
 - 1) Fasten cover boards according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.
 - 2) Apply hot roofing asphalt to underside, and immediately bond cover board to substrate.

F. Roofing Membrane Installation, General

1. If referencing NRCA's roof assembly identification matrix system, install roofing membrane system according to roofing system manufacturer's written instructions and applicable recommendations in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing."
 - a. Install roofing system MBA **OR** MBAH, **as directed**,-3 **OR** 4, **as directed**,-N **OR** I **OR** C, **as directed**,-T **OR** L, **as directed**,-S **OR** M, **as directed**, according to roof assembly identification matrix and roof assembly layout illustrations in NRCA's "The NRCA Roofing and Waterproofing Manual" and to requirements in this Section.
2. For roof system that exceeds requirements of NRCA's roof assemblies, install roofing membrane system according to roofing system manufacturer's written instructions and applicable recommendations in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing" and as follows:
 - a. Deck Type: N (nailable) **OR** I (insulated) **OR** C (concrete or nonnailable), **as directed**.
 - b. Adhering Method: T (torched) **OR** L (cold-applied adhesive), **as directed**.
 - c. Base Sheet: One **OR** One, installed over sheathing paper, **as directed**.
 - d. Number of Glass-Fiber Base-Ply Sheets: One **OR** Two, **as directed**.
 - e. Number of APP-Modified Asphalt Sheets: One **OR** Two, **as directed**.
 - f. Surfacing Type: S (smooth) **OR** M (mineral-granule-surfaced cap sheet), **as directed**.



3. Start installation of roofing membrane in presence of roofing system manufacturer's technical personnel.
 4. Where roof slope exceeds 1/2 inch per 12 inches (1:24) **OR** 3/4 inch per 12 inches (1:18), **as directed**, install roofing membrane sheets parallel with slope.
 - a. Backnail roofing membrane sheets to nailer strips **OR** substrate, **as directed**, according to roofing system manufacturer's written instructions.
 5. Cooperate with testing agencies engaged or required to perform services for installing roofing system.
 6. Coordinate installation of roofing system so insulation and other components of the roofing membrane system not permanently exposed are not subjected to precipitation or left uncovered at the end of the workday or when rain is forecast.
 - a. At end of each day's work, provide tie-offs to cover exposed roofing membrane sheets and insulation with a course of coated felt set in roofing cement or hot roofing asphalt, with joints and edges sealed.
 - b. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system.
 - c. Remove and discard temporary seals before beginning work on adjoining roofing.
 7. Asphalt Heating: Do not raise roofing asphalt temperature above equiviscous temperature range more than one hour before time of application. Do not exceed roofing asphalt manufacturer's recommended temperature limits during roofing asphalt heating. Do not heat roofing asphalt within 25 deg F (14 deg C) of flash point. Discard roofing asphalt maintained at a temperature exceeding finished blowing temperature for more than four hours.

OR

Asphalt Heating: Heat and apply SEBS-modified roofing asphalt according to roofing system manufacturer's written instructions.
 8. Substrate-Joint Penetrations: Prevent roofing asphalt and adhesives from penetrating substrate joints, entering building, or damaging roofing system components or adjacent building construction.
- G. Base-Sheet Installation
1. If sheathing paper is required over wood decks by roofing system manufacturer, loosely lay one course of sheathing paper, lapping edges and ends a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 2. Install lapped base-sheet course, extending sheet over and terminating beyond cants. Attach base sheet as follows:
 - a. Mechanically fasten to substrate, for nailable substrate.

OR

Spot- or strip-mop to substrate with hot roofing asphalt.

OR

Adhere to substrate in a solid mopping of hot roofing asphalt **OR** uniform coating of cold-applied adhesive, **as directed**, for nonnailable or insulated substrates.
- H. Base-Ply Sheet Installation
1. Install glass-fiber base-ply sheets according to roofing system manufacturer's written instructions starting at low point of roofing system. Align glass-fiber base-ply sheets without stretching. Extend sheets over and terminate beyond cants.
 - a. Shingle side laps of glass-fiber base-ply sheets uniformly to ensure that required number of glass-fiber base-ply sheets covers substrate at any point. Shingle in direction to shed water.
 - b. Embed each glass-fiber base-ply sheet in a continuous void-free mopping of hot roofing asphalt to form a uniform membrane without glass-fiber base-ply sheets touching.
- I. APP-Modified Bituminous Membrane Installation
1. Install modified bituminous roofing membrane cap sheet **OR** sheet and cap sheet, **as directed**, according to roofing manufacturer's written instructions, starting at low point of roofing system. Extend roofing membrane sheets over and terminate beyond cants, installing as follows:



- a. Adhere to substrate in cold-applied adhesive.
OR
Torch apply to substrate.
- b. Unroll roofing membrane sheets and allow them to relax for minimum time period required by manufacturer.
2. Laps: Accurately align roofing membrane sheets, without stretching, and maintain uniform side and end laps. Stagger end laps. Completely bond and seal laps, leaving no voids.
 - a. Repair tears and voids in laps and lapped seams not completely sealed.
 - b. Apply roofing granules to cover exuded bead at laps while bead is hot.
3. Install roofing membrane sheets so side and end laps shed water.

J. Flashing And Stripping Installation

1. Install base flashing over cant strips and other sloped and vertical surfaces, at roof edges, and at penetrations through roof; secure to substrates according to roofing system manufacturer's written instructions, and as follows:
 - a. Prime substrates with asphalt primer if required by roofing system manufacturer.
 - b. Backer Sheet Application: Mechanically fasten backer sheet to walls or parapets. Adhere backer sheet over roofing membrane at cants in cold-applied adhesive, **as directed**.
OR
Backer Sheet Application: Adhere backer sheet to substrate in a solid mopping of hot roofing asphalt **OR** cold-applied adhesive at rate required by roofing system manufacturer, **as directed**.
 - c. Flashing Sheet Application: Adhere flashing sheet to substrate in cold-applied adhesive at rate required by roofing system manufacturer.
OR
Flashing Sheet Application: Adhere flashing sheet to substrate in asphalt roofing cement at rate required by roofing system manufacturer.
OR
Flashing Sheet Application: Torch apply flashing sheet to substrate.
2. Extend base flashing up walls or parapets a minimum of 8 inches (200 mm) above roofing membrane and 4 inches (100 mm) onto field of roofing membrane.
3. Mechanically fasten top of base flashing securely at terminations and perimeter of roofing.
 - a. Seal top termination of base flashing with a strip of glass-fiber fabric set in asphalt roofing cement, **as directed**.
4. Install roofing membrane cap-sheet stripping where metal flanges and edgings are set on membrane roofing according to roofing system manufacturer's written instructions.
5. Roof Drains: Set 30-by-30-inch- (760-by-760-mm-) square metal flashing in bed of roofing-manufacturer-approved asphaltic adhesive on completed roofing membrane. Cover metal flashing with roofing membrane cap-sheet stripping and extend a minimum of 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, beyond edge of metal flashing onto field of roofing membrane. Clamp roofing membrane, metal flashing, and stripping into roof-drain clamping ring.
 - a. Install stripping according to roofing system manufacturer's written instructions.

K. Coating Installation

1. Apply coating to roofing membrane **OR** roofing membrane and base flashings, **as directed**, according to manufacturer's written instructions, by spray, roller, or other suitable application method to provide a dry film thickness of not less than 20 mils (0.5 mm), **as directed**.

L. Walkway Installation

1. Walkway Pads: Install walkway pads in cold-applied adhesive, using units of size indicated or, if not indicated, of manufacturer's standard size according to walkway pad manufacturer's written instructions.
2. Walkway Strips: Install walkway cap sheet **OR** backer and cap sheet, **as directed**, strips over roofing membrane using same application method as used for roofing membrane cap sheet.



- M. Field Quality Control
1. Testing Agency: Perform tests and inspections and to prepare test reports.
 2. Test Cuts: Test specimens will be removed to evaluate problems observed during quality-assurance inspections of roofing membrane as follows:
 - a. Approximate quantities of components within roofing membrane will be determined according to ASTM D 3617.
 - b. Test specimens will be examined for interply voids according to ASTM D 3617 and to comply with criteria established in Appendix 3 in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing."
 - c. Repair areas where test cuts were made according to roofing system manufacturer's written instructions.
 3. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.
 - a. Notify the Owner 48 hours in advance of date and time of inspection.
 4. Roofing system will be considered defective if it does not pass tests and inspections.
 - a. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.
- N. Protecting And Cleaning
1. Protect roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to the Owner.
 2. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
 3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 05 13 00b



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**SECTION 07 05 13 00c - SBS-MODIFIED BITUMINOUS MEMBRANE ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for styrene-butadiene-styrene (SBS) modified bituminous membrane roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Styrene-butadiene-styrene (SBS) modified bituminous membrane roofing.
 - b. Hybrid roofing system that combines built-up ply sheets with SBS-modified bituminous membrane roofing.
 - c. Vapor retarder.
 - d. Roof insulation.
2. Section includes the installation of insulation strips in ribs of acoustical roof deck. Insulation strips are furnished under Division 05 Section "Steel Decking".

C. Definitions

1. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.
2. Hot Roofing Asphalt: Roofing asphalt heated to its equiviscous temperature, the temperature at which its viscosity is 125 centipoise for mop-applied roofing asphalt and 75 centipoise for mechanical spreader-applied roofing asphalt, within a range of plus or minus 25 deg F (14 deg C), measured at the mop cart or mechanical spreader immediately before application.

D. Performance Requirements

1. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.
3. Roofing System Design: If membrane roofing system is to be designed to withstand uplift pressure established by ASCE/SEI 7, provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
 - a. Corner Uplift Pressure: <Insert **lbf/sq. ft. (kPa/sq. m)**>.
 - b. Perimeter Uplift Pressure: <Insert **lbf/sq. ft. (kPa/sq. m)**>.
 - c. Field-of-Roof Uplift Pressure: <Insert **lbf/sq. ft. (kPa/sq. m)**>.
4. FM Approvals Listing: If Project is FM Global insured or if FM Approvals requirements will set a minimum quality standard, provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120, **as directed**.
 - b. Hail Resistance Rating: MH **OR** SH, **as directed**.
5. Energy Performance (if required for LEED-NC Credit SS 7.2): Provide roofing system with initial Solar Reflectance Index not less than 78 when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.



6. Energy Performance (for roofs that must comply with DOE's ENERGY STAR requirements): Provide roofing system that is listed on DOE's ENERGY STAR "Roof Products Qualified Product List" for low-slope roof products.
7. Energy Performance (for roofs that must comply with California Energy Commission's CEC-Title 24): Provide roofing system with initial Solar Reflectance not less than 0.70 and Thermal Emittance not less than 0.75 when tested according to Cool Roof Rating Council's CRRC-1.

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Test Reports for Credit SS 7.2: For roof materials, indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.
 - a. Base flashings and membrane terminations.
 - b. Tapered insulation, including slopes.
 - c. Crickets, saddles, and tapered edge strips, including slopes.
 - d. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.
4. Samples: For the following products:
 - a. Sheet roofing materials, including base sheet, base-ply sheet, roofing membrane sheet, flashing backer sheet, membrane cap sheet and flashing sheet, of color specified.
 - b. Roof insulation.
 - c. 3 lb (1.5 kg) of aggregate surfacing material in gradation and color indicated.
 - d. Walkway pads or rolls.
 - e. Six insulation fasteners of each type, length, and finish.
5. Qualification Data: For qualified Installer, manufacturer and testing agency.
6. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of complying with performance requirements.
7. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for components of membrane roofing system.
8. Research/Evaluation Reports: For components of membrane roofing system, from the ICC-ES **OR** applicable model code organization, **as directed**.
9. Maintenance Data: For roofing system to include in maintenance manuals.
10. Warranties: Sample of special warranties.

F. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer that is UL listed **OR** FM Approvals approved, **as directed**, for membrane roofing system identical to that used for this Project.
2. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
3. Source Limitations: Obtain components including roof insulation and fasteners for membrane roofing system from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.
4. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
5. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
6. Preinstallation Roofing Conference: Conduct conference at Project site.



- G. Delivery, Storage, And Handling
1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
 2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
 - a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
 3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
 4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.
- H. Project Conditions
1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.
- I. Warranty
1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within specified warranty period.
 - a. Special warranty includes membrane roofing, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, and other components of membrane roofing system.
 - b. Warranty Period: 10 **OR** 15 **OR** 20 **OR** 25 **OR** 30, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

- A. SBS-Modified Asphalt-Sheet Materials
1. Roofing Membrane Sheet: ASTM D 6164, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
 2. Smooth-Surfaced Roofing Membrane Cap Sheet: ASTM D 6164, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
OR
Granule-Surface Roofing Membrane Cap Sheet: ASTM D 6164, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified, and as follows:
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.
 3. Metal-Foil-Surfaced Roofing Membrane Cap Sheet: ASTM D 6298, metal-foil surfaced SBS-modified asphalt sheet (reinforced with glass fibers); suitable for application method specified, and as follows:
 - a. Foil Surfacing: Aluminum **OR** Copper **OR** Stainless steel **OR** Aluminum, fluoropolymer-coated finish, of color and gloss selected from manufacturer's full range, **as directed**.



B. Base-Sheet Materials

1. Sheathing Paper: Red-rosin type, minimum 3 lb/100 sq. ft. (0.16 kg/sq. m).
2. Base Sheet: ASTM D 4601, Type II, SBS-modified, asphalt-impregnated and -coated sheet, with glass-fiber-reinforcing mat, dusted with fine mineral surfacing on both sides.
 - a. Weight: 25 lb/100 sq. ft. (1.2 kg/sq. m) **OR** 40 lb/100 sq. ft. (1.95 kg/sq. m) **OR** 50 lb/100 sq. ft. (2.4 kg/sq. m) **OR** 60 lb/100 sq. ft. (2.9 kg/sq. m) **OR** 75 lb/100 sq. ft. (3.7 kg/sq. m), **as directed**, minimum.

OR

Base Sheet: ASTM D 4601, Type I **OR** Type II, **as directed**, nonperforated, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.

OR

Base Sheet: ASTM D 4897, Type II, venting, nonperforated, heavyweight, asphalt-impregnated and -coated, glass-fiber base sheet with coarse granular surfacing or embossed venting channels on bottom surface.

OR

Base Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.

C. Base-Ply Sheet Materials

1. Glass-Fiber Base-Ply Sheet: ASTM D 2178, Type IV **OR** Type VI, **as directed**, asphalt-impregnated, glass-fiber felt.

D. Base Flashing Sheet Materials

1. Backer Sheet: ASTM D 4601, Type I **OR** Type II, **as directed**, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.

OR

Backer Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.

OR

Backer Sheet: ASTM D 6164, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.

2. Granule-Surfaced Flashing Sheet: ASTM D 6164, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified, and as follows:
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.

OR

Metal-Foil-Surfaced Flashing Sheet: ASTM D 6298, metal-foil surfaced SBS-modified asphalt sheet (reinforced with glass fibers); suitable for application method specified, and as follows:

- a. Foil Surfacing: Aluminum **OR** Copper **OR** Stainless steel **OR** Aluminum, fluoropolymer-coated finish, of color and gloss selected from manufacturer's full range, **as directed**.
3. Glass-Fiber Fabric: Woven glass-fiber cloth, treated with asphalt, complying with ASTM D 1668, Type I.

E. Auxiliary Roofing Membrane Materials

1. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with roofing membrane.
 - a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.



- b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
- 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Gypsum Board and Panel Adhesives: 50 g/L.
 - 3) Multipurpose Construction Adhesives: 70 g/L.
 - 4) Fiberglass Adhesives: 80 g/L.
 - 5) Contact Adhesive: 80 g/L.
 - 6) Other Adhesives: 250 g/L.
 - 7) Nonmembrane Roof Sealants: 300 g/L.
 - 8) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 9) Sealant Primers for Porous Substrates: 775 g/L.
2. Asphalt Primer: ASTM D 41.
3. Roofing Asphalt: ASTM D 312, Type III **OR** Type IV **OR** Type III or IV as recommended by roofing system manufacturer for application, **as directed**.
OR
Roofing Asphalt: ASTM D 6152, SEBS modified.
4. Cold-Applied Adhesive: Roofing system manufacturer's standard asphalt-based, one- or two-part, asbestos-free, cold-applied adhesive specially formulated for compatibility and use with roofing membrane and base flashings.
5. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required by roofing system manufacturer for application.
6. Mastic Sealant: Polyisobutylene, plain or modified bitumen; nonhardening, nonmigrating, nonskinning, and nondrying.
7. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roofing membrane components to substrate; tested by manufacturer for required pullout strength, and acceptable to roofing system manufacturer.
8. Metal Flashing Sheet: As specified in Division 07 Section "Sheet Metal Flashing And Trim".
9. Roofing Granules: Ceramic-coated roofing granules, No. 11 screen size with 100 percent passing No. 8 (2.36-mm) sieve and 98 percent of mass retained on No. 40 (0.425-mm) sieve, color to match roofing membrane.
10. Aggregate Surfacing: ASTM D 1863, No. 6 or No. 67, clean, dry, opaque, water-worn gravel or crushed stone, free of sharp edges **OR** crushed slag, free of sharp edges, **as directed**.
11. Miscellaneous Accessories: Provide those recommended by roofing system manufacturer.
- F. Substrate Boards
1. Substrate Board: ASTM C 1396/C 1396M, Type X gypsum board, 5/8 inch (16 mm) thick.
OR
Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Substrate Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 728, perlite board, 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick, seal coated.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate board to roof deck.
- G. Vapor Retarder
1. Polyethylene Film: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).



- a. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.

OR

Adhesive: Manufacturer's standard lap adhesive, FM Approvals approved for vapor-retarder application.

2. Laminated Sheet: Kraft paper, two layers, laminated with asphalt and edge reinforced with woven fiberglass yarn, with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and with manufacturer's standard adhesive, **as directed**.
3. Self-Adhering Sheet Vapor Retarder: ASTM D 1970, minimum of 40-mil- (1.0-mm-) thick, polyethylene film laminated to layer of rubberized asphalt adhesive; maximum permeance rating of 0.1 perm (6 ng/Pa x s x sq. m); cold applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.

OR

Self-Adhering Sheet Vapor Retarder: 30- to 40-mil- (0.76- to 1.0-mm-) thick, polyethylene film laminated to layer of butyl rubber adhesive; maximum permeance rating of 0.1 perm (6 ng/Pa x s x sq. m); cold applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.

4. Glass-Fiber Felt: ASTM D 2178, Type IV, asphalt impregnated.

H. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) **OR** Type X, 1.3-lb/cu. ft. (21-kg/cu. m), **as directed**, minimum density, square edged.
3. Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density.
4. Composite Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density, with factory-applied facings, as follows:
 - a. Facer: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, asphalt coated, 1/2 inch (13 mm) thick.

OR

Facer: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
5. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 **OR** Type II, Class I, Grade 3, **as directed**, felt or glass-fiber mat facer on both major surfaces.
6. Composite Polyisocyanurate Board Insulation: ASTM C 1289, with factory-applied facing board, as indicated below by type, on one major surface and felt or glass-fiber mat facer on the other surface.
 - a. Type IV, cellulosic-fiber-insulating-board facer, Grade 2, 1/2 inch (13 mm) thick.
 - b. Type V, OSB facer, 7/16 inch (11 mm) thick.
 - c. Type VII, glass-mat-faced gypsum board facer, 1/4 inch (6 mm) thick.
7. Perlite Board Insulation: ASTM C 728, rigid, mineral-aggregate thermal insulation board composed of expanded perlite, cellulosic fibers, binders, and waterproofing agents with top surface seal coated.
8. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 2, fibrous-felted, rigid insulation boards of wood fiber or other cellulosic-fiber and water-resistant binders, asphalt impregnated, chemically treated for deterioration.
9. Cellular-Glass Board Insulation: ASTM C 552, Type IV, rigid, cellular-glass thermal board insulation faced with manufacturer's standard kraft-paper sheets.
10. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches (1:48) unless otherwise indicated.
11. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.



I. Insulation Accessories

1. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation to substrate, and acceptable to roofing system manufacturer.
3. Modified Asphaltic Insulation Adhesive: Insulation manufacturer's recommended modified asphaltic, asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.
OR
Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one-component or multicomponent urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
OR
Full-Spread Applied Insulation Adhesive: Insulation manufacturer's recommended spray-applied, low-rise, two-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
4. Insulation Cant Strips: ASTM C 728, perlite insulation board.
OR
Insulation Cant Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.
5. Wood Nailer Strips: Comply with requirements in Division 06 Section(s) "Rough Carpentry" OR "Miscellaneous Rough Carpentry", **as directed**.
6. Tapered Edge Strips: ASTM C 728, perlite insulation board.
OR
Tapered Edge Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.
7. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, 1/2 inch (13 mm) thick.
OR
Cover Board: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
OR
Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Cover Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
8. Substrate Joint Tape: 6- or 8-inch- (150- or 200-mm-) wide, coated, glass-fiber joint tape.

J. Walkways

1. Walkway Pads: Reinforced asphaltic composition pads with slip-resisting mineral-granule surface **OR** Polymer-modified, reconstituted rubber pads with slip-resisting textured surface, **as directed**, manufactured as a traffic pad for foot traffic and acceptable to roofing system manufacturer, 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, thick, minimum.
2. Walkway Cap Sheet Strips: ASTM D 6164, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified, and as follows:
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with the following requirements and other conditions affecting performance of roofing system:



- a. Verify that roof openings and penetrations are in place and curbs are set and braced and that roof drain bodies are securely clamped in place.
 - b. Verify that wood cants, blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
 - c. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Division 5 Section "Steel Deck."
 - d. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
 - e. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
 - 1) Test for moisture by pouring 1 pint (0.5 L) of hot roofing asphalt on deck at start of each day's work and at start of each roof area or plane. Do not proceed with roofing work if test sample foams or can be easily and cleanly stripped after cooling.
 - f. Verify that concrete-curing compounds that will impair adhesion of roofing components to roof deck have been removed.
 - g. Verify that deck is securely fastened with no projecting fasteners and with no adjacent units in excess of 1/16 inch (1.6 mm) out of plane relative to adjoining deck.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Prime surface of concrete deck with asphalt primer at a rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
4. Install insulation strips in ribs of acoustical roof decks according to acoustical roof deck manufacturer's written instructions.

C. Substrate Board Installation

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - a. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.
OR
Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to membrane roofing system manufacturers' written instructions.

D. Vapor-Retarder Installation

1. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 - a. Continuously seal side and end laps with tape **OR** adhesive, **as directed**.
2. Laminate Sheet: Install laminate-sheet vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively. Bond vapor retarder to substrate as follows:
 - a. Apply adhesive at rate recommended by vapor-retarder manufacturer. Seal laps with adhesive.
OR
Apply ribbons of hot roofing asphalt at spacing, temperature, and rate recommended by vapor-retarder manufacturer. Seal laps with hot roofing asphalt.



3. Self-Adhering Sheet Vapor Retarder: Prime substrate if required by manufacturer. Install self-adhering sheet vapor retarder over area to receive vapor retarder, side and end lapping each sheet a minimum of 3-1/2 inches (90 mm) and 6 inches (150 mm), respectively. Seal laps by rolling.
4. Built-up Vapor Retarder: Install two glass-fiber felt plies lapping each felt 19 inches (483 mm) over preceding felt. Embed each felt in a solid mopping of hot roofing asphalt. Glaze-coat completed surface with hot roofing asphalt. Apply hot roofing asphalt within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
5. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.

E. Insulation Installation

1. Comply with roofing system manufacturer's written instructions for installing roof insulation.
2. Install one lapped base-sheet course and mechanically fasten to substrate according to roofing system manufacturer's written instructions.
3. Nailer Strips: Mechanically fasten 4-inch nominal- (89-mm actual-) width wood nailer strips of same thickness as insulation perpendicular to sloped roof deck at the following spacing:
 - a. 16 feet (4.88 m) apart for roof slopes steeper than 1 inch per 12 inches (1:12) but less than 3 inches per 12 inches (3:12).
 - b. 48 inches (1220 mm) apart for roof slopes steeper than 3 inches per 12 inches (3:12).
4. Insulation Cant Strips: Install and secure preformed 45-degree insulation cant strips at junctures of roofing membrane system with vertical surfaces or angle changes more than 45 degrees.
5. Install tapered insulation under area of roofing to conform to slopes indicated.
6. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - a. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
7. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or more, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.
 - a. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
8. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
9. Install tapered edge strips at perimeter edges of roof that do not terminate at vertical surfaces.
10. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
 - a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
 - b. Set each layer of insulation in a solid mopping of hot roofing asphalt applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.

OR

Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.

OR

Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
11. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. If Project is FM Global insured or if FM Approvals requirements are proposed as a performance standard, fasten insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
 - b. If number of fasteners will be based on ASCE/SEI 7's uplift pressure or SPRI's factored design uplift pressure, fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.



12. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 13. If Project is FM Global insured or if FM Approvals requirements are proposed as a performance standard, fasten first layer of insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
 14. If fastening is calculated from ASCE/SEI 7's uplift pressure or SPRI's factored design uplift pressure, fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
 - a. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
OR
Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
OR
Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
- F. If cover boards will be field installed over roof insulation and immediately below roofing membrane, install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints a minimum of 6 inches (150 mm) in each direction from joints of insulation below. Loosely butt cover boards together and fasten to roof deck, **as directed**. Tape joints if required by roofing system manufacturer.
- a. Fasten cover boards according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.
 - b. Apply hot roofing asphalt to underside, and immediately bond cover board to substrate.
- G. Roofing Membrane Installation, General
1. If referencing NRCA's roof assembly identification matrix system, install roofing membrane system according to roofing system manufacturer's written instructions and applicable recommendations in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing."
 - a. Install roofing system MBS **OR** MBSH, **as directed**, -2 **OR** 3 **OR** 4, **as directed**, -N **OR** I **OR** C, **as directed**, -T **OR** M **OR** L, **as directed**, -A **OR** M **OR** F, **as directed**, according to roof assembly identification matrix and roof assembly layout illustrations in NRCA's "The NRCA Roofing and Waterproofing Manual" and to requirements in this Section.
 2. For roof system that exceeds requirements of NRCA's roof assemblies, install roofing membrane system according to roofing system manufacturer's written instructions and applicable recommendations in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing" and as follows:
 - a. Deck Type: N (nailable) **OR** I (insulated) **OR** C (concrete or nonnailable), **as directed**.
 - b. Adhering Method: T (torched) **OR** M (mopped) **OR** L (cold-applied adhesive), **as directed**.
 - c. Base Sheet: One **OR** One, installed over sheathing paper, **as directed**.
 - d. Number of Glass-Fiber Base-Ply Sheets: One **OR** Two, **as directed**.
 - e. Number of SBS-Modified Asphalt Sheets: One **OR** Two, **as directed**.
 - f. Surfacing Type: A (aggregate) **OR** M (mineral-granule-surfaced cap sheet) **OR** F (foil-surfaced cap sheet), **as directed**.
 3. Start installation of roofing membrane in presence of roofing system manufacturer's technical personnel.
 4. Where roof slope exceeds 1/2 inch per 12 inches (1:24) **OR** 3/4 inch per 12 inches (1:18), **as directed**, install roofing membrane sheets parallel with slope.



- a. Backnail roofing membrane sheets to nailer strips **OR** substrate, **as directed**, according to roofing system manufacturer's written instructions.
 5. Cooperate with testing agencies engaged or required to perform services for installing roofing system.
 6. Coordinate installation of roofing system so insulation and other components of the roofing membrane system not permanently exposed are not subjected to precipitation or left uncovered at the end of the workday or when rain is forecast.
 - a. At end of each day's work, provide tie-offs to cover exposed roofing membrane sheets and insulation with a course of coated felt set in roofing cement or hot roofing asphalt, with joints and edges sealed.
 - b. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system.
 - c. Remove and discard temporary seals before beginning work on adjoining roofing.
 7. Asphalt Heating: Do not raise roofing asphalt temperature above equiviscous temperature range more than one hour before time of application. Do not exceed roofing asphalt manufacturer's recommended temperature limits during roofing asphalt heating. Do not heat roofing asphalt within 25 deg F (14 deg C) of flash point. Discard roofing asphalt maintained at a temperature exceeding finished blowing temperature for more than four hours.

OR

Asphalt Heating: Heat and apply SEBS-modified roofing asphalt according to roofing system manufacturer's written instructions.
 8. Substrate-Joint Penetrations: Prevent roofing asphalt and adhesives from penetrating substrate joints, entering building, or damaging roofing system components or adjacent building construction.
- H. Base-Sheet Installation
1. Loosely lay one course of sheathing paper, lapping edges and ends a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 2. Install lapped base-sheet course, extending sheet over and terminating beyond cants. Attach base sheet as follows:
 - a. Mechanically fasten to substrate, for nailable substrate.

OR

Spot- or strip-mop to substrate with hot roofing asphalt.

OR

Adhere to substrate in a solid mopping of hot roofing asphalt **OR** uniform coating of cold-applied adhesive, **as directed**, for nonnailable or insulated substrates.
- I. Base-Ply Sheet Installation
1. Install glass-fiber base-ply sheets according to roofing system manufacturer's written instructions starting at low point of roofing system. Align glass-fiber base-ply sheets without stretching. Extend sheets over and terminate beyond cants.
 - a. Shingle side laps of glass-fiber base-ply sheets uniformly to ensure that required number of glass-fiber base-ply sheets covers substrate at any point. Shingle in direction to shed water.
 - b. Embed each glass-fiber base-ply sheet in a continuous void-free mopping of hot roofing asphalt to form a uniform membrane without glass-fiber base-ply sheets touching.
- J. SBS-Modified Bituminous Membrane Installation
1. Install modified bituminous roofing membrane cap sheet **OR** sheet and cap sheet, **as directed**, according to roofing manufacturer's written instructions, starting at low point of roofing system. Extend roofing membrane sheets over and terminate beyond cants, installing as follows:
 - a. Adhere to substrate in a solid mopping of hot roofing asphalt applied at not less than 425 deg F (218 deg C).

OR

Adhere to substrate in cold-applied adhesive.

OR



- Torch apply to substrate.
- b. Unroll roofing membrane sheets and allow them to relax for minimum time period required by manufacturer.
2. Laps: Accurately align roofing membrane sheets, without stretching, and maintain uniform side and end laps. Stagger end laps. Completely bond and seal laps, leaving no voids.
 - a. Repair tears and voids in laps and lapped seams not completely sealed.
 - b. Apply roofing granules to cover exuded bead at laps while bead is hot.
 3. Install roofing membrane sheets so side and end laps shed water.
 4. Aggregate Surfacing: Promptly after installing and testing roofing membrane, base flashing, and stripping, flood-coat roof surface with 60 lb/100 sq. ft. (3 kg/sq. m) of hot roofing asphalt. While flood coat is hot and fluid, cast the following average weight of aggregate in a uniform course:
 - a. Aggregate Weight: 400 lb/100 sq. ft. (20 kg/sq. m) for gravel or crushed stone or 300 lb/100 sq. ft. (15 kg/sq. m) for slag.
- K. Flashing And Stripping Installation
1. Install base flashing over cant strips and other sloped and vertical surfaces, at roof edges, and at penetrations through roof; secure to substrates according to roofing system manufacturer's written instructions, and as follows:
 - a. Prime substrates with asphalt primer if required by roofing system manufacturer.
 - b. Backer Sheet Application: Mechanically fasten backer sheet to walls or parapets. Adhere backer sheet over roofing membrane at cants in a solid mopping of hot roofing asphalt **OR** cold-applied adhesive, **as directed**.
OR
 Backer Sheet Application: Adhere backer sheet to substrate in a solid mopping of hot roofing asphalt **OR** cold-applied adhesive at rate required by roofing system manufacturer, **as directed**.
 - c. Flashing Sheet Application: Adhere flashing sheet to substrate in a solid mopping of hot roofing asphalt applied at not less than 425 deg F (218 deg C). Apply hot roofing asphalt to back of flashing sheet if recommended by roofing system manufacturer.
OR
 Flashing Sheet Application: Adhere flashing sheet to substrate in cold-applied adhesive at rate required by roofing system manufacturer.
OR
 Flashing Sheet Application: Adhere flashing sheet to substrate in asphalt roofing cement at rate required by roofing system manufacturer.
OR
 Flashing Sheet Application: Torch apply flashing sheet to substrate.
 2. Extend base flashing up walls or parapets a minimum of 8 inches (200 mm) above roofing membrane and 4 inches (100 mm) onto field of roofing membrane.
 3. Mechanically fasten top of base flashing securely at terminations and perimeter of roofing.
 - a. Seal top termination of base flashing with a strip of glass-fiber fabric set in asphalt roofing cement, **as directed**.
 4. Install roofing membrane cap-sheet stripping where metal flanges and edgings are set on membrane roofing according to roofing system manufacturer's written instructions.
 5. Roof Drains: Set 30-by-30-inch- (760-by-760-mm-) square metal flashing in bed of asphalt roofing cement on completed roofing membrane. Cover metal flashing with roofing membrane cap-sheet stripping and extend a minimum of 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, beyond edge of metal flashing onto field of roofing membrane. Clamp roofing membrane, metal flashing, and stripping into roof-drain clamping ring.
 - a. Install stripping according to roofing system manufacturer's written instructions.
- L. Walkway Installation
1. Walkway Pads: Install walkway pads using units of size indicated or, if not indicated, of manufacturer's standard size according to walkway pad manufacturer's written instructions.
 - a. Set walkway pads in cold-applied adhesive.



OR

Set walkway pads in additional pour coat of hot roofing asphalt after aggregate surfacing of modified bituminous roofing membrane.

2. Walkway Cap Sheet Strips: Install walkway cap sheet strips over roofing membrane using same application method as used for roofing membrane cap sheet. Install walkway cap sheet strips before flood coat and aggregate surface is applied, **as directed**.

M. Field Quality Control

1. Testing Agency: Perform tests and inspections and to prepare test reports.
2. Test Cuts: Test specimens will be removed to evaluate problems observed during quality-assurance inspections of roofing membrane as follows:
 - a. Approximate quantities of components within roofing membrane will be determined according to ASTM D 3617.
 - b. Test specimens will be examined for interply voids according to ASTM D 3617 and to comply with criteria established in Appendix 3 in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing."
 - c. Repair areas where test cuts were made according to roofing system manufacturer's written instructions.
3. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.
 - a. Notify the Owner 48 hours in advance of date and time of inspection.
4. Roofing system will be considered defective if it does not pass tests and inspections.
 - a. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.

N. Protecting And Cleaning

1. Protect roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to the Owner.
2. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 05 13 00c



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**SECTION 07 05 13 00d - PREPARATION FOR RE-ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for preparation for re-roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Roof tear-off.
 - b. Partial roof tear-off.
 - c. Temporary roofing membrane.
 - d. Roof re-cover preparation.
 - e. Removal of base flashings.

C. Materials Ownership

1. Except for items or materials indicated to be reused, reinstalled, or otherwise indicated to remain the Owner's property, demolished materials shall become Contractor's property and shall be removed from Project site.

D. Definitions

1. Roofing Terminology: Refer to ASTM D 1079 and glossary in NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.
2. Existing Membrane Roofing System: Built-up asphalt, Built-up coal-tar, EPDM, CSPE, PVC, TPO, APP-modified bituminous, or SBS-modified bituminous roofing membrane, roof insulation, surfacing, and components and accessories between deck and roofing membrane.
3. Roof Re-Cover Preparation: Existing roofing membrane that is to remain and be prepared for reuse.
4. Roof Tear-Off: Removal of existing membrane roofing system from deck.
5. Partial Roof Tear-Off: Removal of a portion of existing membrane roofing system from deck or removal of selected components and accessories from existing membrane roofing system.
6. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and reinstalled.
7. Existing to Remain: Existing items of construction that are not indicated to be removed.

E. Submittals

1. Product Data: For each type of product indicated.
2. Temporary Roofing: Include Product Data and description of temporary roofing system. If temporary roof will remain in place, submit surface preparation requirements needed to receive permanent roof, and submit a letter from roofing membrane manufacturer stating acceptance of the temporary membrane and that its inclusion will not adversely affect the roofing system's resistance to fire and wind or its FM Global rating, **as directed**.
3. Coal tar roofs can't be mixed with asphalt roofs. Test materials in accordance with the American Society for Testing and Materials (ASTM).
4. Fastener pull-out test report.
5. Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including exterior and interior finish surfaces that might be misconstrued as having been damaged by reroofing operations. Submit before Work begins.
6. Landfill Records: Indicate receipt and acceptance of hazardous wastes, such as asbestos-containing material, by a landfill facility licensed to accept hazardous wastes.



7. Qualification Data: For Installer including certificate that Installer is licensed to perform asbestos abatement and is approved by warrantor of existing roofing system.

F. Quality Assurance

1. Installer Qualifications: Installer of new membrane roofing system, licensed to perform asbestos abatement in the State or jurisdiction where Project is located, **as directed**, and approved by warrantor of existing roofing system to work on existing roofing, **as directed**.
2. Regulatory Requirements: Comply with governing EPA notification regulations before beginning membrane roofing removal. Comply with hauling and disposal regulations of authorities having jurisdiction.
3. Reroofing Conference: Conduct conference at Project site.

G. Project Conditions

1. the Owner will occupy portions of building immediately below reroofing area. Conduct reroofing so the Owner's operations will not be disrupted. Provide the Owner with not less than 72 hours' notice of activities that may affect the Owner's operations.
 - a. Coordinate work activities daily with the Owner so the Owner can place protective dust or water leakage covers over sensitive equipment or furnishings, shut down HVAC and fire-alarm or -detection equipment if needed, and evacuate occupants from below the work area.
 - b. Before working over structurally impaired areas of deck, notify the Owner to evacuate occupants from below the affected area. Verify that occupants below the work area have been evacuated before proceeding with work over the impaired deck area.
2. Protect building to be reroofed, adjacent buildings, walkways, site improvements, exterior plantings, and landscaping from damage or soiling from reroofing operations.
3. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities.
4. Conditions existing at time of inspection for bidding will be maintained by the Owner as far as practical.
 - a. A roof moisture survey of existing membrane roofing system is available for Contractor's reference.
 - b. The results of an analysis of test cores from existing membrane roofing system are available for Contractor's reference.
 - c. Construction Drawings and Project Manual for existing roofing system are provided for Contractor's reference. Contractor is responsible for conclusions derived from existing documents.
5. Limit construction loads on roof, as directed by the Owner. Rooftop equipment wheel loads and for uniformly distributed loads.
6. Weather Limitations: Proceed with reroofing preparation only when existing and forecasted weather conditions permit Work to proceed without water entering existing roofing system or building.
7. Hazardous Materials: It is not expected that hazardous materials such as asbestos-containing materials will be encountered in the Work.
 - a. Hazardous materials will be removed by the Owner before start of the Work. Existing roof will be left no less watertight than before removal.
 - b. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify the Owner. Hazardous materials will be removed by the Owner under a separate contract.

OR

Hazardous Materials: Present in building to be reroofed. A report on the presence of hazardous materials is on file for review and use. Examine report to become aware of locations where hazardous materials are present.

- a. Hazardous material remediation is specified elsewhere in the Contract Documents.
- b. Do not disturb hazardous materials or items suspected of containing hazardous materials except according to procedures specified elsewhere in the Contract Documents.



- c. Coordinate with hazardous material remediation subcontractor to prevent water from entering existing roofing system or building.

H. Warranty

1. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during reroofing, by methods and with materials so as not to void existing roofing system warranty. Notify warrantor before proceeding.
 - a. Notify warrantor of existing roofing system on completion of reroofing, and obtain documentation verifying that existing roofing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

1.2 PRODUCTS

A. Infill Materials

1. Use infill materials matching existing membrane roofing system materials unless otherwise indicated.
 - a. Infill materials are specified in a Division 07.

B. Temporary Roofing Materials

1. Design and selection of materials for temporary roofing are responsibilities of Contractor.
2. Sheathing Paper: Red-rosin type, minimum 3 lb/100 sq. ft. (0.16 kg/sq. m).
3. Base Sheet: ASTM D 4601, Type II, nonperforated, asphalt-impregnated and -coated, glass-fiber sheet.
4. Glass-Fiber Felts: ASTM D 2178, Type IV, asphalt-impregnated, glass-fiber felt.
5. Asphalt Primer: ASTM D 41.
6. Roofing Asphalt: ASTM D 312, Type III or IV.

C. Recover Boards

1. Recover Board: ASTM C 208, Type II, Grade 1 **OR** 2, **as directed**, cellulosic-fiber insulation board; 1/2 inch (13 mm) thick.
OR
Recover Board: Fan-folded, unfaced, extruded-polystyrene board insulation; 3/16-inch (5-mm) **OR** 1/4-inch (6-mm) **OR** 3/8-inch (10-mm), **as directed**, nominal thickness.
OR
Recover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate; 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick.
OR
Recover Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate; 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR
Recover Board: ASTM C 728, perlite board; 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
2. Fasteners: Factory-coated steel fasteners, No. 12 or 14, and metal or plastic plates listed in FM Approval's "Approval Guide," designed for fastening recover boards to deck.

D. Auxiliary Reroofing Materials

1. General: Auxiliary reroofing preparation materials recommended by roofing system manufacturer for intended use and compatible with components of existing and new membrane roofing system.
2. Base Sheet Fasteners: Capped head, factory-coated steel fasteners, listed in FM Approval's "Approval Guide."
3. Metal Flashing Sheet: Metal flashing sheet is specified in Division 07 Section "Sheet Metal Flashing And Trim".



1.3 EXECUTION

A. Preparation

1. Protect existing membrane roofing system that is indicated not to be reroofed.
 - a. Loosely lay 1-inch- (25-mm-) minimum thick, molded expanded polystyrene (MEPS) insulation over the roofing membrane in areas indicated. Loosely lay 15/32-inch (12-mm) plywood or OSB panels over MEPS. Extend MEPS past edges of plywood or OSB panels a minimum of 1 inch (25 mm).
 - b. Limit traffic and material storage to areas of existing roofing membrane that have been protected.
 - c. Maintain temporary protection and leave in place until replacement roofing has been completed. Remove temporary protection on completion of reroofing.
2. Coordinate with the Owner to shut down air-intake equipment in the vicinity of the Work. Cover air-intake louvers before proceeding with reroofing work that could affect indoor air quality or activate smoke detectors in the ductwork.
3. During removal operations, have sufficient and suitable materials on-site to facilitate rapid installation of temporary protection in the event of unexpected rain.
4. Maintain roof drains in functioning condition to ensure roof drainage at end of each workday. Prevent debris from entering or blocking roof drains and conductors. Use roof-drain plugs specifically designed for this purpose. Remove roof-drain plugs at end of each workday, when no work is taking place, or when rain is forecast.
 - a. If roof drains are temporarily blocked or unserviceable due to roofing system removal or partial installation of new membrane roofing system, provide alternative drainage method to remove water and eliminate ponding. Do not permit water to enter into or under existing membrane roofing system components that are to remain.
5. Verify that rooftop utilities and service piping have been shut off before beginning the Work.

B. Roof Tear-Off

1. General: Notify the Owner each day of extent of roof tear-off proposed for that day and obtain authorization to proceed.
2. Remove aggregate ballast from roofing membrane. Store aggregate ballast for reuse, **as directed**.
3. Remove loose aggregate from aggregate-surfaced built-up bituminous roofing using a power broom.
4. Remove pavers and accessories from roofing membrane. Store and protect pavers and accessories for reuse, **as directed**. Discard cracked pavers, **as directed**.
5. Remove protection mat and extruded-polystyrene insulation from protected roofing membrane.
 - a. Discard extruded-polystyrene insulation that is wet and exceeds 8 lb/cu. ft. (128 kg/cu. m).
 - b. Store extruded-polystyrene insulation for reuse and protect from physical damage.
6. Roof Tear-Off: Remove existing roofing membrane and other membrane roofing system components down to the deck.
 - a. Remove cover boards **OR** roof insulation **OR** substrate boards, **as directed**.
 - b. Bitumen and felts that are firmly bonded to concrete decks are permitted to remain if felts are dry. Remove unadhered bitumen and felts and wet felts.
 - c. Remove excess asphalt from steel deck. A maximum of 15 lb/100 sq. ft. (0.72 kg/sq. m) of asphalt is permitted to remain on steel decks.
 - d. Remove fasteners from deck or cut fasteners off slightly above deck surface, **as directed**.
7. Partial Roof Tear-Off: Where indicated, remove existing roofing membrane and other membrane roofing system components down to the deck.
 - a. Remove cover boards **OR** roof insulation **OR** substrate boards, **as directed**.
 - b. Bitumen and felts that are firmly bonded to concrete decks are permitted to remain if felts are dry. Remove unadhered bitumen and felts and wet felts.
 - c. Remove excess asphalt from steel deck. A maximum of 15 lb/100 sq. ft. (0.72 kg/sq. m) of asphalt is permitted to remain on steel decks.
 - d. Remove fasteners from deck or cut fasteners off slightly above deck surface, **as directed**.

**OR**

Partial Roof Tear-Off: Remove existing roofing membrane and immediately check for presence of moisture by visually observing cover boards **OR** roof insulation **OR** substrate boards, **as directed**, that will remain.

- a. Coordinate with the Owner's inspector to schedule times for tests and inspections immediately after membrane removal.
- b. With an electrical capacitance moisture-detection meter, spot check cover boards **OR** roof insulation **OR** substrate boards, **as directed**, that will remain.
- c. Remove wet or damp boards and roof insulation. Removal will be paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents, **as directed**.
- d. Bitumen and felts that are firmly bonded to concrete decks are permitted to remain if felts are dry. Remove unadhered bitumen and felts and wet felts.
- e. Remove excess asphalt from steel deck. A maximum of 15 lb/100 sq. ft. (0.72 kg/sq. m) of asphalt is permitted to remain on steel decks.
- f. Remove fasteners from deck or cut fasteners off slightly above deck surface, **as directed**.

C. Deck Preparation

1. Inspect deck after tear-off **OR** partial tear-off, **as directed**, of membrane roofing system.
2. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263 or by pouring 1 pint (0.5 L) of hot roofing asphalt on deck at start of each day's work and at start of each roof area or plane. Do not proceed with roofing work if moisture condenses under the plastic sheet or if asphalt test sample foams or can be easily and cleanly stripped after cooling.
3. If broken or loose fasteners that secure deck panels to one another or to structure are observed or if deck appears or feels inadequately attached, immediately notify the Owner. Do not proceed with installation until directed by the Owner.
4. If deck surface is not suitable for receiving new roofing or if structural integrity of deck is suspect, immediately notify the Owner. Do not proceed with installation until directed by the Owner.
5. Provide additional deck securement as indicated on Drawings.
6. Replace deck as indicated on Drawings. Replacement deck is specified in Division 31 **OR** Division 03 **OR** Division 21 Section(s) "Fire-suppression Standpipes".

D. Infill Materials Installation

1. Immediately after removal of selected portions of existing membrane roofing system, and inspection and repair, if needed, of deck, fill in the tear-off areas to match existing membrane roofing system construction.
 - a. Installation of infill materials is specified in Division 07.
 - b. Install new roofing membrane patch over roof infill area. If new roofing membrane is installed the same day tear-off is made, roofing membrane patch is not required.

E. Temporary Roofing Membrane

1. Install approved temporary roofing membrane over area to be reroofed.
OR
Install temporary roofing membrane over area to be reroofed. Install two glass-fiber felts **OR** Mechanically fasten base sheet and install a glass-fiber felt, **as directed**, lapping each sheet 19 inches (483 mm) over preceding sheet. Embed glass-fiber felt in a solid mopping of hot roofing asphalt applied within equiviscous temperature range. Glaze-coat completed surface with hot roofing asphalt.
2. Remove temporary roofing membrane before installing new roofing membrane.
OR
Prepare the temporary roof to receive new roofing membrane according to approved temporary roofing membrane proposal **OR** by patching and repairing temporary roofing membrane, **as directed**. Restore temporary roofing membrane to watertight condition. Obtain approval for temporary roof substrate from roofing membrane manufacturer and the Owner before installing new roof.



F. Roof Re-Cover Preparation

1. Remove blisters, ridges, buckles, mechanically attached roofing membrane fastener buttons projecting above the membrane, **as directed**, and other substrate irregularities from existing roofing membrane that inhibit new recover boards from conforming to substrate.
 - a. Remove loose aggregate from aggregate-surfaced built-up bituminous roofing with a power broom.
 - b. Scarify the surface of sprayed polyurethane foam as necessary to achieve a sufficiently uniform plane to receive new recover boards.
 - c. Broom clean existing substrate.
 - d. Coordinate with the Owner's inspector to schedule times for tests and inspections before proceeding with installation of recover boards.
 - e. Verify that existing substrate is dry before proceeding with installation of recover boards. Spot check substrates with an electrical capacitance moisture-detection meter.
 - f. Remove materials that are wet or damp. Removal will be paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents.
2. Remove blisters, ridges, buckles, mechanically attached roofing membrane fastener buttons projecting above the membrane, **as directed**, and other substrate irregularities from existing roofing membrane that inhibit new recover boards **OR** roofing membrane, **as directed**, from conforming to substrate.
 - a. Remove loose aggregate from aggregate-surfaced built-up bituminous roofing with a power broom.
 - b. Scarify the surface of sprayed polyurethane foam as necessary to achieve a sufficiently uniform plane to receive new recover boards **OR** roofing membrane, **as directed**.
 - c. Broom clean existing substrate.
 - d. Coordinate with the Owner's inspector to schedule times for tests and inspections.
 - e. Verify that existing substrate is dry before proceeding with installation. Spot check substrates with an electrical capacitance moisture-detection meter.
 - f. Remove materials that are wet and damp. Removal will be paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents.
3. Remove blisters and areas of membrane not fully adhered.

OR

Remove mechanically attached roofing membrane fastener buttons projecting above the membrane and other, **as directed**, substrate irregularities that inhibit new recover boards from conforming to substrate.

 - a. Remove loose aggregate from aggregate-surfaced built-up bituminous roofing with a power broom.
 - b. Clean substrate of contaminants such as dirt, debris, oil, and grease that can affect adhesion of coated foamed roofing.
 - c. Power vacuum the existing roof surface. If recommended by foam manufacturer, prime dried surface at recommended rate with recommended primer.
 - d. Scarify the surface of coated polyurethane roofing as necessary to achieve a suitable substrate for new roofing.
 - e. Provide additional uplift securement for existing roofing system with new screws and plates applied to each roof zone at the following densities:
 - 1) Field of roof, one fastener for each.
 - 2) Corners of roof, one fastener for each.
 - 3) Perimeters of roof, one fastener for each. Width of perimeter zone of roof as directed by the Owner.
 - f. Verify that surface is dry by pressing litmus paper to surface areas most likely to retain moisture, such as shaded areas and low spots. If paper changes color, surface is too wet to apply foam.
 - g. Build up isolated low spots on existing roofing membrane with sprayed foam specified in Division 07 Section "Coated Foamed Roofing" to prevent ponding.

G. Existing Base Flashings



1. Remove existing base flashings around parapets, curbs, walls, and penetrations.
 - a. Clean substrates of contaminants such as asphalt, sheet materials, dirt, and debris.
 2. Do not damage metal counterflashings that are to remain. Replace metal counterflashings damaged during removal with counterflashings of same metal, weight or thickness, and finish **OR** specified in Division 07 Section "Sheet Metal Flashing And Trim" **OR** specified in Division 07 Section "Roof Specialties", **as directed**.
 3. Inspect parapet sheathing for deterioration and damage. If parapet sheathing has deteriorated, immediately notify the Owner.
 4. Remove existing parapet sheathing and replace with new pressure-preservative **OR** exterior fire-retardant, **as directed**, -treated plywood sheathing, 19/32 inch (15 mm) thick. If parapet framing has deteriorated, immediately notify the Owner.
 - a. Plywood parapet sheathing is specified in Division 06 Section(s) "Rough Carpentry" **OR** "Miscellaneous Rough Carpentry", **as directed**.
- H. Fastener Pull-Out Testing
1. Perform **OR** Retain independent testing and inspecting agency to conduct, **as directed**, fastener pull-out tests according to SPRI FX-1, and submit test report to the Owner **OR** roofing membrane manufacturer, **as directed**, before installing new membrane roofing system.
 - a. Obtain the Owner's **OR** roofing membrane manufacturer's, **as directed**, approval to proceed with specified fastening pattern. the Owner **OR** Roofing membrane manufacturer, **as directed**, may furnish revised fastening pattern commensurate with pull-out test results.
- I. Recover Board Installation
1. Install recover boards over roof insulation **OR** roofing membrane, **as directed**, with long joints in continuous straight lines and end joints staggered between rows. Loosely butt recover boards together and fasten to deck, **as directed**.
 - a. Tape joints of recover boards if required by roofing membrane manufacturer.
 - b. Fasten recover boards to resist wind-uplift pressure at corners, perimeter, and field of roof specified in Division 07 Section "Built-up Asphalt Roofing".
 - c. Install additional fasteners near board corners and edges as necessary to conform boards to substrate and to adjacent boards.
- J. Disposal
1. Collect demolished materials and place in containers. Promptly dispose of demolished materials. Do not allow demolished materials to accumulate on-site.
 - a. Storage or sale of demolished items or materials on-site is not permitted.
 2. Transport and legally dispose of demolished materials off the Owner's property.

END OF SECTION 07 05 13 00d



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Task	Specification	Specification Description
07 05 13 00	07 51 13 00	Built-Up Asphalt Roofing
07 05 13 00	07 53 16 00	EPDM Membrane Roofing



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SECTION 07 11 13 00 - BITUMINOUS DAMPPROOFING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This specification covers the furnishing and installation of materials for bituminous dampproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 SUMMARY

- A. Section Includes:
 - 1. Hot-applied asphalt dampproofing.
 - 2. Cold-applied, cut-back-asphalt dampproofing.
 - 3. Cold-applied, emulsified-asphalt dampproofing.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.2: For dampproofing, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for Credit IEQ 4: For dampproofing, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.4 FIELD CONDITIONS

- A. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit dampproofing to be performed according to manufacturers' written instructions.
- B. Ventilation: Provide adequate ventilation during application of dampproofing in enclosed spaces. Maintain ventilation until dampproofing has cured.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

- A. Source Limitations: Obtain primary dampproofing materials and primers from single source from single manufacturer. Provide protection course, molded-sheet drainage panels and auxiliary materials recommended in writing by manufacturer of primary materials.



- B. VOC Content: Products shall comply with VOC content limits of authorities having jurisdiction unless otherwise required.

2.2 HOT-APPLIED ASPHALT DAMPPROOFING

- A. Hot-Applied Asphalt: ASTM D 449, Type II **OR** Type III, **as directed**.
- B. VOC Content: 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Low-Emitting Materials: Dampproofing shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 COLD-APPLIED, CUT-BACK-ASPHALT DAMPPROOFING

- A. Trowel Coats: ASTM D 4586, Type I, Class 1, fibered.
- B. Brush and Spray Coats: ASTM D 4479, Type I, fibered or nonfibered.
- C. VOC Content: 250 **OR** 300, **as directed**, g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. Low-Emitting Materials: Dampproofing shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

- A. Trowel Coats: ASTM D 1227, Type II, Class 1.
- B. Fibered Brush and Spray Coats: ASTM D 1227, Type II, Class 1.
- C. Brush and Spray Coats: ASTM D 1227, Type III, Class 1.
- D. VOC Content: Zero **OR** 30 g/L or less, **as directed**.
- E. Low-Emitting Materials: Dampproofing shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 AUXILIARY MATERIALS

- A. General: Furnish auxiliary materials recommended in writing by dampproofing manufacturer for intended use and compatible with bituminous dampproofing.
- B. Cut-Back-Asphalt Primer: ASTM D 41.
- C. Emulsified-Asphalt Primer: ASTM D 1227, Type III, Class 1, except diluted with water as recommended in writing by manufacturer.



1. Primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

- D. Asphalt-Coated Glass Fabric: ASTM D 1668, Type I.
- E. Patching Compound: Epoxy or latex-modified repair mortar **OR** Asbestos-free fibered mastic, **as directed**, of type recommended in writing by dampproofing manufacturer.
- F. Protection Course: ASTM D 6506, 1/8-inch- (3-mm-) thick, semirigid sheets of fiberglass or mineral-reinforced-asphalitic core, pressure laminated between two asphalt-saturated fibrous liners.
- G. Protection Course: Fan folded, with a core of extruded-polystyrene board insulation faced on one side or both sides with plastic film, nominal thickness 1/4 inch (6 mm), with a compressive strength of not less than 8 psi (55 kPa) per ASTM D 1621, and maximum water absorption by volume of 0.6 percent per ASTM C 272.
- H. Protection Course: Extruded-polystyrene board insulation, unfaced, ASTM C 578, Type X, 1/2 inch (13 mm) thick.
- I. Protection Course: Smooth-surfaced roll roofing complying with ASTM D 6380, Class S, Type III.

2.6 MOLDED-SHEET DRAINAGE PANELS

- A. Molded-Sheet Drainage Panel: Comply with Section 334600 "Subdrainage."
- B. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Composite subsurface drainage panel consisting of a studded, nonbiodegradable, molded-plastic-sheet drainage core; with a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve laminated to one side of the core; and with a vertical flow rate of 9 to 15 gpm per ft. (112 to 188 L/min. per m).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions with Applicator present, for compliance with requirements for surface smoothness, surface moisture, and other conditions affecting performance of bituminous dampproofing work.
 - 1. Test for surface moisture according to ASTM D 4263.
- B. Proceed with application only after substrate construction and penetrating work have been completed and unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Mask or otherwise protect adjoining exposed surfaces from being stained, spotted, or coated with dampproofing. Prevent dampproofing materials from entering and clogging weep holes and drains.



- B. Clean substrates of projections and substances detrimental to the dampproofing work; fill voids, seal joints, and remove bond breakers if any, as recommended in writing by prime material manufacturer.
- C. Apply patching compound to patch and fill tie holes, honeycombs, reveals, and other imperfections; cover with asphalt-coated glass fabric.

3.3 APPLICATION, GENERAL

- A. Comply with manufacturer's written instructions for dampproofing application, cure time between coats, and drying time before backfilling unless more stringent requirements are indicated.
 - 1. Apply dampproofing to provide continuous plane of protection.
 - 2. Apply additional coats if recommended in writing by manufacturer or to achieve a smooth surface and uninterrupted coverage.
- B. Where dampproofing footings and foundation walls, apply from finished-grade line to top of footing; extend over top of footing and down a minimum of 6 inches (150 mm) over outside face of footing.
 - 1. Extend dampproofing 12 inches (300 mm) onto intersecting walls and footings, but do not extend onto surfaces exposed to view when Project is completed.
 - 2. Install flashings and corner protection stripping at internal and external corners, changes in plane, construction joints, cracks, and where shown as "reinforced," by embedding an 8-inch- (200-mm-) wide strip of asphalt-coated glass fabric in a heavy coat of dampproofing. Dampproofing coat for embedding fabric is in addition to other coats required.
- C. Where dampproofing exterior face of inner wythe of exterior masonry cavity walls, lap dampproofing at least 1/4 inch (6 mm) onto flashing, masonry reinforcement, veneer ties, and other items that penetrate inner wythe.
 - 1. Extend dampproofing over outer face of structural members and concrete slabs that interrupt inner wythe.
 - 2. Lap dampproofing at least 1/4 inch (6 mm) onto shelf angles supporting veneer.
- D. Where dampproofing interior face of above-grade, exterior concrete and masonry single-wythe masonry walls, continue dampproofing through intersecting walls by keeping vertical mortar joints at intersection temporarily open or by dampproofing wall before constructing intersecting walls.

3.4 HOT-APPLIED ASPHALT DAMPPROOFING

- A. Do not apply hot asphalt when substrate condition causes foaming.
- B. Kettle Temperature: Comply with dampproofing-material manufacturer's written instructions, and keep at least 25 deg F (14 deg C) below the flash point.
- C. Prime masonry and other porous substrates.
- D. Apply a uniform coat of hot asphalt by mopping or spraying at not less than 20 lb or 2.5 gal./100 sq. ft. (1 kg or 1 L/sq. m).
 - 1. Apply a second coat to below-grade foundation walls and where first application has failed to produce a smooth surface and uninterrupted coverage. Apply second coat at the rate specified for first coat.



3.5 COLD-APPLIED, CUT-BACK-ASPHALT DAMPPROOFING

- A. Concrete Foundations and Parged Masonry Foundation Walls: Apply two brush or spray coats at not less than 1.25 gal./100 sq. ft. (0.5 L/sq. m) for first coat and 1 gal./100 sq. ft. (0.4 L/sq. m) for second coat or one trowel coat at not less than 4 gal./100 sq. ft. (1.6 L/sq. m).
- B. Unparged Masonry Foundation Walls: Apply primer and two brush or spray coats at not less than 1.25 gal./100 sq. ft. (0.5 L/sq. m) for first coat and 1 gal./100 sq. ft. (0.4 L/sq. m) for second coat or primer and one trowel coat at not less than 4 gal./100 sq. ft. (1.6 L/sq. m).
- C. Unexposed Face of Concrete Retaining Walls: Apply one brush or spray coat at not less than 1.25 gal./100 sq. ft. (0.5 L/sq. m).
- D. Unexposed Face of Masonry Retaining Walls: Apply primer and one brush or spray coat at not less than 1.25 gal./100 sq. ft. (0.5 L/sq. m).
- E. Concrete Backup for Brick Veneer Assemblies, Stone Veneer Assemblies and Dimension Stone Cladding: Apply one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).
- F. Masonry Backup for Brick Veneer Assemblies, Stone Veneer Assemblies and Dimension Stone Cladding: Apply primer and one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).
- G. Exterior Face of Inner Wythe of Cavity Walls: Apply primer and one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).

3.6 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

- A. Concrete Foundations and Parged Masonry Foundation Walls: Apply two brush or spray coats at not less than 1.5 gal./100 sq. ft. (0.6 L/sq. m) for first coat and 1 gal./100 sq. ft. (0.4 L/sq. m) for second coat one fibered brush or spray coat at not less than 3 gal./100 sq. ft. (1.2 L/sq. m) or one trowel coat at not less than 4 gal./100 sq. ft. (1.6 L/sq. m).
- B. Unparged Masonry Foundation Walls: Apply primer and two brush or spray coats at not less than 1.5 gal./100 sq. ft. (0.6 L/sq. m) for first coat and 1 gal./100 sq. ft. (0.4 L/sq. m) for second coat primer and one fibered brush or spray coat at not less than 3 gal./100 sq. ft. (1.2 L/sq. m) or primer and one trowel coat at not less than 5 gal./100 sq. ft. (2 L/sq. m).
- C. Unexposed Face of Concrete Retaining Walls: Apply one brush or spray coat at not less than 1.25 gal./100 sq. ft. (0.5 L/sq. m).
- D. Unexposed Face of Masonry Retaining Walls: Apply primer and one brush or spray coat at not less than 1.25 gal./100 sq. ft. (0.5 L/sq. m).
- E. Concrete Backup for Brick Veneer Assemblies, Stone Veneer Assemblies and Dimension Stone Cladding: Apply one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).
- F. Masonry Backup for Brick Veneer Assemblies, Stone Veneer Assemblies and Dimension Stone Cladding: Apply primer and one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).
- G. Exterior Face of Inner Wythe of Cavity Walls: Apply primer and one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).
- H. Interior Face of Exterior Concrete Walls: Where above grade and indicated to be furred and finished, apply one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).



- I. Interior Face of Single-Wythe Exterior Masonry Walls: Where above grade and indicated to be furred and finished, apply primer and one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).

3.7 INSTALLATION OF PROTECTION COURSE

- A. Where indicated, install protection course over completed-and-cured dampproofing. Comply with dampproofing-material and protection-course manufacturers' written instructions for attaching protection course.
 - 1. Support protection course over cured coating with spot application of adhesive type recommended in writing by protection-board manufacturer.
 - 2. Install protection course on same day **OR** within 24 hours, **as directed**, of installation of dampproofing (while coating is tacky) to ensure adhesion.

3.8 INSTALLATION OF MOLDED-SHEET DRAINAGE PANELS

- A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall substrate, according to manufacturer's written instructions. Use adhesives or other methods that do not penetrate dampproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
 - 1. Install protection course before installing drainage panels.

3.9 CLEANING

- A. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended in writing by manufacturer of affected construction.

END OF SECTION 07 11 13 00



Task	Specification	Specification Description
07 11 13 00	07 14 16 00	Cold Fluid-Applied Waterproofing



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**SECTION 07 13 13 00 - BITUMINOUS WATERPROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for bituminous waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated. Include recommendations for method of application, primer, number of coats, coverage or thickness, and protection course.

C. Delivery, Storage And Handling

1. Waterproofing materials shall be delivered to the project site in the original sealed containers bearing the name of the manufacturer, contents and brand name. Asphalt shall be protected from freezing in a weathertight enclosure. Reinforcement fabrics shall be protected from moisture damage and moisture absorption in a weathertight enclosure or shall be stored off the ground on pallets, and covered on top and all sides with breathable-type canvas tarpaulins. Plastic sheets cause condensation buildup and therefore shall not be used to cover waterproofing materials. Damaged or deteriorated materials shall be removed from project site.

D. Project Conditions

1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit waterproofing to be performed according to manufacturers' written instructions.
2. Ventilation: Provide adequate ventilation during application of waterproofing in enclosed spaces. Maintain ventilation until waterproofing has cured.

1.2 PRODUCTS

A. Asphalt Waterproofing

1. Primer: Primer for hot-applied asphalt waterproofing shall conform to ASTM D41, asbestos-free, non-fibrated, manufactured with highly ductile soft asphalts and selected hydrocarbons.
2. Above-Grade Hot-Applied Asphalt: For above-grade applications where asphalt will not be exposed to temperatures exceeding 122 degrees F (50 degrees C), hot-applied asphalt for membrane waterproofing system shall conform to ASTM D449, Type II. For above-grade applications where asphalt will be exposed to sunlight and temperatures exceeding 122 degrees F (50 degrees C), hot-applied asphalt shall conform to ASTM D449, Type III.
3. Below-Grade Hot-Applied Asphalt: Hot-applied asphalt for below-grade applications shall conform to ASTM D449, Type I, asbestos-free, manufactured from crude petroleum, suitable for use with membrane waterproofing systems.
4. Reinforcement Fabrics
 - a. Cotton Fabrics: Cotton fabrics shall be woven entirely of cotton conforming with ASTM D173, thoroughly and uniformly saturated with asphalt.
 - b. Woven Burlap Fabrics: Woven burlap fabrics shall be composed of 100 percent jute fiber and two cotton threads at each selvage conforming with ASTM D1327, thoroughly and uniformly saturated with asphalt. The fabric mesh shall not be completely closed or sealed by the process of saturation. Sufficient porosity shall be maintained to allow successive moppings of the plying asphalt to seep through. The surface shall not be coated or covered with talc or any other substances that will interfere with the adhesion between fabric and plying asphalt. The fabric surface shall be uniformly smooth and free of



irregularities, folds and knots. The finished woven burlap fabrics shall be free of ragged edges, untrue edges, breaks or cracks, and other visible external defects.

- c. Glass Fabrics: Glass fabrics shall conform to ASTM D1668 Type I, asphalt-treated woven glass waterproofing fabrics coated with asphalt.
- d. Flashing Cement: Flashing cement shall conform to ASTM D4586, Type I, trowel grade, asbestos free, manufactured from asphalts characterized as adhesive, healing and ductile.

B. Insulation Boards

- 1. Insulation boards shall conform to ASTM C208 cellulosic fiber boards, construction grade, 1/2 inch (13 mm) thick, fibrous-felted homogeneous panel. Insulation boards shall be manufactured from ligno-cellulosic fibers (wood or cane) by a felting or molding process, asphalt-saturated or coated, with a density of 10 to 31 psf (49 to 151 kg/square meter). Surfaces of insulation boards shall be free of cracks, lumps, excessive departure from planeness, or other defects that adversely affect performance.

1.3 EXECUTION

A. Surface Preparation

- 1. Surfaces scheduled for bituminous waterproofing shall be prepared in accordance with waterproofing manufacturer's recommendations. Surface preparation shall be approved prior to waterproofing application.
- 2. Protection of Surrounding Areas: Before starting the waterproofing work, the surrounding areas and surfaces shall be protected from spillage and migration of asphalt onto other work. Drains and conductors shall be protected from clogging with asphalt.
- 3. Masonry Surfaces: Surfaces shall be free of oil, grease, dirt, laitance, loose material, frost, debris and other contaminants. Mortar joints shall be flush and free of extraneous mortar and chipped or broken masonry.
- 4. Concrete Surfaces: Surfaces shall be properly cured, free of form release agents, oil, grease, dirt, laitance, loose material, frost, debris and other contaminants. Form ties shall be cut flush with surface. Sharp protrusions and form match lines shall be removed. Holes, voids, spalled areas and cracks which can damage waterproofing materials shall be repaired. Rough surfaces shall be parged with a well-adhering coat of cement mortar.
- 5. Metal Surfaces: Surfaces shall be dry and be free of rust, scale, loose paint, oil, grease, dirt, frost and debris.

B. Hot-Applied Asphalt Waterproofing

- 1. Asphalt waterproofing shall be applied when the ambient temperature is 40 degrees F (4 degrees C) or above. Heating kettles and tanks shall be provided with automatic thermostatic control capable of maintaining asphalt temperature. Controls shall be calibrated and maintained in working order for duration of work. At time of application, asphalt shall not be heated above the equiviscous temperature (EVT) recommended by manufacturer. Immediately before use, temperature shall be measured with a portable thermometer at the point of application. EVT and flashpoint temperatures of asphalt in kettle shall be conspicuously posted on kettle. Asphalt with a temperature not conforming to the manufacturer's recommendations shall be returned to the kettle. Asphalt overheated by more than 50 degrees F (10 degrees C) for more than 1 hour shall be removed from site.
- 2. Below-Grade Wall Waterproofing: Waterproofing for foundation walls shall consist of a 1-ply **OR** 2-ply **OR** 3-ply **OR** 4-ply **OR** 5-ply, **as directed**, hot-applied asphalt membrane system. Fabrics shall be installed using the "shingle" method. Joints shall be caulked prior to primer applications. Primer shall be applied at a rate of 1/2 gallon per 100 square feet (0.2 L/square meter). Fabrics shall be overlapped at ends and staggered a minimum 10 inch (250 mm) for 1-ply **OR** 19 inch (480 mm) for 2-ply **OR** 24 inch (610 mm) for 3-ply **OR** 27 inch (685 mm) for 4-ply **OR** 30 inch (750 mm) for 5-ply, **as directed**, system. End-to-end taping is not acceptable. Each fabric shall be firmly embedded into a solid uniform coating of hot asphalt at a rate of 20 pounds per 100 square



feet (0.98 kg/square meter) by pressing with broom. Fabrics shall not touch fabrics. Hot asphalt shall penetrate each fabric to provide the required adhesion. Asphalt between fabrics shall not be excessive to prevent slippage. Waterproofing system consisting of two or more fabrics shall be provided with fabric reinforcement at corners, angles, over construction joints, and in locations where waterproofing fabrics are subject to unusual stress.

3. Floor Waterproofing: Primer shall be applied at a rate of 1/2 gallon per 100 square feet (0.2 L/square meter). Primer shall not be left in puddles. Primer shall be dry to the touch before application of asphalt. Where slab abuts walls, first reinforcing fabric shall extend 6 inches (150 mm) minimum on slab and 8 inches (200 mm) on wall. At vertical corners, first fabric shall extend minimum 5 inches (125 mm) from corner on each side. Second fabric shall lap the first fabric 2 inches (50 mm) minimum. At floor drains, and elsewhere as indicated, the fabric shall extend into a clamping device, set in a heavy coating of flashing cement, and securely clamped.

C. Flood Testing

1. Prior to concealment, waterproofed floors over occupied spaces shall be tested for watertightness. Drains shall be plugged and floors shall be submerged with 3 inches (75 mm) of clean water. Water shall be permitted to stand for a minimum of 24 hours. If leaks occur, water shall be drained and repairs made. Upon completion of repairs, floors shall be flooded with 3 inches (75 mm) of clean water and flood testing shall be repeated for minimum of 24 hours from the time each leak is repaired. Waterproofing system shall be completely watertight, and shall be approved in writing before covering up with other materials. Additional coats of asphalt are not an acceptable method for repairing leaks.

D. Clean-Up

1. Surfaces of other work which are stained with waterproofing materials shall be cleaned with a cleaner recommended by waterproofing manufacturer.

E. Protection Of Completed Work

1. Floor Waterproofing: The completed waterproofing work shall be protected from damage during and after construction. Protective covering shall be placed immediately before proceeding with the work which will conceal the waterproofing.
2. Wall Waterproofing: Waterproofing against which backfill is to be placed shall be protected with a single layer of insulation board. Insulation boards shall be pressed into the final mopping while the asphalt is still hot, with edges of boards placed into moderate contact and joints staggered. For two-layer installation, joints in second layer shall be staggered over joints in first layer. Where surfaced insulation board is used, the surfaced side shall face outward. Boards shall be carefully and neatly fitted around projections, and shall cover the entire surface of the waterproofing materials. Waterproofing system not covered with protection board shall be protected to prevent damage from subsequent building operations. Installed boards shall not remain exposed at the end of a work day.

END OF SECTION 07 13 13 00



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Task	Specification	Specification Description
07 13 13 00	07 11 13 00	Bituminous Dampproofing



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**SECTION 07 13 53 00 - SELF-ADHERING SHEET WATERPROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for self-adhering sheet waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Modified bituminous sheet waterproofing.
 - b. Modified bituminous sheet waterproofing, fabric reinforced.
 - c. Modified bituminous deck paving sheet waterproofing.
 - d. Modified bituminous composite panel waterproofing.
 - e. Adhesive-coated HDPE sheet waterproofing.
 - f. Molded-sheet drainage panels.
 - g. Insulation.
 - h. Plaza deck pavers and paver pedestals.

C. Submittals

1. Product Data: Include manufacturer's written instructions for evaluating, preparing, and treating substrate, technical data, and tested physical and performance properties of waterproofing.
2. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.
3. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for waterproofing.
4. Special warranties.
5. LEED Submittals:
 - a. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
 - b. Shop Drawings: Show locations and extent of waterproofing and details of substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.
 - 1) Include setting drawings showing layout, sizes, sections, profiles, and joint details of pedestal-supported concrete pavers.
 - c. Samples: For each exposed product and for each color and texture specified, including the following products:
 - 1) 8-by-8-inch (200-by-200-mm) square of waterproofing and flashing sheet.
 - 2) 8-by-8-inch (200-by-200-mm) square of insulation.
 - 3) 4-by-4-inch (100-by-100-mm) square of drainage panel.
 - 4) Plaza-deck paver, 4-by-4-inch (100-by-100-mm) square **OR** full sized, **as directed**, in each color and texture required.
 - 5) Paver pedestal assembly.

D. Quality Assurance

1. Installer Qualifications: A firm that is approved or licensed by **OR** acceptable to, **as directed**, waterproofing manufacturer for installation of waterproofing required for this Project.
2. Preinstallation Conference: Conduct conference at Project site.



- a. Review waterproofing requirements including surface preparation, substrate condition and pretreatment, minimum curing period, forecasted weather conditions, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs.

E. Delivery, Storage, And Handling

1. Deliver liquid materials to Project site in original packages with seals unbroken, labeled with manufacturer's name, product brand name and type, date of manufacture, and directions for storing and mixing with other components.
2. Store liquid materials in their original undamaged packages in a clean, dry, protected location and within temperature range required by waterproofing manufacturer.
3. Remove and replace liquid materials that cannot be applied within their stated shelf life.
4. Store rolls according to manufacturer's written instructions.
5. Protect stored materials from direct sunlight.

F. Project Conditions

1. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate.

G. Warranty

1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to replace waterproofing material that does not comply with requirements or that fails to remain watertight within specified warranty period.
 - a. Warranty Period: Three **OR** Five, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Modified Bituminous Sheet Waterproofing

1. Modified Bituminous Sheet: Not less than 60-mil- (1.5-mm-) thick, self-adhering sheet consisting of 56 mils (1.4 mm) of rubberized asphalt laminated to a 4-mil- (0.10-mm-) thick, polyethylene film with release liner on adhesive side and formulated for application with primer or surface conditioner that complies with VOC limits of authorities having jurisdiction.
 - a. Physical Properties:
 - 1) Tensile Strength: 250 psi (1.7 MPa) minimum; ASTM D 412, Die C, modified.
 - 2) Ultimate Elongation: 300 percent minimum; ASTM D 412, Die C, modified.
 - 3) Low-Temperature Flexibility: Pass at minus 20 deg F (minus 29 deg C); ASTM D 1970.
 - 4) Crack Cycling: Unaffected after 100 cycles of 1/8-inch (3-mm) movement; ASTM C 836.
 - 5) Puncture Resistance: 40 lbf (180 N) minimum; ASTM E 154.
 - 6) Hydrostatic-Head Resistance: 150 feet (45 m) minimum; ASTM D 5385.
 - 7) Water Absorption: 0.15 percent weight-gain maximum after 48-hour immersion at 70 deg F (21 deg C); ASTM D 570.
 - 8) Vapor Permeance: 0.05 perms (2.9 ng/Pa x s x sq. m); ASTM E 96, Water Method.
2. Modified Bituminous Sheet, Fabric Reinforced: 60-mil- (1.5-mm-) thick, self-adhering sheet consisting of rubberized-asphalt membrane embedded in spun-bonded polyester or fiberglass nonwoven fabric reinforcement laminated to a 0.50-mil- (0.01-mm-) thick polyester film with release liner on adhesive side.
 - a. Physical Properties:
 - 1) Pliability: No cracks when bent 180 degrees over a 1-inch (25-mm) mandrel at minus 25 deg F (minus 32 deg C); ASTM D 146.
 - 2) Hydrostatic-Head Resistance: 150 feet (45 m) minimum.
 - 3) Vapor Permeance: 0.05 perms (2.9 ng/Pa x s x sq. m); ASTM E 96, Water Method.



- B. Modified Bituminous Deck Paving Sheet Waterproofing
1. Modified Bituminous Deck Paving Sheet: Provide one of the products described below, **as directed**:
 - a. 65-mil- (1.6-mm-) thick, self-adhering sheets consisting of 53 to 56 mils (1.3 to 1.4 mm) of rubberized asphalt laminated to a heat-resisting, 9- to 12-mil- (0.2- to 0.3-mm-) thick, woven polypropylene geotextile reinforcement with release liner on adhesive side.
 - b. 70-mil- (1.8-mm-) thick, self-adhering sheets consisting of rubberized asphalt embedded in inert fabric reinforcement laminated to a reflective geotextile protective topping with release liner on adhesive side.
 - c. 60-mil- (1.5-mm-) thick, self-adhering sheets consisting of rubberized asphalt embedded in nonwoven **OR** woven, **as directed**, fiberglass fabric reinforcement laminated to a 0.50-mil- (0.01-mm-) thick polyester mat with release liner on adhesive side.
 - d. Physical Properties:
 - 1) Tensile Strength, Membrane: 50 lbf/in (8.75 kN/m) minimum; ASTM D 882.
 - 2) Pliability: Unaffected when bent 180 degrees over a 1/4-inch (6.4-mm) mandrel at minus 15 deg F (minus 26 deg C); ASTM D 146.
 - 3) Puncture Resistance, Mesh: 200 lbf (890 N) minimum; ASTM E 154.
- C. Modified Bituminous Composite Panel Waterproofing
1. Modified Bituminous Composite Panel: 90-mil- (2.2-mm-) thick, multilaminated panel consisting of a protection course bonded to an asphalt saturated carrier sheet bonded to a rubberized asphalt waterproofing self-adhering membrane with release liner.
- D. Adhesive-Coated HDPE Sheet Waterproofing
1. Adhesive-Coated HDPE Sheet for Vertical Applications: 32-mil- (0.8-mm-) thick, uniform, flexible sheets consisting of 16-mil- (0.4-mm-) thick, HDPE sheet coated with a pressure-sensitive rubber adhesive, a protective adhesive coating, and a release liner with the following physical properties:
 - a. Tensile Strength, Film: 4000 psi (27.6 MPa) minimum; ASTM D 412.
 - b. Low-Temperature Flexibility: Pass at minus 10 deg F (minus 23 deg C); ASTM D 1970.
 - c. Peel Adhesion to Concrete: 5 lbf/in. (875 N/m); ASTM D 903, modified.
 - d. Lap Adhesion: 2.5 lbf/in. (440 N/m); ASTM D 1876, modified.
 - e. Hydrostatic-Head Resistance: 231 feet (70 m); ASTM D 5385, modified.
 - f. Vapor Permeance: 0.01 perms (0.6 ng/Pa x s x sq. m); ASTM E 96, Water Method.
 - g. Water Absorption: 0.5 percent; ASTM D 570.
 2. Adhesive-Coated HDPE Sheet for Horizontal Applications: 46-mil- (1.2-mm-) thick, uniform, flexible sheets consisting of 30-mil- (0.76-mm-) thick, HDPE sheet coated with a pressure-sensitive rubber adhesive, a protective adhesive coating, a detackifying surface treatment, an uncoated self-adhering side lap strip, and a release liner with the following physical properties:
 - a. Tensile Strength, Film: 4000 psi (27.6 MPa) minimum; ASTM D 412.
 - b. Low-Temperature Flexibility: Pass at minus 10 deg F (minus 23 deg C); ASTM D 1970.
 - c. Peel Adhesion to Concrete: 5 lbf/in. (875 N/m); ASTM D 903, modified.
 - d. Lap Adhesion: 2.5 lbf/in. (440 N/m); ASTM D 1876, modified.
 - e. Hydrostatic-Head Resistance: 231 feet (70 m); ASTM D 5385, modified.
 - f. Vapor Permeance: 0.01 perms (0.6 ng/Pa x s x sq. m); ASTM E 96, Water Method.
 - g. Water Absorption: 0.5 percent; ASTM D 570.
- E. Auxiliary Materials
1. General: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.
 - a. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.
 2. Primer: Liquid waterborne **OR** solvent-borne, **as directed**, primer recommended for substrate by manufacturer of sheet waterproofing material.
 3. Surface Conditioner: Liquid, waterborne surface conditioner recommended for substrate by manufacturer of sheet waterproofing material.



4. Liquid Membrane: Elastomeric, two-component liquid, cold fluid applied, trowel grade or low viscosity.
 5. Substrate Patching Membrane: Low-viscosity, two-component, asphalt-modified coating.
 6. Sheet Strips: Self-adhering, rubberized-asphalt sheet strips of same material and thickness as sheet waterproofing.
 7. Mastic, Adhesives, and Tape: Liquid mastic and adhesives, and adhesive tapes recommended by waterproofing manufacturer.
 - a. Detail Tape: Two-sided, pressure-sensitive, self-adhering reinforced tape, 4-1/2 inches (114 mm) wide, with a tack-free protective adhesive coating on one side and release film on self-adhering side.
 - b. Detail Strips: 62.5-mil- (1.58-mm-) thick, felt-reinforced self-adhesive strip, 9 inches (229 mm) wide, with release film on adhesive side.
 8. Metal Termination Bars: Aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick, predrilled at 9-inch (229-mm) centers.
 9. Protection Course: ASTM D 6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:
 - a. Thickness: 1/8 inch (3 mm), nominal, for vertical applications; 1/4 inch (6 mm), nominal, elsewhere.
 - b. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for type of protection course.
 10. Protection Course: Fan folded, with a core of extruded-polystyrene board insulation faced one side or both sides with plastic film, nominal thickness 1/4 inch (6 mm), with compressive strength of not less than 8 psi (55 kPa) per ASTM D 1621, and maximum water absorption by volume of 0.6 percent per ASTM C 272.
 11. Protection Course: Unfaced, fan-folded, extruded-polystyrene board insulation, nominal thickness 1/4 inch (6 mm) with compressive strength of not less than 8 psi (55 kPa) per ASTM D 1621.
 12. Protection Course: Extruded-polystyrene board insulation, unfaced, ASTM C 578, Type X, 1/2 inch (13 mm) thick.
 13. Protection Course: Molded-polystyrene board insulation, ASTM C 578, Type I, 0.90-lb/cu. ft. (15-kg/cu. m) minimum density, 1-inch (25-mm) minimum thickness.
- F. Molded-Sheet Drainage Panels
1. Molded-Sheet Drainage Panel: Comply with Division 33 Section "Subdrainage".
 2. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve laminated to one side with or without a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a vertical flow rate of 9 to 15 gpm per ft. (112 to 188 L/min. per m).
 3. Woven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a woven-geotextile facing with an apparent opening size not exceeding No. 40 (0.425-mm) sieve laminated to one side with or without a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a horizontal flow rate not less than 2.8 gpm per ft. (35 L/min. per m).
- G. Insulation
1. Board Insulation: Extruded-polystyrene board insulation complying with ASTM C 578, square or shiplap edged.
 - a. Type IV, 25-psi (173-kPa) minimum compressive strength.
 - b. Type VI, 40-psi (276-kPa) minimum compressive strength.
 - c. Type VII, 60-psi (414-kPa) minimum compressive strength.
 - d. Type V, 100-psi (690-kPa) minimum compressive strength.
 2. Unfaced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) or Type VI, 40-psi (276-kPa) minimum compressive



- strength; unfaced; fabricated with shiplap or channel edges and with 1 side having grooved drainage channels.
3. Geotextile-Faced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) or Type VI, 40-psi (276-kPa) minimum compressive strength; fabricated with tongue-and-groove edges and with 1 side having grooved drainage channels faced with nonwoven geotextile filter fabric.
 4. Unfaced Plaza Deck Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) **OR** Type VII, 60-psi (414-kPa), **as directed**, minimum compressive strength; unfaced; fabricated with shiplapped or channel edges and with 1 side having ribbed drainage channels.
 5. Geotextile-Faced Plaza Deck Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VII, 60-psi (414-kPa) minimum compressive strength; fabricated with tongue-and-groove edges and with 1 side having grooved drainage channels faced with manufacturer's standard, nonwoven geotextile filter fabric.
- H. Plaza Deck Pavers
1. Plaza Deck Pavers: Brick **OR** Concrete **OR** Asphalt-Block, **as directed**, pavers specified in Division 32 Section "Unit Paving".
 2. Plaza Deck Pavers: Granite **OR** Limestone **OR** Marble **OR** Quartz-Based Stone **OR** Slate, **as directed**, pavers specified in Division 09 Section "Stone Flooring".
 3. Plaza Deck Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, manufactured for use as plaza deck pavers; minimum compressive strength 7500 psi (52 mpa) **or** 6500 psi (45 mpa), **as directed**, ASTM C 140; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67.
 - a. Thickness: 1-5/8 inches (41 mm) **OR** 1-3/4 inches (45 mm) **OR** 2 inches (51 mm) **OR** 2-3/8 inches (60 mm), **as directed**.
 - b. Face Size: 8-7/8 inches (225 mm) square **OR** 9 inches (229 mm) square **OR** 9 by 18 inches (229 by 457 mm) **OR** 12 inches (305 mm) square **OR** 12 by 24 inches (305 by 610 mm) **OR** 18 inches (457 mm) square **OR** 24 inches (610 mm) square **OR** As indicated, **as directed**.
 - c. Color: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
 4. Setting Bed: Provide aggregate **OR** mortar **OR** bituminous, **as directed**, setting-bed materials specified in Division 32 Section "Unit Paving".
 5. Paver Pedestals: Paver manufacturer's standard SBR rubber, HDPE, or polyurethane paver support assembly, including fixed-height **OR** adjustable or stackable, **as directed**, pedestals, shims, and spacer tabs for joint spacing of 1/8 inch (3 mm) **OR** 3/16 inch (5 mm) **OR** 1/8 to 3/16 inch (3 to 5 mm), **as directed**.
 - a. Concrete Fill: ACI 301, compressive strength of 5000 psi (34 MPa) at 28 days and air content of 6 percent.

1.3 EXECUTION

- A. Surface Preparation
1. Clean, prepare, and treat substrates according to manufacturer's written instructions. Provide clean, dust-free, and dry substrates for waterproofing application.
 2. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.
 3. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.
 4. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids.
 5. Prepare, fill, prime, and treat joints and cracks in substrates. Remove dust and dirt from joints and cracks according to ASTM D 4258.



- a. Install sheet strips and center over treated construction and contraction joints and cracks exceeding a width of 1/16 inch (1.6 mm) or 1/8 inch (3 mm) for modified bituminous deck paving waterproofing.
 6. Bridge and cover isolation joints, expansion joints, and discontinuous deck-to-wall and deck-to-deck joints with overlapping sheet strips.
 - a. Invert and loosely lay first sheet strip over center of joint. Firmly adhere second sheet strip to first and overlap to substrate.
 7. Corners: Prepare, prime, and treat inside and outside corners according to ASTM D 6135.
 - a. Install membrane strips centered over vertical inside corners. Install 3/4-inch (19-mm) fillets of liquid membrane on horizontal inside corners and as follows:
 - 1) At footing-to-wall intersections, extend liquid membrane each direction from corner or install membrane strip centered over corner.
 - 2) At plaza deck-to-wall intersections, extend liquid membrane or sheet strips onto deck waterproofing and to finished height of sheet flashing.
 8. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through waterproofing and at drains and protrusions according to ASTM D 6135.
- B. Modified Bituminous Sheet Waterproofing Application
1. Install modified bituminous sheets according to waterproofing manufacturer's written instructions and according to recommendations in ASTM D 6135.
 2. Apply primer to substrates at required rate and allow to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than 24 hours.
 3. Apply and firmly adhere sheets over area to receive waterproofing. Accurately align sheets and maintain uniform 2-1/2-inch- (64-mm-) minimum lap widths and end laps. Overlap and seal seams and stagger end laps to ensure watertight installation.
 - a. When ambient and substrate temperatures range between 25 and 40 deg F (minus 4 and plus 5 deg C), install self-adhering, modified bituminous sheets produced for low-temperature application. Do not use low-temperature sheets if ambient or substrate temperature is higher than 60 deg F (16 deg C).
 4. Two-Ply Application: Install sheets to form a membrane with lap widths not less than 50 percent of sheet widths to provide a minimum of 2 thicknesses of sheet membrane over areas to receive waterproofing.
 5. Horizontal Application: Apply sheets from low point to high point of decks to ensure that side laps shed water.
 6. Apply continuous sheets over sheet strips bridging substrate cracks, construction, and contraction joints.
 7. Seal exposed edges of sheets at terminations not concealed by metal counterflashings or ending in reglets with mastic.
 8. Install sheet waterproofing and auxiliary materials to tie into adjacent waterproofing.
 9. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending 6 inches (150 mm) beyond repaired areas in all directions.
 10. Install protection course with butted joints over waterproofing membrane immediately.
 - a. Molded-sheet drainage panels **OR** Insulation drainage panels **OR** Board insulation, **as directed**, may be used in place of a separate protection course to vertical applications when approved by waterproofing manufacturer and installed immediately.
 11. Correct deficiencies in or remove sheet waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.
- C. Modified Bituminous Deck Paving Sheet Waterproofing Application
1. Install modified bituminous deck paving sheets according to waterproofing manufacturer's written instructions.
 2. Apply primer to substrates at required rate and allow to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than 24 hours.



3. Apply and firmly adhere sheets over areas to receive waterproofing. Accurately align sheets and maintain uniform 2-1/2-inch- (64-mm-) minimum lap widths and 6-inch (150-mm) end laps. Overlap and seal seams and stagger end laps to ensure watertight installation.
 4. Apply sheet waterproofing from low point to high point of decks to ensure that side laps shed water.
 5. Apply continuous sheets over sheet strips bridging substrate cracks, construction, and contraction joints.
 6. Seal edges of sheet waterproofing terminations with mastic.
 7. Install sheet waterproofing and auxiliary materials to tie into adjacent waterproofing.
 8. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending 6 inches (150 mm) beyond repaired areas in all directions.
 9. Correct deficiencies in or remove sheet waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.
- D. Modified Bituminous Composite Panel Waterproofing Application
1. Install modified bituminous composite panels according to waterproofing manufacturer's written instructions.
 2. Apply primer to substrate at required rate and allow to dry. Limit priming to areas that will be covered by waterproofing in same day. Reprime areas exposed for more than 24 hours.
 3. Install and firmly adhere composite panels over area to receive waterproofing. Accurately align and butt vertical and horizontal joints.
 4. Seal vertical and horizontal butt joints and exposed top, side, and bottom edges at composite panel waterproofing terminations with detail strips.
 5. Correct deficiencies in or remove composite panel waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair detail strips.
- E. Adhesive-Coated HDPE Sheet Waterproofing Application
1. Install adhesive-coated HDPE sheets according to manufacturer's written instructions.
 2. Place and secure molded-sheet drainage panels over substrate. Lap edges and ends of geotextile to maintain continuity.
 3. Vertical Applications: Install adhesive-coated HDPE sheet with HDPE face against substrate. Accurately align sheets and maintain uniform 3-inch- (75-mm-) minimum lap widths and end laps. Overlap and seal seams and stagger and tape end laps to ensure watertight installation. Mechanically fasten to substrate.
 - a. Securely fasten top termination of membrane with continuous metal termination bar anchored into substrate and cover with detailing tape.
 4. Horizontal Applications: Install adhesive-coated HDPE sheet with HDPE face against substrate. Accurately align sheets and maintain uniform 3-inch- (75-mm-) minimum lap widths and end laps. Overlap and seal seams. Overlap, stagger, and seal end laps with detail tape to ensure watertight installation.
 5. Corners: Seal lapped terminations and cut edges of sheet waterproofing at inside and outside corners with detail tape.
 6. Seal penetrations through sheet waterproofing to provide watertight seal with detail tape patches or wraps and a liquid-membrane troweling.
 7. Install sheet waterproofing and auxiliary materials to produce a continuous watertight tie into adjacent waterproofing.
 8. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Tape perimeter of damaged or nonconforming area extending 6 inches (150 mm) beyond repaired areas in all directions. Apply a patch of sheet waterproofing and firmly secure with detail tape.
 9. Correct deficiencies in or remove waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.
- F. Molded-Sheet Drainage Panel Installation
1. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, according to manufacturer's written instructions. Use adhesives or mechanical



fasteners that do not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.

- a. For vertical applications, install board insulation **OR** protection course, **as directed**, before installing drainage panels.

G. Insulation Installation

1. Install one or more layers of board insulation to achieve required thickness and insulation drainage panels over waterproofed surfaces. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.
2. On vertical surfaces, set insulation units in adhesive or tape applied according to manufacturer's written instructions.
3. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

H. Plaza Deck Paver Installation

1. Setting Bed: Install setting bed in locations and of thickness indicated to comply with requirements in Division 32 Section(s) "Unit Paving" OR Division 09 Section(s) "Stone Flooring", **as directed**.
2. Install concrete pavers in locations indicated according to manufacturer's written instructions.
3. Accurately install fixed **OR** adjustable, **as directed**, -height paver pedestals and accessories in locations and to elevations required. Adjust for final level and slope with shims.
 - a. Fill paver pedestal with concrete mix, strike smooth with top of pedestal, and cure according to ACI 301.
4. Loosely lay pavers on pedestals, maintaining a uniform open joint width. Tightly seat pavers against spacers to eliminate lateral movement or drift of paving assembly. Align joint patterns parallel in each direction.
 - a. Lay out pavers to avoid less-than-half-width pavers at perimeter or other terminations.
5. Install pavers to not vary more than 1/16 inch (1.6 mm) in elevation between adjacent pavers or more than 1/16 inch (1.6 mm) from surface plane elevation of individual paver.
6. Maintain tolerances of paving installation within 1/4 inch in 10 feet (1:48) of surface plane in any direction.

I. Field Quality Control

1. Flood Testing: Flood test each deck area for leaks, according to recommendations in ASTM D 5957, after completing waterproofing but before overlying construction is placed. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
 - a. Flood to an average depth of 2-1/2 inches (64 mm) with a minimum depth of 1 inch (25 mm) and not exceeding a depth of 4 inches (100 mm). Maintain 2 inches (51 mm) of clearance from top of sheet flashings.
 - b. Flood each area for 24 **OR** 48 **OR** 72, **as directed**, hours.
 - c. After flood testing, repair leaks, repeat flood tests, and make further repairs until waterproofing installation is watertight.
2. Engage an independent testing agency to observe flood testing and examine underside of decks and terminations for evidence of leaks during flood testing.

J. Protection And Cleaning

1. Do not permit foot or vehicular traffic on unprotected membrane.
2. Protect waterproofing from damage and wear during remainder of construction period.
3. Protect installed board insulation **OR** insulation drainage panels, **as directed**, from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation will be subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
4. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.



END OF SECTION 07 13 53 00



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**SECTION 07 13 53 00a - ELASTOMERIC SHEET WATERPROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for elastomeric sheet waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Butyl rubber sheet waterproofing.
 - b. EPDM rubber sheet waterproofing.
 - c. Molded-sheet drainage panels.
 - d. Insulation.
 - e. Plaza deck pavers and paver pedestals.

C. Submittals

1. Product Data: Include manufacturer's written instructions for evaluating, preparing, and treating substrate, technical data, and tested physical and performance properties of waterproofing.
2. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.
3. Product test reports.
4. Special warranties.

D. Quality Assurance

1. Installer Qualifications: A firm that is approved or licensed by **OR** acceptable to, **as directed**, waterproofing manufacturer for installation of units required for this Project.
2. Preinstallation Conference: Conduct conference at Project site.
 - a. Review waterproofing requirements including surface preparation, substrate condition and pretreatment, minimum curing period, forecasted weather conditions, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs.

E. Delivery, Storage, And Handling

1. Deliver liquid materials to Project site in original packages with seals unbroken, labeled with manufacturer's name, product brand name and type, date of manufacture, and directions for storing and mixing with other components.
2. Store liquid materials in their original undamaged packages in a clean, dry, protected location and within temperature range required by waterproofing manufacturer.
3. Remove and replace liquid materials that cannot be applied within their stated shelf life.
4. Store rolls according to manufacturer's written instructions.
5. Protect stored materials from direct sunlight.

F. Project Conditions

1. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate.

G. Warranty



1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to replace waterproofing material that does not comply with requirements or that fails to remain watertight within 10 **OR** 20, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Sheet Waterproofing

1. Butyl Rubber Sheet: ASTM D 6134, Type II, 60-mil- (1.5-mm-) **OR** 90-mil- (2.3-mm-) **OR** 120-mil- (3.0-mm-), **as directed**, thick flexible sheet, unreinforced, formed from isobutylene-isoprene rubber.
2. EPDM Rubber Sheet: ASTM D 6134, Type I, 60-mil- (1.5-mm-) thick flexible sheet, unreinforced, formed from EPDM.

B. Auxiliary Materials

1. General: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.
 - a. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.
2. Concealed Sheet Flashing: Same material, construction, and thickness as sheet waterproofing or 60-mil- (1.5-mm-) thick, uncured EPDM as required by manufacturer.
3. Exposed Sheet Flashing: 60-mil- (1.5-mm-) thick EPDM, cured or uncured, as required by manufacturer.
4. Bonding Adhesives: Adhesive for bonding polymeric sheets and sheet flashings to substrates and projections.
5. Splicing Cement and Cleaner: Single-component butyl splicing cement and solvent-based splice cleaner.
 - a. Butyl Gum Tape: 30-mil- (0.76-mm-) thick-by-6-1/4-inch- (160-mm-) wide, uncured butyl with polyethylene release film.
6. Lap Sealant: Single-component sealant.
7. In-Seam Sealant: Single-component sealant.
8. Water Cutoff Mastic: Butyl mastic sealant.
9. Waterproofing and Sheet Flashing Accessories: Provide sealants, pourable sealers, cone and vent flashings, inside and outside corner flashings, termination reglets, and other accessories recommended by waterproofing manufacturer for intended use.
10. Metal Termination Bars: Manufacturer's standard aluminum bars, approximately 1 inch (25 mm) wide, prepunched, with zinc-alloy-body fasteners and stainless-steel pins.
11. Protection Course: ASTM D 6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:
 - a. Thickness: 1/8 inch (3 mm), nominal, for vertical applications; 1/4 inch (6 mm), nominal, elsewhere.
 - b. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for type of protection course.
12. Protection Course:
 - a. Faced, fan folded, with a core of extruded-polystyrene board insulation sandwiched between 2 sheets of plastic film, nominal thickness 1/4 inch (6 mm), with compressive strength of not less than 8 psi (55 kPa) per ASTM D 1621, and maximum water absorption by volume of 0.6 percent per ASTM C 272.
 - b. Unfaced, fan-folded, extruded-polystyrene board insulation, nominal thickness 1/4 inch (6 mm) with compressive strength of not less than 8 psi (55 kPa) per ASTM D 1621.
 - c. Extruded-polystyrene board insulation, unfaced, ASTM C 578, Type X, 1/2 inch (13 mm) thick.
 - d. Molded-polystyrene board insulation, ASTM C 578, Type I, 0.90-lb/cu. ft. (15-kg/cu. m) minimum density, 1-inch (25-mm) minimum thickness.



- C. Molded-Sheet Drainage Panels
1. Molded-Sheet Drainage Panel: Comply with Division 33 Section "Subdrainage".
 2. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve laminated to one side with or without a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a vertical flow rate of 9 to 15 gpm per ft. (112 to 188 L/min. per m).
 3. Woven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a woven-geotextile facing with an apparent opening size not exceeding No. 40 (0.425-mm) sieve laminated to one side with or without a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a horizontal flow rate not less than 2.8 gpm per ft. (35 L/min. per m).
- D. Insulation
1. Board Insulation: Extruded-polystyrene board insulation complying with ASTM C 578, square or shiplap edged.
 - a. Type IV, 25-psi (173-kPa) minimum compressive strength.
 - b. Type VI, 40-psi (276-kPa) minimum compressive strength.
 - c. Type VII, 60-psi (414-kPa) minimum compressive strength.
 - d. Type V, 100-psi (690-kPa) minimum compressive strength.
 2. Unfaced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) or Type VI, 40-psi (276-kPa) minimum compressive strength; unfaced; fabricated with shiplap or channel edges and with 1 side having grooved drainage channels.
 3. Geotextile-Faced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) or Type VI, 40-psi (276-kPa) minimum compressive strength; fabricated with tongue-and-groove edges and with 1 side having grooved drainage channels faced with nonwoven geotextile filter fabric.
 4. Unfaced Plaza Deck Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) **OR** Type VII, 60-psi (414-kPa), **as directed**, minimum compressive strength; unfaced; fabricated with shiplapped or channel edges and with 1 side having ribbed drainage channels.
 5. Geotextile-Faced Plaza Deck Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VII, 60-psi (414-kPa) minimum compressive strength; fabricated with tongue-and-groove edges and with 1 side having grooved drainage channels faced with manufacturer's standard, nonwoven geotextile filter fabric.
- E. Plaza Deck Pavers
1. Plaza Deck Pavers: Brick **OR** Concrete **OR** Asphalt-block, **as directed**, pavers specified in Division 32 Section "Unit Paving".
 2. Plaza Deck Pavers: Granite **OR** Limestone **OR** Marble **OR** Quartz-based stone **OR** Slate, **as directed**, pavers specified in Division 09 Section "Stone Flooring".
 3. Plaza Deck Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, manufactured for use as plaza deck pavers; minimum compressive strength 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, ASTM C 140; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67.
 - a. Color: As selected from manufacturer's full range.
 4. Setting Bed: Provide aggregate **OR** mortar **OR** bituminous, **as directed**, setting-bed materials specified in Division 32 Section "Unit Paving".
 5. Paver Pedestals: Paver manufacturer's standard SBR rubber, HDPE, or polyurethane paver support assembly, including fixed-height **OR** adjustable or stackable, **as directed**, pedestals, shims, and spacer tabs for joint spacing of 1/8 inch (3 mm) **OR** 3/16 inch (5 mm) **OR** 1/8 to 3/16 inch (3 to 5 mm), **as directed**.
 - a. Concrete Fill: ACI 301, compressive strength of 5000 psi (34 MPa) at 28 days and air content of 6 percent.



1.3 EXECUTION

A. Surface Preparation

1. Clean, prepare, and treat substrates according to manufacturer's written instructions. Provide clean, dust-free, and dry substrates for waterproofing application.
2. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.
3. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.
4. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids.
5. Prepare, fill, prime, and treat joints and cracks in substrates. Remove dust and dirt from joints and cracks according to ASTM D 4258.
6. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through waterproofing and at drains and protrusions.

B. Fully Adhered Sheet Installation

1. Install fully adhered sheets over entire area to receive waterproofing according to manufacturer's written instructions and recommendations in ASTM D 5843.
2. Accurately align sheets and maintain uniform side and end laps of minimum dimensions required. Stagger end laps.
3. Apply bonding adhesive to substrates at required rate and allow to partially dry.
4. Apply bonding adhesive to sheets and firmly adhere sheets to substrates. Do not apply bonding adhesive to splice area of sheet.
5. Install fully adhered sheets and auxiliary materials to tie into existing waterproofing.
6. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending beyond repaired areas in all directions.
7. Horizontal Application: Apply sheets with side laps shingled with slope of deck where possible.
 - a. Spread sealant bed over deck drain flange at deck drains and securely seal sheet waterproofing in place with clamping ring.

C. Partially Adhered Sheet Installation

1. Install partially adhered sheets over entire area to receive waterproofing according to manufacturer's written instructions.
2. Accurately align sheets and maintain uniform side and end laps of minimum dimensions required. Stagger end laps.
3. Apply bonding adhesive to the following areas of substrates and to each sheet at required rate and allow to partially dry:
 - a. Upper 25 percent of length of each sheet and 18 inches (457 mm) around perimeter of each sheet.
4. Firmly adhere sheets to substrate. Do not apply bonding adhesive to splice area of sheet.
5. Install partially adhered sheets and auxiliary materials to tie into existing waterproofing.
6. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending beyond repaired areas in all directions.

D. Compartmented, Loosely Laid Sheet Installation

1. Install compartmented, loosely laid sheets over entire area to receive waterproofing according to manufacturer's written instructions.
2. Accurately align sheets and maintain uniform side and end laps of minimum dimensions required. Stagger end laps.
3. Apply continuous beads of water cutoff mastic, of size recommended by waterproofing manufacturer, to substrates in a 60-by-60-inch (1500-by-1500-mm) grid pattern before installing sheet.



4. Apply sheets with side laps shingled with slope of deck where possible.
 5. Spread sealant bed over deck drain flange at deck drains and securely seal sheet waterproofing in place with clamping ring.
 6. Install compartmented, loosely laid sheets and auxiliary materials to tie into existing waterproofing.
 7. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending beyond repaired areas in all directions.
- E. Seam Installation
1. Cement Splice: Clean splice areas, apply splicing cement and in-seam sealant, and firmly roll side and end laps of overlapping sheets according to manufacturer's written instructions to produce a splice not less than 6 inches (150 mm) wide and to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet terminations.
 2. Cement and Tape Splice: Clean splice areas, apply splicing cement and butyl gum tape, and firmly roll side and end laps of overlapping sheets according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet terminations.
- F. Sheet Flashing Installation
1. Install sheet flashings and preformed flashing accessories and adhere to substrates according to waterproofing manufacturer's written instructions.
 2. Form wall flashings using exposed sheet flashing.
 3. Extend deck sheet waterproofing to form wall flashings.
 - a. Flash penetrations and field-formed inside and outside corners with uncured sheet flashing.
 - b. Clean splice areas, apply splicing cement, and firmly roll side and end laps of overlapping sheets to ensure a watertight installation. Apply lap sealant and seal exposed edges of sheet flashing terminations.
 4. Cover expansion joints and discontinuous deck-to-wall or deck-to-deck joints by extending deck sheet waterproofing over joints.
 5. Terminate and seal top of sheet flashings with mechanically anchored termination bars.
- G. Protection Course Installation
1. Install protection course over waterproofing membrane according to manufacturer's written instructions and before beginning subsequent construction operations. Minimize exposure of membrane.
 - a. Molded-sheet drainage panels **OR** Insulation drainage panels **OR** Board insulation, **as directed**, may be used in place of a separate protection course to vertical applications when approved by waterproofing manufacturer.
- H. Molded-Sheet Drainage Panel Installation
1. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, according to manufacturer's written instructions. Use adhesives or mechanical fasteners that do not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
 - a. For vertical applications, install board insulation **OR** protection course, **as directed**, before installing drainage panels.
- I. Insulation Installation
1. Install one or more layers of board insulation to achieve required thickness and insulation drainage panels over waterproofed surfaces. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.
 2. On vertical surfaces, place and secure insulation units according to manufacturer's written instructions.



3. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

J. Plaza Deck Paver Installation

1. Setting Bed: Install setting bed in locations and of thickness indicated to comply with requirements in Division 32 Section(s) "Unit Paving" OR Division 09 Section(s) "Stone Flooring", **as directed**.
2. Install concrete pavers in locations indicated according to manufacturer's written instructions.
3. Accurately install fixed **OR** adjustable, **as directed**, -height paver pedestals and accessories in locations and to elevations required. Adjust for final level and slope with shims.
 - a. Fill paver pedestal with concrete mix, strike smooth with top of pedestal, and cure according to ACI 301.
4. Loosely lay pavers on pedestals, maintaining a uniform open joint width. Tightly seat pavers against spacers to eliminate lateral movement or drift of paving assembly. Align joint patterns parallel in each direction.
 - a. Lay out pavers to avoid less-than-half-width pavers at perimeter or other terminations.
5. Install pavers to not vary more than 1/16 inch (1.6 mm) in elevation between adjacent pavers or more than 1/16 inch (1.6 mm) from surface plane elevation of individual paver.
6. Maintain tolerances of paving installation within 1/4 inch in 10 feet (1:48) of surface plane in any direction.

K. Protection And Cleaning

1. Do not permit foot or vehicular traffic on unprotected membrane.
2. Protect waterproofing from damage and wear during remainder of construction period.
3. Protect installed board insulation **OR** insulation drainage panels, **as directed**, from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation will be subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
4. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 13 53 00a

**SECTION 07 14 13 00 - HOT FLUID-APPLIED RUBBERIZED ASPHALT WATERPROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for hot fluid-applied rubberized asphalt waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Rubberized-asphalt waterproofing membrane, unreinforced and reinforced.
 - b. Molded-sheet drainage panels.
 - c. Insulation.
 - d. Plaza deck pavers.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins to adjoining waterproofing, and other termination conditions.
 - a. Include setting drawings showing layout, sizes, sections, profiles, and joint details of pedestal-supported concrete pavers.
3. Product test reports.
4. Sample warranties

D. Quality Assurance

1. Installer Qualifications: A firm that is approved or licensed by **OR** acceptable to, **as directed**, manufacturer for installation of waterproofing required for this Project and is eligible to receive special warranties specified.
2. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling

1. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by waterproofing manufacturer.
2. Remove and replace liquid materials that cannot be applied within their stated shelf life.
3. Protect stored materials from direct sunlight.

F. Project Conditions

1. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate, or when temperature is below 0 deg F (minus 18 deg C).
 - a. Do not apply waterproofing in snow, rain, fog, or mist.
2. Maintain adequate ventilation during application and curing of waterproofing materials.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace waterproofing and sheet flashings that do not comply with requirements or that fail to remain watertight within five **OR** 10, **as directed**, years from date of Final Completion.



1.2 PRODUCTS

A. Waterproofing Membrane

1. Hot Fluid-Applied, Rubberized-Asphalt Waterproofing Membrane: Single component; 100 percent solids; hot fluid-applied, rubberized asphalt.

B. Flashing Sheet Materials

1. Elastomeric Flashing Sheet: 50-mil- (1.3-mm-) minimum, uncured sheet neoprene as follows:
 - a. Tensile Strength: 1400 psi (9.6 MPa) minimum; ASTM D 412, Die C.
 - b. Elongation: 300 percent minimum; ASTM D 412.
 - c. Tear Resistance: 125 psi (860 kPa) minimum; ASTM D 624, Die C.
 - d. Brittleness: Does not break at minus 30 deg F (34 deg C); ASTM D 2137.

C. Auxiliary Materials

1. Primer: ASTM D 41, asphaltic primer.
2. Elastomeric Sheet: 50-mil- (1.3-mm-) minimum, uncured sheet neoprene as follows:
 - a. Tensile Strength: 1400 psi (9.6 MPa) minimum; ASTM D 412, Die C.
 - b. Elongation: 300 percent minimum; ASTM D 412.
 - c. Tear Resistance: 125 psi (860 kPa) minimum; ASTM D 624, Die C.
 - d. Brittleness: Does not break at minus 30 deg F (34 deg C); ASTM D 2137.
3. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum termination bars; approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.
4. Sealants and Accessories: Manufacturer's recommended sealants and accessories.
5. Reinforcing Fabric: Manufacturer's recommended, spun-bonded polyester fabric.
6. Protection Course: ASTM D 6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and nominal thickness of 1/8 inch (3 mm) **OR** 1/4 inch (6 mm), **as directed**.
7. Protection Course: Manufacturer's standard, 80- to 90-mil- (2.0- to 2.3-mm-) thick, fiberglass-reinforced rubberized asphalt or modified bituminous sheet.

D. Molded-Sheet Drainage Panels

1. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve, laminated to one side with **OR** without, **as directed**, a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a vertical flow rate of 9 to 15 gpm/ft. (112 to 188 L/min. per m).
2. Woven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a woven-geotextile facing with an apparent opening size not exceeding No. 40 (0.43-mm) sieve, laminated to one side with **OR** without, **as directed**, a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a horizontal flow rate not less than 2.8 gpm/ft. (35 L/min. per m).

E. Insulation

1. Board Insulation: Extruded-polystyrene board insulation complying with ASTM C 578, square **OR** shiplap, **as directed**, edged.
 - a. Type IV, 25-psi (173-kPa) minimum compressive strength.
 - b. Type VI, 40-psi (276-kPa) minimum compressive strength.
 - c. Type VII, 60-psi (414-kPa) minimum compressive strength.
 - d. Type V, 100-psi (690-kPa) minimum compressive strength.
2. Unfaced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) **OR** Type VI, 40-psi (276-kPa), **as directed**, minimum compressive strength; unfaced; fabricated with shiplap or channel edges and with one side having grooved drainage channels.



3. Geotextile-Faced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) **OR** Type VI, 40-psi (276-kPa), **as directed**, minimum compressive strength; fabricated with tongue-and-groove edges and with one side having grooved drainage channels faced with a nonwoven, geotextile filter fabric.
 4. Unfaced Plaza Deck Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) **OR** Type VII, 60-psi (414-kPa), **as directed**, minimum compressive strength; unfaced; fabricated with shiplapped or channel edges and with one side having ribbed drainage channels.
 5. Geotextile-Faced Plaza Deck Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VII, 60-psi (414-kPa) minimum compressive strength; fabricated with tongue-and-groove edges and with one side having grooved drainage channels faced with a nonwoven, geotextile filter fabric.
- F. Plaza Deck Pavers
1. Plaza Deck Pavers:
 - a. Brick **OR** Concrete **OR** Asphalt-block, **as directed**, pavers specified in Division 32 Section "Unit Paving".
OR
Granite **OR** Limestone **OR** Marble **OR** Quartz-based stone **OR** Slate, **as directed**, pavers specified in Division 09 Section "Stone Flooring".
OR
Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, manufactured for use as plaza deck pavers; minimum compressive strength 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, ASTM C 140; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67.
 - 1) Thickness: 1-5/8 inches (41 mm) **OR** 1-3/4 inches (45 mm) **OR** 2 inches (51 mm) **OR** 2-3/8 inches (60 mm), **as directed**.
 - 2) Face Size: 8-7/8 inches (225 mm) square **OR** 9 inches (229 mm) square **OR** 9 by 18 inches (229 by 457 mm) **OR** 12 inches (305 mm) square **OR** 12 by 24 inches (305 by 610 mm) **OR** 18 inches (457 mm) square **OR** 24 inches (610 mm) square, **as directed**.
 - 3) Color: As selected from manufacturer's full range.
 2. Setting Bed: Provide aggregate **OR** mortar **OR** bituminous, **as directed**, setting-bed materials specified in Division 32 Section "Unit Paving".
 3. Paver Supports: Paver manufacturer's standard SBR rubber, high-density polyethylene, or polyurethane paver support assembly, including fixed-height **OR** adjustable or stackable, **as directed**, pedestals, shims, and spacer tabs for joint spacing of 1/8 inch (3 mm) **OR** 3/16 inch (5 mm), **as directed**.
 - a. Concrete Fill: ACI 301, compressive strength of 5000 psi (34 MPa) at 28 days, and air content of 6 percent.

1.3 EXECUTION

A. Preparation

1. Clean and prepare substrates according to manufacturer's written instructions. Provide clean, dust-free, and dry substrate for waterproofing application.
2. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.
3. Close off deck drains and other deck penetrations to prevent spillage and migration of waterproofing fluids.
4. Remove grease, oil, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.



- a. Abrasive blast clean concrete surfaces uniformly to expose top surface of fine aggregate according to ASTM D 4259 with a self-contained, recirculating, blast-cleaning apparatus. Remove material to provide a sound surface free of laitance, glaze, efflorescence, curing compounds, concrete hardeners, or form-release agents. Remove remaining loose material and clean surfaces according to ASTM D 4258.
 5. Remove fins, ridges, and other projections and fill honeycomb, aggregate pockets, and other voids.
- B. Joints, Cracks, And Terminations
1. Prepare and treat substrates to receive waterproofing membrane, including joints and cracks, deck drains, corners, and penetrations according to manufacturer's written instructions.
 - a. Rout and fill joints and cracks in substrate. Before filling, remove dust and dirt according to ASTM D 4258.
 - b. Adhere strip of elastomeric sheet to substrate in a layer of hot rubberized asphalt. Extend elastomeric sheet a minimum of 6 inches (150 mm) on each side of moving joints and cracks or joints and cracks exceeding 1/8 inch (3 mm) thick, and beyond deck drains and penetrations. Apply second layer of hot fluid-applied, rubberized asphalt over elastomeric sheet.
 - c. Embed strip of reinforcing fabric into a layer of hot rubberized asphalt. Extend reinforcing fabric a minimum of 6 inches (150 mm) on each side of nonmoving joints and cracks not exceeding 1/8 inch (3 mm) thick, and beyond roof drains and penetrations.
 - 1) Apply second layer of hot fluid-applied, rubberized asphalt over reinforcing fabric.
 2. At expansion joints and discontinuous deck-to-wall or deck-to-deck joints, bridge joints with elastomeric sheet extended a minimum of 6 inches (150 mm) on each side of joints and adhere to substrates in a layer of hot rubberized asphalt. Apply second layer of hot fluid-applied, rubberized asphalt over elastomeric sheet.
- C. Flashing Installation
1. Install elastomeric flashing sheets at terminations of waterproofing membrane according to manufacturer's written instructions.
 2. Prime substrate with asphalt primer.
 3. Install elastomeric flashing sheet and adhere to deck and wall substrates in a layer of hot rubberized asphalt.
 4. Extend elastomeric flashing sheet up walls or parapets a minimum of 8 inches (200 mm) above plaza deck pavers and 6 inches (150 mm) onto deck to be waterproofed.
 5. Install termination bars and mechanically fasten to top of elastomeric flashing sheet at terminations and perimeter of roofing.
- D. Membrane Application
1. Apply primer, at manufacturer's recommended rate, over prepared substrate and allow to dry.
 2. Heat and apply rubberized asphalt according to manufacturer's written instructions.
 - a. Heat rubberized asphalt in an oil- or air-jacketed melter with mechanical agitator specifically designed for heating rubberized asphalt.
 3. Start application with manufacturer's authorized representative present.
 4. Unreinforced Membrane: Apply hot rubberized asphalt to substrates and adjoining surfaces indicated. Spread to form a uniform, unreinforced, seamless membrane, 180-mil (4.5-mm) minimum thickness **OR** 180-mil (4.5-mm) average thickness, but not less than 125 mil (3.2 mm) thick, **as directed**.
 5. Reinforced Membrane: Apply hot rubberized asphalt to substrates and adjoining surfaces indicated. Spread to a thickness of 90 mils (2.3 mm); embed reinforcing fabric, overlapping sheets 2 inches (50 mm); spread another 125-mil- (3.2-mm-) thick layer to provide a uniform, reinforced, seamless membrane 215 mils (5.5 mm) thick.
 6. Apply waterproofing over prepared joints and up wall terminations and vertical surfaces to heights indicated or required by manufacturer.



7. Cover waterproofing with protection course with overlapped joints before membrane is subject to backfilling **OR** construction or vehicular traffic, **as directed**.
- E. Molded-Sheet Drainage Panel Installation
1. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate according to manufacturer's written instructions. Use methods that do not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
 - a. For vertical applications, install board insulation **OR** protection course, **as directed**, before installing drainage panels.
- F. Insulation Installation
1. Install one or more layers of board insulation to achieve required thickness and insulation drainage panels over waterproofed surfaces. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.
 2. On vertical surfaces, set insulation units into rubberized asphalt according to manufacturer's written instructions.
 3. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.
- G. Plaza Deck Paver Installation
1. Setting Bed: Install setting bed in locations and of thickness indicated to comply with requirements in Division 32 Section(s) "Unit Paving" **OR** Division 09 Section(s) "Stone Flooring", **as directed**.
 2. Install concrete pavers in locations indicated according to manufacturer's written instructions.
 3. Accurately install fixed-height **OR** adjustable-height, **as directed**, paver pedestals and accessories in locations and to elevations required. Adjust for final level and slope with shims.
 - a. Fill paver pedestal with concrete mix, strike smooth with top of pedestal, and cure according to ACI 301.
 4. Loosely lay pavers on pedestals, maintaining a uniform open joint width. Tightly seat pavers against spacers to eliminate lateral movement or drift of paving assembly. Align joint patterns parallel in each direction.
 - a. Lay out pavers to avoid less-than-half-width pavers at perimeter or other terminations.
 5. Install pavers to not vary more than 1/16 inch (1.6 mm) in elevation between adjacent pavers or more than 1/16 inch (1.6 mm) from surface plane elevation of individual paver.
 6. Maintain tolerances of paving installation within 1/4 inch in 10 feet (1:48) of surface plane in any direction.
- H. Cleaning And Protection
1. Protect waterproofing from damage and wear during remainder of construction period.
 2. Protect installed board insulation **OR** insulation drainage panels, **as directed**, from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation will be subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
 3. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 14 13 00



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**SECTION 07 14 16 00 - COLD FLUID-APPLIED WATERPROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for cold fluid-applied waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Single-component polyurethane waterproofing.
 - b. Two-component polyurethane waterproofing.
 - c. Polyester waterproofing.
 - d. Latex-rubber waterproofing.
 - e. Molded-sheet drainage panels.
 - f. Insulation.
 - g. Plaza deck pavers.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.
3. Product test reports.

D. Quality Assurance

1. Installer Qualifications: A firm that is approved or licensed by **OR** acceptable to, **as directed**, waterproofing manufacturer for installation of waterproofing required for this Project.
2. Preinstallation Conference: Conduct conference at Project site.
 - a. Review waterproofing requirements including surface preparation, substrate condition and pretreatment, minimum curing period, forecasted weather conditions, special details and flashings, installation procedures, testing and inspection procedures, and protection and repairs.

E. Delivery, Storage, And Handling

1. Deliver liquid materials to Project site in original containers with seals unbroken, labeled with manufacturer's name, product brand name and type, date of manufacture, shelf life, and directions for storing and mixing with other components.
2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by waterproofing manufacturer.
3. Remove and replace liquid materials that cannot be applied within their stated shelf life.
4. Protect stored materials from direct sunlight.

F. Project Conditions

1. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate, when relative humidity exceeds 85 percent, or when temperatures are less than 5 deg F (3 deg C) above dew point.

G. Warranty



1. Special Manufacturer's Warranty: Manufacturer's standard form in which waterproofing manufacturer and Installer agree to repair or replace waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.
 - a. Warranty Period: Five years from date of Final Completion.

1.2 PRODUCTS

A. Single-Component Polyurethane Waterproofing

1. Single-Component, Modified Polyurethane Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.
2. Single-Component, Reinforced, Modified Polyurethane Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.
3. Single-Component, Unmodified Polyurethane Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.

B. Two-Component Polyurethane Waterproofing

1. Two-Component, Modified Polyurethane Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.
2. Two-Component, Unmodified Polyurethane Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.
3. Two-Component, Reinforced, Unmodified Polyurethane Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.

C. Polyester Waterproofing

1. Two-Component, Reinforced, Unsaturated Polyester Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.

D. Latex-Rubber Waterproofing

1. Two-Component, Unreinforced, Latex-Rubber Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.
2. Two-Component, Reinforced, Latex-Rubber Waterproofing: Comply with ASTM C 836 and with manufacturer's written physical requirements.

E. Auxiliary Materials

1. General: Provide auxiliary materials recommended by manufacturer to be compatible with one another and with waterproofing, as demonstrated by waterproofing manufacturer, based on testing and field experience.
2. Primer: Manufacturer's standard, factory-formulated polyurethane or epoxy primer.
3. Sheet Flashing: 50-mil- (1.3-mm-) minimum, nonstaining, uncured sheet neoprene.
 - a. Adhesive: Manufacturer's recommended contact adhesive.
4. Membrane-Reinforcing Fabric: Nonwoven, needle-punched white polyester fabric, 6-oz./sq. yd. (200-g/sq. m) **OR** 5-oz./sq. yd. (169-g/sq. m) **OR** 3.2-oz./sq. yd. (109-g/sq. m) **OR** manufacturer's standard, **as directed**, weight.
5. Joint Reinforcing Strip: Manufacturer's recommended fiberglass mesh or polyester fabric.
6. Joint Sealant: Multicomponent polyurethane sealant, compatible with waterproofing, complying with ASTM C 920 Type M, Class 25; Grade NS for sloping and vertical applications or Grade P for deck applications; Use NT exposure; and as recommended by manufacturer for substrate and joint conditions.
 - a. Backer Rod: Closed-cell polyethylene foam.

F. Protection Course

1. Protection Course: ASTM D 6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:



- a. Thickness: 1/8 inch (3 mm), nominal, for vertical applications; 1/4 inch (6 mm), nominal, elsewhere.
 - b. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for type of protection course.
 2. Protection Course: Fan folded, with a core of extruded-polystyrene board insulation faced one or both side(s) with plastic film, nominal thickness of 1/4 inch (6 mm), with compressive strength not less than 8 psi (55 kPa) per ASTM D 1621 and maximum water absorption by volume of 0.6 percent per ASTM C 272.
 3. Protection Course: Unfaced, fan-folded, rigid, extruded-polystyrene board insulation; nominal thickness of 1/4 inch (6 mm) with compressive strength of not less than 8 psi (55 kPa) per ASTM D 1621.
 4. Protection Course: Fan folded, with a core of molded-polystyrene board insulation faced both sides with plastic film, nominal thickness of 1/4 inch (6 mm) **OR** 3/8 inch (9.5 mm) **OR** 1/2 inch (13 mm), **as directed**, with compressive strength not less than 12 psi (83 kPa) per ASTM D 1621 and water absorption by volume of less than 1 percent per ASTM C 272.
 5. Protection Course: Unfaced, extruded-polystyrene board insulation; ASTM C 578, Type X, 1/2 inch (13 mm) thick.
 6. Protection Course: Molded-polystyrene board insulation, ASTM C 578, Type I, 0.90-lb/cu. ft. (15-kg/cu. m) minimum density, 1-inch (25-mm) minimum thickness.
- G. Molded-Sheet Drainage Panels
1. Molded-Sheet Drainage Panel: Comply with Division 33 Section "Subdrainage".
 2. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve laminated to one side with or without a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a vertical flow rate of 9 to 15 gpm per ft. (112 to 188 L/min. per m).
 3. Woven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a woven-geotextile facing with an apparent opening size not exceeding No. 40 (0.43-mm) sieve, laminated to one side with or without a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a horizontal flow rate not less than 2.8 gpm per ft. (35 L/min. per m).
- H. Insulation
1. Board Insulation: Extruded-polystyrene board insulation complying with ASTM C 578, square or shiplap edged.
 - a. Type IV, 25-psi (173-kPa) minimum compressive strength.
 - b. Type VI, 40-psi (276-kPa) minimum compressive strength.
 - c. Type VII, 60-psi (414-kPa) minimum compressive strength.
 - d. Type V, 100-psi (690-kPa) minimum compressive strength.
 2. Unfaced, Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) **OR** Type VI, 40-psi (276-kPa), **as directed**, minimum compressive strength; unfaced; fabricated with shiplap or channel edges and with one side having grooved drainage channels.
 3. Geotextile-Faced, Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) **OR** Type VI, 40-psi (276-kPa), **as directed**, minimum compressive strength; fabricated with tongue-and-groove edges and with one side having grooved drainage channels faced with a nonwoven-geotextile filter fabric.
 4. Unfaced, Plaza Deck, Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) **OR** Type VII, 60-psi (414-kPa), **as directed**, minimum compressive strength; unfaced; fabricated with shiplapped or channel edges and with one side having ribbed drainage channels.
 5. Geotextile-Faced, Plaza Deck, Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VII, 60-psi (414-kPa) minimum compressive strength; fabricated with tongue-and-groove edges and with one side having grooved drainage channels faced with manufacturer's standard, nonwoven-geotextile filter fabric.



- I. Plaza Deck Pavers
 1. Plaza Deck Pavers: Brick **OR** Concrete **OR** Asphalt-block, **as directed**, pavers specified in Division 32 Section "Unit Paving".
 2. Plaza Deck Pavers: Granite **OR** Limestone **OR** Marble **OR** Quartz-based stone **OR** Slate, **as directed**, pavers specified in Division 09 Section "Stone Flooring".
 3. Plaza Deck Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, manufactured for use as plaza deck pavers; minimum compressive strength of 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, ASTM C 140; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67.
 - a. Thickness: 1-5/8 inches (41 mm) **OR** 1-3/4 inches (45 mm) **OR** 2 inches (51 mm) **OR** 2-3/8 inches (60 mm), **as directed**.
 - b. Face Size: 8-7/8 inches (225 mm) square **OR** 9 inches (229 mm) square **OR** 9-by-18 inches (229-by-457 mm) **OR** 12 inches (305 mm) square **OR** 12-by-24 inches (305-by-610 mm) **OR** 18 inches (457 mm) square **OR** 24 inches (610 mm) square **OR** As indicated, **as directed**.
 - c. Color: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
 4. Setting Bed: Provide aggregate **OR** mortar **OR** bituminous, **as directed**, setting-bed materials specified in Division 32 Section "Unit Paving".
 5. Paver Pedestals: Paver manufacturer's standard SBR rubber, high-density polyethylene, or polyurethane paver support assembly, including fixed-height **OR** adjustable or stackable, **as directed**, pedestals, shims, and spacer tabs for joint spacing of 1/8 inch (3 mm) **OR** 3/16 inch (5 mm) **OR** 1/8 to 3/16 inch (3 to 5 mm), **as directed**.
 - a. Concrete Fill: ACI 301, compressive strength of 5000 psi (34 MPa) at 28 days and air content of 6 percent.

1.3 EXECUTION

- A. Surface Preparation
 1. Clean and prepare substrate according to manufacturer's written recommendations. Provide clean, dust-free, and dry substrate for waterproofing application.
 2. Mask off adjoining surfaces not receiving waterproofing to prevent spillage or overspray affecting other construction.
 3. Close off deck drains and other deck penetrations to prevent spillage and migration of waterproofing fluids.
 4. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, acid residues, and other penetrating contaminants or film-forming coatings from concrete.
 - a. Abrasive blast clean concrete surfaces uniformly to expose top surface of fine aggregate according to ASTM D 4259 with a self-contained, recirculating, blast-cleaning apparatus. Remove material to provide a sound surface free of laitance, glaze, efflorescence, curing compounds, concrete hardeners, or form-release agents. Remove remaining loose material and clean surfaces according to ASTM D 4258.
 5. Remove fins, ridges, and other projections and fill honeycomb, aggregate pockets, and other voids.
- B. Preparation At Terminations And Penetrations
 1. Prepare vertical and horizontal surfaces at terminations and penetrations through waterproofing and at expansion joints, drains, and sleeves according to ASTM C 898 **OR** ASTM C 1471, **as directed**, and manufacturer's written instructions.
 2. Prime substrate unless otherwise instructed by waterproofing manufacturer.
 3. Apply waterproofing in two separate applications, and embed a joint reinforcing strip in the first preparation coat when recommended by waterproofing manufacturer.



- a. Provide sealant cants around penetrations and at inside corners of deck-to-wall butt joints when recommended by waterproofing manufacturer.
- C. Joint And Crack Treatment
1. Prepare, treat, rout, and fill joints and cracks in substrate according to ASTM C 898 **OR** ASTM C 1471, **as directed**, and waterproofing manufacturer's written instructions. Remove dust and dirt from joints and cracks, complying with ASTM D 4258, before coating surfaces.
 - a. Comply with ASTM C 1193 for joint-sealant installation.
 - b. Apply bond breaker between sealant and preparation strip.
 - c. Prime substrate and apply a single thickness of preparation strip extending a minimum of 3 inches (75 mm) along each side of joint. Apply waterproofing in two separate applications and embed a joint reinforcing strip in the first preparation coat.
 2. Install sheet flashing and bond to deck and wall substrates where indicated or required according to waterproofing manufacturer's written instructions.
 - a. Extend sheet flashings onto perpendicular surfaces and other work penetrating substrate according to ASTM C 898.
- D. Waterproofing Application
1. Apply waterproofing according to ASTM C 898 **OR** ASTM C 1471, **as directed**, and manufacturer's written instructions.
 2. Start installing waterproofing in presence of manufacturer's technical representative.
 3. Apply primer over prepared substrate.
 4. Unreinforced Waterproofing Applications: Mix materials and apply waterproofing by spray, roller, notched squeegee, trowel, or other application method suitable to slope of substrate.
 - a. Apply one or more coats of waterproofing to obtain a seamless membrane free of entrapped gases, with an average dry film thickness of 60 mils (1.5 mm) and a minimum dry film thickness of 50 mils (1.3 mm) at any point **OR** 120 mils (3 mm), **as directed**.
 - b. Apply waterproofing to prepared wall terminations and vertical surfaces.
 - c. Verify wet film thickness of waterproofing every 100 sq. ft. (9.3 sq. m).
 5. Reinforced Waterproofing Applications: Mix materials and apply waterproofing by roller, notched squeegee, trowel, or other suitable application method.
 - a. Apply first coat of waterproofing, embed membrane-reinforcing fabric, and apply second coat of waterproofing to completely saturate reinforcing fabric and to obtain a seamless reinforced membrane free of entrapped gases, with an average dry film total thickness of 70 mils (1.8 mm) **OR** 80 mils (2 mm) **OR** 120 mils (3 mm) **as directed**, .
 - b. Apply reinforced waterproofing to prepared wall terminations and vertical surfaces.
 - c. Verify wet film thickness of waterproofing every 100 sq. ft. (9.3 sq. m).
 6. Install protection course with butted joints over nominally cured membrane before starting subsequent construction operations.
 - a. Molded-sheet drainage panels **OR** Insulation drainage panels **OR** Board insulation, **as directed**, may be used in place of a separate protection course to vertical applications when approved by waterproofing manufacturer.
- E. Molded-Sheet Drainage Panel Installation
1. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, according to manufacturer's written instructions. Use adhesives or mechanical fasteners that do not penetrate waterproofing. Lap edges and ends of geotextile fabric to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
 - a. For vertical applications, install board insulation **OR** protection course, **as directed**, before installing drainage panels.
- F. Insulation Installation
1. Install one or more layers of board insulation to achieve required thickness **OR** insulation drainage panels, **as directed**, over waterproofed surfaces. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.



2. On vertical surfaces, set insulation units in adhesive applied according to manufacturer's written instructions. Use type of adhesive recommended in writing by insulation manufacturer.
3. On horizontal surfaces, place insulation units unadhered according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

G. Plaza Deck Paver Installation

1. Setting Bed: Install setting bed in locations and of thickness indicated to comply with requirements in Division 32 Section(s) "Unit Paving" OR Division 09 Section(s) "Stone Flooring", **as directed**.
2. Install concrete pavers, in locations indicated, according to manufacturer's written instructions.
3. Accurately install fixed **OR** adjustable, **as directed**, -height paver pedestals in locations and to elevations required. Adjust for final level and slope with shims.
 - a. Fill paver pedestal with concrete mix, strike smooth with top of pedestal, and cure according to ACI 301.
4. Loosely lay pavers on pedestals, maintaining a uniform open joint width. Tightly seat pavers against spacers to eliminate lateral movement or drift of paving assembly. Align joint patterns parallel in each direction.
 - a. Lay out pavers to avoid less-than-half-width pavers at perimeter or other terminations.
5. Install pavers to not vary more than 1/16 inch (1.6 mm) in elevation between adjacent pavers or more than 1/16 inch (1.6 mm) from surface plane elevation of individual paver.
6. Maintain tolerances of paving installation within 1/4 inch in 10 feet (1:48) of surface plane in any direction.

H. Field Quality Control

1. Flood Testing: Flood test each deck area for leaks, according to recommendations in ASTM D 5957, after completing waterproofing but before overlaying construction is placed. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
 - a. Flood to an average depth of 2-1/2 inches (64 mm) with a minimum depth of 1 inch (25 mm) and not exceeding a depth of 4 inches (100 mm). Maintain 2 inches (50 mm) of clearance from top of sheet flashings.
 - b. Flood each area for 24 **OR** 48 **OR** 72, **as directed**, hours.
 - c. After flood testing, repair leaks, repeat flood tests, and make further repairs until waterproofing installation is watertight.
2. Engage an independent testing agency to observe flood testing and examine underside of decks and terminations for evidence of leaks during flood testing.

I. Curing, Protection, And Cleaning

1. Cure waterproofing according to manufacturer's written recommendations, taking care to prevent contamination and damage during application stages and curing.
 - a. Do not permit foot or vehicular traffic on unprotected membrane.
2. Protect waterproofing from damage and wear during remainder of construction period.
3. Protect installed board insulation **OR** insulation drainage panels, **as directed**, from damage due to ultraviolet light, harmful weather exposures, physical abuse, and other causes. Immediately after installation, provide temporary coverings where insulation will be subject to abuse and cannot be concealed and protected by permanent construction.
4. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 14 16 00

**SECTION 07 16 13 00 - MODIFIED CEMENT WATERPROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for modified cement waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes polymer-modified cement waterproofing for positive or negative-side application to concrete, concrete unit masonry, and clay masonry.

C. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions and installation instructions for polymer-modified cement waterproofing.
2. Samples: For each type of polymer-modified cement waterproofing indicated.
3. Qualification Data: For Applicator.
4. Product Certificates: For waterproofing, patching, and plugging materials, from manufacturer.
5. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for each type of polymer-modified cement waterproofing.
6. Field quality-control reports.

D. Quality Assurance

1. Applicator Qualifications: A firm experienced in applying polymer-modified cement waterproofing similar in material, design, and extent to that indicated for this Project, whose work has resulted in applications with a record of successful in-service performance, and that employs workers trained and approved by manufacturer.
2. Preinstallation Conference: Conduct conference at Project site.

E. Project Conditions

1. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit polymer-modified cement waterproofing to be performed according to manufacturer's written instructions.
2. Proceed with waterproofing work only after pipe sleeves, vents, curbs, inserts, drains, and other projections through the substrate to be waterproofed have been completed. Proceed only after substrate defects, including honeycombs, voids, and cracks, have been repaired to provide a sound substrate free of forming materials, including reveal inserts.
3. Ambient Conditions: Proceed with waterproofing work only if temperature is maintained at 40 deg F (4.4 deg C) or above during work and cure period, and space is well ventilated and kept free of water.

1.2 PRODUCTS

A. Field-Mixed, Polymer-Modified Cement Waterproofing

1. Admixture for Field Mixing: Manufacturer's standard polymer admixture for mixing with portland cement and sand to produce a waterproof coating that is suitable for vertical and horizontal applications below or above grade, is breathable, resists positive-side **OR** negative-side, **as directed**, hydrostatic pressure, has VOC content complying with limits of authorities having jurisdiction, and has properties meeting or exceeding the criteria specified below.



- a. Water Permeability: Maximum zero for water at 30 feet (9 m) when tested according to CE CRD-C 48.
 - b. Compressive Strength: Minimum 4000 psi (27.6 MPa) at 28 days when tested according to ASTM C 109/C 109M.
 - c. Flexural Strength: Minimum 710 psi (4.8 MPa) at 28 days when tested according to ASTM C 348.
 - d. Bond Strength: Minimum 220 psi (1.5 MPa) at 14 days when tested according to ASTM C 321.
- B. Prepackaged, Polymer-Modified Cement Waterproofing
1. Negative-Side, Polymer-Modified Cement Waterproofing: Manufacturer's proprietary blend of dry cementitious and other ingredients for mixing with potable water **OR** polymer admixture, **as directed**, to produce a waterproof coating that is suitable for vertical and horizontal applications below or above grade, is breathable, resists negative-side hydrostatic pressure, has VOC content complying with limits of authorities having jurisdiction, and has properties meeting or exceeding the criteria specified below.
 - a. Water Permeability: Maximum zero for water at 30 feet (9 m) when tested according to CE CRD-C 48.
 - b. Compressive Strength: Minimum 4000 psi (27.6 MPa) at 28 days when tested according to ASTM C 109/C 109M.
 - c. Flexural Strength: Minimum 710 psi (4.8 MPa) at 28 days when tested according to ASTM C 348.
 - d. Bond Strength: Minimum 220 psi (1.5 MPa) at 14 days when tested according to ASTM C 321.
 - e. Color: White **OR** Gray **OR** As selected from full range **OR** As indicated in a color schedule, **as directed**.
 2. Positive-Side, Polymer-Modified Cement Waterproofing: Manufacturer's proprietary blend of dry cementitious and other ingredients for mixing with potable water or polymer admixture to produce a waterproof coating that is suitable for vertical and horizontal applications below or above grade, is breathable, resists positive-side hydrostatic pressure, has VOC content complying with limits of authorities having jurisdiction, and has properties meeting or exceeding the criteria specified below.
 - a. Water Permeability: Maximum zero for water at 30 feet (9 m) when tested according to CE CRD-C 48.
 - b. Compressive Strength: Minimum 4000 psi (27.6 MPa) at 28 days when tested according to ASTM C 109/C 109M.
 - c. Flexural Strength: Minimum 710 psi (4.8 MPa) at 28 days when tested according to ASTM C 348.
 - d. Bond Strength: Minimum 220 psi (1.5 MPa) at 14 days when tested according to ASTM C 321.
 - e. Color: White **OR** Gray **OR** As selected from full range **OR** As indicated in a color schedule, **as directed**.
- C. Accessory Materials
1. Patching Compound: Factory-premixed cementitious repair mortar, crack filler, or sealant recommended by waterproofing manufacturer for filling and patching tie holes, honeycombs, reveals, and other imperfections; compatible with substrate and other materials indicated; and VOC content complying with limits of authorities having jurisdiction.
 2. Plugging Compound: Factory-premixed cementitious compound with hydrophobic properties and recommended by waterproofing manufacturer; resistant to water and moisture but vapor permeable for all standard applications (vertical, overhead, and horizontal surfaces not exposed to vehicular traffic); compatible with substrate and other materials indicated; and VOC content complying with limits of authorities having jurisdiction.
 3. Portland Cement: ASTM C 150, Type I.
 4. Slurry-Coat and Protective-Topping Sand: ASTM C 144.



5. Trowel-Coat Sand: ASTM C 33, fine aggregate.
6. Polymer Admixture for Protective Topping: Polymer bonding agent and admixture designed to improve adhesion to prepared substrates and to not create a vapor barrier.
7. Water: Potable.

D. Mixes

1. Field-Mixed, Polymer-Modified Cement Waterproofing: Add polymer admixture to portland cement and sand according to manufacturer's written instructions. Blend together with mechanical mixer or by hand to required consistency.
OR
Prepackaged, Polymer-Modified Cement Waterproofing: Add prepackaged dry ingredients to mixing liquid according to manufacturer's written instructions. Mix together with mechanical mixer or by hand to required consistency.
2. Protective Topping: Measure, batch, and mix portland cement and sand in the proportion of 1:3 and water gaged with a polymer admixture. Blend together with mechanical mixer to required consistency.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Applicator present, for suitable conditions where waterproofing is to be applied.
2. Proceed with application only after unsatisfactory conditions have been corrected.
3. Notify the Owner in writing of active leaks or defects that would affect system performance.

B. Preparation

1. Protect other work from damage caused by cleaning, preparation, and application of waterproofing. Provide temporary enclosure to confine spraying operation and to ensure adequate ambient temperatures and ventilation conditions for application.
2. Do not allow waterproofing, patching, and plugging materials to enter reveals or annular spaces intended for resilient sealants or gaskets, such as joint spaces between pipes and pipe sleeves.
3. Stop active water leaks with plugging compound according to waterproofing manufacturer's written instructions.
4. Repair damaged or unsatisfactory substrate with patching compound according to manufacturer's written instructions.
 - a. At holes and cracks in substrate, remove loosened chips and cut reveal with sides perpendicular to surface, not tapered, and approximately 1 inch (25.4 mm) deep. Fill reveal with patching compound flush with surface.
5. Surface Preparation: Comply with waterproofing manufacturer's written instructions to remove efflorescence, chalk, dust, dirt, mortar spatter, grease, oils, paint, curing compounds, and form-release agents to ensure that waterproofing bonds to surfaces.
 - a. Clean concrete surfaces according to ASTM D 4258.
 - 1) Scratch- and Float-Finished Concrete: Etch with 10 percent muriatic (hydrochloric) acid solution according to ASTM D 4260.
 - 2) Prepare smooth-formed and trowel-finished concrete by mechanical abrading or abrasive-blast cleaning according to ASTM D 4259.
 - b. Clean concrete unit masonry surfaces according to ASTM D 4261.
 - 1) Lightweight Concrete Unit Masonry: Etch with 10 percent muriatic (hydrochloric) acid solution or abrade surface by wire brushing. Remove acid residue until pH readings of water after rinse are not more than 1.0 pH lower or 2.0 pH higher than pH of water before rinse.
 - 2) Medium- and Normal-Weight Concrete Unit Masonry: Sandblast or bushhammer to a depth of 1/16 inch (1.6 mm).
 - c. Clean clay masonry surfaces according to ASTM D 5703.



- d. Concrete Joints: Clean reveals according to waterproofing manufacturer's written instructions.

C. Application

1. General: Comply with waterproofing manufacturer's written instructions for application and curing.
 - a. Saturate surface with water for several hours prior to application with water and maintain damp condition until applying waterproofing. Remove standing water.
 - b. Apply waterproofing to surfaces indicated on Drawings.
 - c. Number of Coats: Number required for specified water permeability **OR** Two **OR** Three, **as directed**.
 - 1) Coating Thickness: Maximum application thickness of 47 mils (1.2 mm) per coat for total thickness as required for specified water permeability **OR** of 100 mils (2.5 mm), **as directed**.
 - 2) Apply first coat as a slurry with brush or roller, and apply subsequent coats with brush, roller, spray, or trowel.
 - 3) Vigorously work first coat onto the substrate, forcing the material into surface voids. Apply each subsequent coat into full contact with previous coat.
 - 4) Allow manufacturer's recommended time between coats. Dampen surface between coats.
2. Final Coat Finish: Smooth troweled **OR** Brushed **OR** Textured, **as directed**.
3. Curing: Air-cure waterproofing for not less than five days immediately after application and prior to being placed in service.
4. Curing: Moist-cure waterproofing for not less than three days immediately after application has set, followed by air drying prior to being placed in service unless otherwise recommended in writing by manufacturer.
5. Waterproofing Treatment Extensions: Extend waterproofing treatment as follows:
 - a. Onto columns integral with treated walls.
 - b. Onto interior nontreated walls intersecting exterior treated walls, for a distance of 24 inches (600 mm) for cast-in-place concrete and 48 inches (1200 mm) for masonry.
 - c. Onto exterior walls and onto both exterior and interior columns, for a height of 12 inches (300 mm), where floors, but not walls, are treated.
 - d. Onto every substrate in areas indicated for treatment, including pipe trenches, pipe chases, pits, sumps, and similar offsets and features.
6. Protective Floor Topping: Apply 1-inch- (25.4-mm-) thick, protective topping over floor surfaces.

D. Field Quality Control

1. Inspection: Engage manufacturer's representative to inspect completed application and provide a written report that application complies with manufacturer's written instructions.

END OF SECTION 07 16 13 00



SECTION 07 16 16 00 - CRYSTALLINE WATERPROOFING

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for crystalline waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes crystalline waterproofing for positive or negative-side application to concrete and concrete unit masonry.

C. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions and installation instructions for crystalline waterproofing.
2. Qualification Data: For Applicator.
3. Product Certificates: For waterproofing, patching, and plugging materials, from manufacturer.
4. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for crystalline waterproofing.
5. Field quality-control reports.

D. Quality Assurance

1. Applicator Qualifications: A firm experienced in applying crystalline waterproofing similar in material, design, and extent to that indicated for this Project, whose work has resulted in applications with a record of successful in-service performance, and that employs workers trained and approved by manufacturer.
2. Preinstallation Conference: Conduct conference at Project site.

E. Project Conditions

1. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit crystalline waterproofing to be performed according to manufacturer's written instructions.
2. Proceed with waterproofing work only after pipe sleeves, vents, curbs, inserts, drains, and other projections through the substrate to be waterproofed have been completed. Proceed only after substrate defects, including honeycombs, voids, and cracks, have been repaired to provide a sound substrate free of forming materials, including reveal inserts.
3. Ambient Conditions: Proceed with waterproofing work only if temperature is maintained at 40 deg F (4.4 deg C) or above during work and cure period, and space is well ventilated and kept free of water.

1.2 PRODUCTS

A. Waterproofing Materials

1. Crystalline Waterproofing: Prepackaged, gray-colored **OR** white-colored, **as directed**, proprietary blend of portland cement, specially treated sand, and active chemicals that, when mixed with water and applied, penetrates into concrete and concrete unit masonry and reacts chemically with the byproducts of cement hydration in the presence of water to develop crystalline growth within substrate capillaries to produce an impervious, dense, waterproof substrate; that has VOC content complying with limits of authorities having jurisdiction; with properties meeting or exceeding the criteria specified below.



- a. Water Permeability: Maximum zero for water at 30 feet (9 m) when tested according to CE CRD-C 48.
- b. Compressive Strength: Minimum 4000 psi (27.6 MPa) at 28 days when tested according to ASTM C 109/C 109M.

B. Accessory Materials

1. Patching Compound: Factory-premixed cementitious repair mortar, crack filler, or sealant recommended by waterproofing manufacturer for filling and patching tie holes, honeycombs, reveals, and other imperfections; compatible with substrate and other materials indicated; and VOC content complying with limits of authorities having jurisdiction.
2. Plugging Compound: Factory-premixed cementitious compound with hydrophobic properties and recommended by waterproofing manufacturer; resistant to water and moisture but vapor permeable for all standard applications (vertical, overhead, and horizontal surfaces not exposed to vehicular traffic); compatible with substrate and other materials indicated; and VOC content complying with limits of authorities having jurisdiction.
3. Portland Cement: ASTM C 150, Type I.
4. Sand: ASTM C 144.
5. Polymer Admixture for Protective Topping: Polymer bonding agent and admixture designed to improve adhesion to prepared substrates and not to create a vapor barrier.
6. Water: Potable.

C. Mixes

1. Crystalline Waterproofing: Add prepackaged dry ingredients to water according to manufacturer's written instructions. Mix together with mechanical mixer or by hand to required consistency.
2. Protective Topping: Measure, batch, and mix portland cement and sand in the proportion of 1:3 and water gaged with a polymer admixture. Blend together with mechanical mixer to required consistency.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Applicator present, for suitable conditions where waterproofing is to be applied.
2. Proceed with application only after unsatisfactory conditions have been corrected.
3. Notify the Owner in writing of active leaks or defects that would affect system performance.

B. Preparation

1. Protect other work from damage caused by cleaning, preparation, and application of waterproofing. Provide temporary enclosure to confine spraying operation and to ensure adequate ambient temperatures and ventilation conditions for application.
2. Do not allow waterproofing, patching, and plugging materials to enter reveals or annular spaces intended for resilient sealants or gaskets, such as joint spaces between pipes and pipe sleeves.
3. Stop active water leaks with plugging compound according to waterproofing manufacturer's written instructions.
4. Repair damaged or unsatisfactory substrate with patching compound according to manufacturer's written instructions.
 - a. At holes and cracks in substrate, remove loosened chips and cut reveal with sides perpendicular to surface, not tapered, and approximately 1 inch (25.4 mm) deep. Fill reveal with patching compound flush with surface.
5. Surface Preparation: Comply with waterproofing manufacturer's written instructions to remove efflorescence, chalk, dust, dirt, mortar spatter, grease, oils, paint, curing compounds, and form-release agents to ensure that waterproofing bonds to surfaces.
 - a. Clean concrete surfaces according to ASTM D 4258.



- 1) Scratch- and Float-Finished Concrete: Etch with 10 percent muriatic (hydrochloric) acid solution according to ASTM D 4260.
 - 2) Prepare smooth-formed and trowel-finished concrete by mechanical abrading or abrasive-blast cleaning according to ASTM D 4259.
 - b. Clean concrete unit masonry surfaces according to ASTM D 4261.
 - 1) Lightweight Concrete Unit Masonry: Etch with 10 percent muriatic (hydrochloric) acid solution or abrade surface by wire brushing. Remove acid residue until pH readings of water after rinse are not more than 1.0 pH lower or 2.0 pH higher than pH of water before rinse.
 - 2) Medium- and Normal-Weight Concrete Unit Masonry: Sandblast or bushhammer to a depth of 1/16 inch (1.6 mm).
 - c. Concrete Joints: Clean reveals according to waterproofing manufacturer's written instructions.
- C. Application
1. General: Comply with waterproofing manufacturer's written instructions for application and curing.
 - a. Saturate surface with water for several hours prior to application and maintain damp condition until applying waterproofing. Remove standing water.
 - b. Apply waterproofing to surfaces indicated on Drawings.
 - c. Number of Coats: Number required for specified water permeability **OR Two OR Three, as directed.**
 - d. Application Method: Brush **OR Spray, as directed.** Apply to ensure that each coat fills voids and is in full contact with substrate or previous coat.
 - e. Dampen surface between coats.
 2. Final Coat Finish: Smooth **OR Brushed OR Spray Textured, as directed.**
 3. Curing: Moist-cure waterproofing for three, **as directed,** days immediately after final coat has set, followed by air drying, unless otherwise recommended in writing by manufacturer.
 4. Waterproofing Treatment Extensions: Extend waterproofing treatment as follows:
 - a. Onto columns integral with treated walls.
 - 1) Onto interior nontreated walls intersecting exterior treated walls, for a distance of 24 inches (600 mm) for cast-in-place concrete and 48 inches (1200 mm) for masonry.
 - 2) Onto exterior walls and onto both exterior and interior columns, for a height of 12 inches (300 mm), where floors, but not walls, are treated.
 - 3) Onto every substrate in areas indicated for treatment, including pipe trenches, pipe chases, pits, sumps, and similar offsets and features.
 5. Protective Topping: Apply 1-inch- (25.4-mm-) thick, protective topping over floor surfaces.
- D. Field Quality Control
1. Inspection: Engage manufacturer's representative to inspect completed application and provide a written report that application complies with manufacturer's written instructions.

END OF SECTION 07 16 16 00



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**SECTION 07 16 19 00 - METAL-OXIDE WATERPROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for metal-oxide waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes metal-oxide waterproofing for positive or negative-side application to concrete, concrete unit masonry, and clay masonry.

C. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions and installation instructions for metal-oxide waterproofing.
2. Qualification Data: For Applicator.
3. Product Certificates: For waterproofing, patching, and plugging materials, from manufacturer.
4. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for metal-oxide waterproofing.
5. Field quality-control reports.

D. Quality Assurance

1. Applicator Qualifications: A firm experienced in applying metal-oxide waterproofing similar in material, design, and extent to that indicated for this Project, whose work has resulted in applications with a record of successful in-service performance, and that employs workers trained and approved by manufacturer.
2. Preinstallation Conference: Conduct conference at Project site.

E. Project Conditions

1. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit metal-oxide waterproofing to be performed according to manufacturer's written instructions.
2. Proceed with waterproofing work only after pipe sleeves, vents, curbs, inserts, drains, and other projections through the substrate to be waterproofed have been completed. Proceed only after substrate defects, including honeycombs, voids, and cracks, have been repaired to provide a sound substrate free of forming materials, including reveal inserts.
3. Ambient Conditions: Proceed with waterproofing work only if temperature is maintained at 40 deg F (4.4 deg C) or above during work and cure period, and space is well ventilated and kept free of water.

1.2 PRODUCTS

A. Waterproofing Materials

1. Metal-Oxide Waterproofing Compound: A product specifically formulated for waterproofing concrete and masonry substrates; containing pulverized iron and a chemical oxidizing agent to cause the iron particles to rust and grow in size in the presence of water; with VOC content complying with limits of authorities having jurisdiction.

B. Accessory Materials

1. Patching Compound: Factory-premixed cementitious repair mortar, crack filler, or sealant recommended by waterproofing manufacturer for filling and patching tie holes, honeycombs,



reveals, and other imperfections; compatible with substrate and other materials indicated; and VOC content complying with limits of authorities having jurisdiction.

2. Plugging Compound: Factory-premixed cementitious compound with hydrophobic properties and recommended by waterproofing manufacturer; resistant to water and moisture but vapor permeable for all standard applications (vertical, overhead, and horizontal surfaces not exposed to vehicular traffic); compatible with substrate and other materials indicated; and VOC content complying with limits of authorities having jurisdiction.
3. Portland Cement: ASTM C 150, Type I.
4. Sand: ASTM C 144.
5. Water: Potable.

C. Mixes

1. Metal-Oxide Coats: Add metal-oxide waterproofing compound to portland cement, sand, and water according to manufacturer's written instructions. Blend together with mechanical mixer or by hand to required consistency for each coat.
2. Protection Coat: Field mix protection coat consisting of portland cement and sand as recommended by same manufacturer as metal-oxide waterproofing according to manufacturer's written instructions for application over waterproofing. Measure, batch, and mix materials with potable water. Blend together with mechanical mixer to required consistency.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Applicator present, for suitable conditions where waterproofing is to be applied.
2. Proceed with application only after unsatisfactory conditions have been corrected.
3. Notify the Owner in writing of active leaks or defects that would affect system performance.

B. Preparation

1. Protect other work from damage caused by cleaning, preparation, and application of waterproofing. Provide temporary enclosure to confine spraying operation and to ensure adequate ambient temperatures and ventilation conditions for application.
2. Do not allow waterproofing, patching, and plugging materials to enter reveals or annular spaces intended for resilient sealants or gaskets, such as joint spaces between pipes and pipe sleeves.
3. Stop active water leaks with plugging compound according to waterproofing manufacturer's written instructions.
4. Repair damaged or unsatisfactory substrate with patching compound according to manufacturer's written instructions.
 - a. At holes and cracks in substrate, remove loosened chips and cut reveal with sides perpendicular to surface, not tapered, and approximately 1 inch (25.4 mm) deep. Fill reveal with patching compound flush with surface.
5. Surface Preparation: Comply with waterproofing manufacturer's written instructions to remove efflorescence, chalk, dust, dirt, mortar spatter, grease, oils, paint, curing compounds, and form-release agents to ensure that waterproofing bonds to surfaces.
 - a. Clean concrete surfaces according to ASTM D 4258.
 - 1) Scratch- and Float-Finished Concrete: Etch with 10 percent muriatic (hydrochloric) acid solution according to ASTM D 4260.
 - 2) Prepare smooth-formed and trowel-finished concrete by mechanical abrading or abrasive-blast cleaning according to ASTM D 4259.
 - b. Clean concrete unit masonry surfaces according to ASTM D 4261.
 - 1) Lightweight Concrete Unit Masonry: Etch with 10 percent muriatic (hydrochloric) acid solution or abrade surface by wire brushing. Remove acid residue until pH readings of water after rinse are not more than 1.0 pH lower or 2.0 pH higher than pH of water before rinse.



- 2) Medium- and Normal-Weight Concrete Unit Masonry: Sandblast or bushhammer to a depth of 1/16 inch (1.6 mm).
- c. Clean clay masonry surfaces according to ASTM D 5703.
- d. Concrete Joints: Clean reveals according to waterproofing manufacturer's written instructions.

C. Application

1. General: Comply with waterproofing manufacturer's written instructions for application and curing.
 - a. Saturate surface for several hours prior to application with water and maintain damp condition until applying waterproofing. Remove standing water.
 - b. Apply waterproofing to surfaces indicated on Drawings.
 - c. Number of Metal-Oxide Coats: Number required for specified water permeability **OR Two OR Three, as directed.**
 - d. Application Method: Brush apply the waterproofing, vigorously working first coat onto the substrate and forcing the material into surface voids. Brush each subsequent coat into full contact with previous coat.
 - e. Dampen surface between coats.
 - f. Allow each coat to set for 24 hours between coats.
 - g. Protection Coat: Apply to a thickness of 1/8 inch (3 mm) **OR 1/4 inch (6 mm), as directed,** for walls and 1 inch (25 mm) for floors.
2. Final Coat Finish: Smooth **OR Brushed OR Textured, as directed.**
3. Curing: Moist-cure waterproofing for three days immediately after final coat has set, followed by air drying prior to being placed in service, unless otherwise recommended in writing by manufacturer.
4. Waterproofing Treatment Extensions: Extend waterproofing treatment as follows:
 - a. Onto columns integral with treated walls.
 - b. Onto interior nontreated walls intersecting exterior treated walls, for a distance of 24 inches (600 mm) for cast-in-place concrete and 48 inches (1200 mm) for masonry.
 - c. Onto exterior walls and onto both exterior and interior columns, for a height of 12 inches (300 mm), where floors, but not walls, are treated.
 - d. Onto every substrate in areas indicated for treatment, including pipe trenches, pipe chases, pits, sumps, and similar offsets and features.

D. Field Quality Control

1. Inspection: Engage manufacturer's representative to inspect completed application and provide a written report that application complies with manufacturer's written instructions.

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**SECTION 07 17 13 00 - BENTONITE WATERPROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for bentonite waterproofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Bentonite waterproofing.
 - b. Molded-sheet drainage panels.
 - c. Insulation.

C. Submittals

1. Product Data: For each type of product indicated. Include product specifications and manufacturer's written installation instructions.
2. Shop Drawings: Show installation details for interface with other work.
3. Samples: For each of the following products, in sizes indicated:
 - a. Waterproofing: 6 inches (150 mm) square.
 - b. Drainage Panels: 6 inches (150 mm) square.
 - c. Insulation: 6 inches (150 mm) square.
4. Material Certificates: For each type of bentonite waterproofing, from manufacturer.
5. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency **OR** a qualified testing agency, **as directed**, for bentonite waterproofing.
6. Field quality-control reports.
7. Warranty: Sample of special warranty.

D. Quality Assurance

1. Source Limitations: Obtain bentonite waterproofing system from single source from single manufacturer. Obtain accessory products used with bentonite waterproofing from sources acceptable to bentonite waterproofing manufacturer.
2. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling

1. Deliver materials to Project site in manufacturer's original unopened and undamaged containers.
2. Store materials in a dry, well-ventilated space.
3. Remove and replace bentonite materials that have been prematurely exposed to moisture.

F. Project Conditions

1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit bentonite waterproofing to be installed according to manufacturers' written instructions and warranty requirements.
 - a. Do not apply waterproofing materials to surfaces where ice or frost is visible. Do not apply bentonite waterproofing materials in areas with standing water.
 - b. Placing bentonite clay products in panel or composite form on damp surfaces is allowed if approved in writing by manufacturer.

G. Warranty



1. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree(s) to repair or replace components of bentonite waterproofing system that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period: Five years from date of Final Completion.

1.2 PRODUCTS

A. Geotextile/Bentonite Sheets

1. Geotextile/Bentonite Waterproofing: Minimum of 1.0 lb/sq. ft. (5 kg/sq. m) of bentonite clay granules between two layers of geotextile polypropylene fabric, one woven and one nonwoven, needle punched and heat fused together.
 - a. Grab Tensile Strength: 95 lbf (422 N) according to ASTM D 4632.
2. Contaminant-Resistant Geotextile/Bentonite Waterproofing: Minimum of 1.0 lb/sq. ft. (5 kg/sq. m) of bentonite clay granules specially formulated for use in saltwater or contaminated ground water, between two layers of geotextile polypropylene fabric, one woven and one nonwoven, needle punched and heat fused together.
 - a. Grab Tensile Strength: 95 lbf (422 N) according to ASTM D 4632.
3. Geotextile-Geomembrane/Bentonite Waterproofing: Minimum of 1.0 lb/sq. ft. (5 kg/sq. m) of bentonite clay granules between two layers of geotextile polypropylene fabric, one woven and one nonwoven, needle punched and heat fused together; and the woven fabric coated with a low-permeable polypropylene geomembrane.
 - a. Grab Tensile Strength: 95 lbf (422 N) according to ASTM D 4632.
4. Composite Geotextile-HDPE/Bentonite Membrane: Minimum of 1.1 lb/sq. ft. (5.4 kg/sq. m) of bentonite clay granules bonded to nonwoven geotextile polypropylene fabric, with HDPE bonded to surface of nonwoven fabric.
 - a. Grab Tensile Strength: 120 lbf (534 N) according to ASTM D 4632.
 - b. Puncture Resistance: 140 lbf (620 N) according to ASTM D 4833.
 - c. Vapor Permeance: 0.03 perms according to ASTM E 96.
5. Contaminant-Resistant Composite Geotextile-HDPE/Bentonite Membrane: Minimum of 1.1 lb/sq. ft. (5.4 kg/sq. m) of bentonite clay granules specially formulated for use in saltwater or contaminated ground water, bonded to nonwoven geotextile polypropylene fabric, with HDPE bonded to surface of nonwoven fabric.
 - a. Grab Tensile Strength: 120 lbf (534 N) according to ASTM D 4632.
 - b. Puncture Resistance: 140 lbf (620 N) according to ASTM D 4833.
 - c. Vapor Permeance: 0.03 perms according to ASTM E 96.

B. Composite HDPE/Bentonite Membrane

1. Composite HDPE/Bentonite Membrane: Minimum 90-mil- (2.3-mm-) thick membrane consisting of a 12-mil- (0.5-mm-) thick, HDPE geomembrane liner bonded to a layer of bentonite clay granules 78 mils (1.9 mm) thick.
 - a. Puncture Resistance: 169 lbf (752 N) according to ASTM E 154.
 - b. Vapor Permeance: 0.03 perms according to ASTM E 96.
2. Composite HDPE/Bentonite Membrane with Protective Facing: Minimum 170-mil- (4.3-mm-) thick membrane consisting of HDPE geomembrane liner bonded to a layer of bentonite clay granules and with a spun polypropylene facing.
 - a. Puncture Resistance: 169 lbf (752 N) according to ASTM E 154.
 - b. Vapor Permeance: 0.03 perms according to ASTM E 96.
3. Composite HDPE/Bentonite-Polymer Membrane: Minimum 200-mil- (5-mm-) thick membrane consisting of HDPE geomembrane liner bonded to a layer of bentonite-polymer clay granules.
 - a. Puncture Resistance: 75 lbf (334 N) according to ASTM D 4833.
 - b. Vapor Permeance: 0.005 perms according to ASTM E 96.
4. Composite Gastight HDPE/Bentonite Membrane: Minimum 150-mil- (3.8-mm-) thick membrane consisting of a 60-mil- (1.5-mm-) thick, HDPE geomembrane liner bonded to a layer of bentonite clay.



- a. Puncture Resistance: 169 lbf (752 N) according to ASTM E 154.
 - b. Vapor Permeance: 0.03 perms according to ASTM E 96.
 5. Composite Saline/Alkaline HDPE/Bentonite Membrane: Minimum 150-mil- (3.8-mm-) thick membrane consisting of a 60-mil- (1.5-mm-) thick, HDPE geomembrane liner bonded to a layer of bentonite clay granules.
 - a. Puncture Resistance: 169 lbf (752 N) according to ASTM E 154.
 - b. Vapor Permeance: 0.03 perms according to ASTM E 96.
- C. Composite Geotextile-HDPE/Bentonite Membrane
 1. Geotextile/Bentonite-Polymer Waterproofing: Minimum 250-mil- (6.4-mm-) thick membrane of bentonite-polymer clay granules between two layers of geotextile polypropylene fabric, one woven and one nonwoven, needle punched and heat fused together.
 - a. Puncture Resistance: 75 lbf (334 N) according to ASTM D 4833.
 - b. Vapor Permeance: 0.005 perms according to ASTM E 96.
- D. Bentonite Panels
 1. Standard Panels: 3/16-inch- (5-mm-) thick, corrugated kraft-paper panels with a minimum of 1.0 lb/sq. ft. (5 kg/sq. m) of bentonite confined in corrugations of boards.
 2. Coated Panels: 3/16-inch- (5-mm-) thick, corrugated kraft-paper panels specially coated to resist premature hydration due to incidental moisture; filled with a minimum of 1.0 lb/sq. ft. (5 kg/sq. m) of bentonite.
 3. Contaminant-Resistant Panels: 3/16-inch- (5-mm-) thick, corrugated kraft-paper panels with a minimum of 1.0 lb/sq. ft. (5 kg/sq. m) of contaminant-resistant granular bentonite specially formulated for use in contaminated ground-water conditions; confined in corrugations of boards.
- E. Installation Accessories
 1. Granular Bentonite: Sodium bentonite clay containing a minimum of 90 percent montmorillonite (hydrated aluminum silicate), with a minimum of 90 percent passing a No. 20 (0.85-mm) sieve.
 2. Bentonite Mastic: Trowelable consistency, bentonite compound, specifically formulated for application at joints and penetrations.
 3. Granular Bentonite Tubes: Manufacturer's standard 2-inch- (50-mm-) diameter, water-soluble tube containing approximately 1.5 lb/ft. (2.2 kg/m) of bentonite; hermetically sealed; designed specifically for placing on wall footings at line of joint with exterior base of wall.
 4. Termination Bar: Extruded-aluminum or formed-stainless-steel bars with upper flange to receive sealant.
 5. Plastic Protection Sheet: Polyethylene sheeting complying with ASTM D 4397; thickness recommended by waterproofing manufacturer to suit application but at least 6 mils (0.15 mm) thick.
 6. Cement Grout Patching Material: Manufacturer's recommended grout mix compatible with substrate being patched.
 7. Masonry Fasteners: Case-hardened nails or hardened-steel, powder-actuated fasteners. Depending on manufacturer's written requirements, provide 1/2- or 1-inch- (13- or 25-mm-) diameter washers under fastener heads.
 8. Sealants: As recommended in writing by waterproofing manufacturer. Comply with requirements specified in Division 7 Section "Joint Sealants."
 9. Tapes: Waterproofing manufacturer's recommended tape for joints between sheets, membranes, or panels.
 10. Adhesive: Water-based adhesive used to secure waterproofing to both vertical and horizontal surfaces.
 11. Protection Course: ASTM D 6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners, and as follows:
 - a. Thickness: 1/8 inch (3 mm), nominal, for vertical applications; 1/4 inch (6 mm), nominal, elsewhere.
 12. Geotextile Protection Course: As recommended by waterproofing manufacturer.
 13. Molded-Sheet Drainage Panel: Comply with Division 33 Section "Subdrainage".



14. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve laminated to one side with **OR** without, **as directed**, a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a vertical flow rate of 9 to 15 gpm per foot (112 to 188 L/min. per m).
15. Woven-Geotextile-Faced, Molded-Sheet Drainage Panel: Manufactured composite subsurface drainage panels consisting of a woven-geotextile facing with an apparent opening size not exceeding No. 40 (0.425-mm) sieve laminated to one side with **OR** without, **as directed**, a polymeric film bonded to the other side of a studded, nonbiodegradable, molded-plastic-sheet drainage core, with a horizontal flow rate not less than 2.8 gpm per foot (35 L/min. per m).
16. Board Insulation: Extruded-polystyrene board insulation complying with ASTM C 578, square **OR** shiplap, **as directed**, edged.
 - a. Type VI, 40-psi (276-kPa) minimum compressive strength.
 - b. Type VII, 60-psi (414-kPa) minimum compressive strength.
 - c. Type V, 100-psi (690-kPa) minimum compressive strength.
17. Unfaced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) minimum compressive strength; unfaced; fabricated with shiplap or channel edges and with one side having grooved drainage channels.
18. Geotextile-Faced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) minimum compressive strength; fabricated with tongue-and-groove edges and with one side having grooved drainage channels faced with nonwoven geotextile filter fabric.
19. Unfaced Plaza Deck Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) **OR** Type VII, 60-psi (414-kPa), **as directed**, minimum compressive strength; unfaced; fabricated with shiplapped or channel edges and with one side having ribbed drainage channels.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for substrate preparations affecting performance of bentonite waterproofing.
2. Verify that substrate is complete and that work that will penetrate waterproofing is complete and rigidly installed.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Coordinate work in the vicinity of waterproofing to ensure proper conditions for installing the waterproofing system and to prevent damage to waterproofing after installation.
2. Formed Concrete Surfaces: Remove fins and projections. Fill voids, rock pockets, form-tie holes, and other defects with bentonite mastic or cement grout patching material according to manufacturer's written instructions.
3. Horizontal Concrete Surfaces: Remove debris, standing water, oily substances, mud, and similar substances that could impair the bonding ability of concrete or the effectiveness of waterproofing. Fill voids, cracks greater than 1/8 inch (3 mm), honeycomb areas, and other defects with bentonite mastic or cement grout patching material according to manufacturer's written instructions.
4. Excavation Support and Protection System: If water is seeping, use plastic protection sheets or other suitable means to prevent wetting the bentonite waterproofing. Fill minor gaps and spaces 1/8 inch (3 mm) wide or wider with wood, metal, concrete, or other appropriate filling material. Cover or fill large voids and crevices with cement mortar according to manufacturer's written instructions.

**C. Installation, General**

1. Install waterproofing and accessories according to manufacturer's written instructions.
 - a. Apply granular bentonite around penetrations in horizontal surfaces and changes in plane according to manufacturer's details in preparation for granular bentonite tubes and mastic.
 - b. Apply granular bentonite tubes, bentonite mastic, or both at changes of plane, construction joints in substrate, projections, and penetrations.
2. Apply granular bentonite tubes continuously on footing against base of wall to be waterproofed according to manufacturer's written instructions.
3. Protect waterproofing from damage and wetting before and during subsequent construction operations. Repair punctures, tears, and cuts according to manufacturer's written instructions.
4. Install protection course before backfilling or placing overburden when recommended by waterproofing manufacturer.

D. Geotextile/Bentonite Sheet Installation

1. General: Install a continuous layer of waterproofing sheets directly against concrete to be waterproofed. Lap ends and edges a minimum of 4 inches (100 mm) on horizontal and vertical substrates. Stagger end joints between sheets a minimum of 24 inches (600 mm). Fasten seams by stapling to adjacent sheet or nailing to substrate.
2. Below Structural Slabs-on-Grade: Place waterproofing sheets on compacted substrate with ends and edges lapped and stapled.
 - a. Install a layer of waterproofing sheets under footings, grade beams, and pile caps; or continue waterproofing through key joints between footings and foundation walls, and extend a minimum of 8 inches (200 mm) up or beyond perimeter slab forms.
3. Concrete Walls: Starting at bottom of wall, apply waterproofing sheets horizontally with primary backing side against wall. Secure with masonry fasteners spaced according to manufacturer's written instructions. Extend to bottom of footing, grade beam, or wall, and secure.
 - a. Termination at Grade: Extend waterproofing sheets to within 2 inches (50 mm) of finish grade unless otherwise indicated. Secure top edge with termination bar. Apply sealant to top edge of termination bar.
OR
Termination at Grade: Fasten top edge of waterproofing sheets to wall and protect top edge with sheet metal counterflashing. Cover waterproofing with a lapped course of plastic protection sheets if backfilling does not proceed immediately.
4. Excavation Support and Protection (Permanent Shoring): Encase tieback rods, nuts, and plates, using bentonite mastic and waterproofing sheets, according to waterproofing manufacturer's written instructions for each configuration.
 - a. Install a layer of waterproofing sheets, with ends and edges lapped and nailed to shoring. Cover waterproofing with plastic protection sheets if needed for protection from precipitation; remove plastic sheets before placing concrete.
 - b. Inspect and repair waterproofing after reinforcing steel has been placed. Coordinate and control concrete placement to avoid damage to waterproofing.

E. Composite HDPE/Bentonite Membrane Installation

1. General: Install a continuous layer of waterproofing membrane with ends and edges lapped a minimum of 3 inches (75 mm). Stagger end joints between membranes. Seal joints with permanent seam tape.
2. Below Structural Slabs-on-Grade: Apply waterproofing membrane with HDPE side down and staple ends and edges.
 - a. Install under footings, grade beams, and pile caps; or continue waterproofing through key joints between footings and foundation walls, and extend a minimum of 8 inches (200 mm) up or beyond perimeter slab forms.
 - b. Protect waterproofing from damage caused by reinforcing bar supports with sharp edges.
3. Slabs: Starting at lowest point, install a continuous layer of waterproofing membrane, with ends and edges lapped a minimum of 2 inches (50 mm).
4. Vertical Concrete or Masonry Walls: Apply mastic around penetrations and form continuous 2-inch (50-mm) cant at intersection of footings and walls with mastic.



- a. Starting at lowest point, install a layer of waterproofing membrane horizontally, extending a minimum of 6 inches (150 mm) onto the footing. Lap membrane ends and edges a minimum of 2 inches (50 mm).
 - b. Secure membrane to wall with adhesive or washer-headed fasteners, and tape terminations of membrane at grade.
5. Excavation Support and Protection: Cut, clean, and treat tiebacks and similar projections. Encase tieback rods, nuts, and plates. If water is present, cover shoring and lagging with plastic protection sheets.
- a. Starting at lowest point, install a layer of waterproofing membrane, with ends and edges lapped and nailed to shoring.
6. Horizontal Roofs, Plazas, and between Slabs: Starting at lowest point, install a layer of waterproofing membrane, with ends and edges lapped and taped a minimum of 3 inches (75 mm).
- a. Prime concrete substrates. Primer may be omitted on concrete surfaces that comply with requirements for dryness, surface texture, and freedom from imperfections.
 - b. Install bentonite side of membrane against the material to be waterproofed.
 - c. Terminations at Vertical Surfaces: Provide a fillet or cant at intersection of horizontal and vertical substrates. Extend waterproofing membrane to top of curb or to a minimum of 6 inches (150 mm) above plane of waterproofing; secure with manufacturer's recommended tape.
 - d. Cover waterproofing with a plastic slip-sheet.
- F. Composite Geotextile-HDPE/Bentonite Membrane Installation
1. General: Install a continuous layer of waterproofing membrane with ends and edges lapped a minimum of 3 inches (75 mm). Stagger end joints between membranes. Seal joints with permanent seam tape.
 2. Below Structural Slabs-on-Grade: Apply waterproofing membrane with HDPE side down and staple ends and edges.
 - a. Install under footings, grade beams, and pile caps; or continue waterproofing through key joints between footings and foundation walls, and extend a minimum of 8 inches (200 mm) up or beyond perimeter slab forms.
 - b. Protect waterproofing from damage caused by reinforcing bar supports with sharp edges.
 3. Concrete Walls: Starting at bottom of wall, apply waterproofing membrane with HDPE side facing Installer; overlap sheets 3 inches (75 mm). Secure with powder-actuated fasteners or case-hardened nails. Extend to bottom of footing, grade beam, or wall, and secure.
 - a. Termination at Grade: Extend waterproofing membrane to within 2 inches (50 mm) of finish grade unless otherwise indicated. Secure top edge with termination bar. Apply sealant to top edge of termination bar.
 4. Excavation Support and Protection (Permanent Shoring): Cut, clean, and treat tiebacks and similar projections. Encase tieback rods, nuts, and plates. If water is present, cover shoring and lagging with plastic protection sheets; remove plastic sheets before placing concrete.
 - a. Starting at lowest point, install a layer of waterproofing membrane, with ends and edges lapped and mechanically secured to shoring.
 - b. Inspect and repair waterproofing membrane after reinforcing steel has been placed. Coordinate and control concrete placement to avoid damage to waterproofing.
 5. Horizontal Slabs, Roofs, and Plazas: Starting at lowest point, install a layer of waterproofing membrane, with ends and edges lapped and taped a minimum of 3 inches (75 mm).
 - a. Clean overlap area and apply waterproof tape, rolling the exposed edge to seal to sheet below.
 - b. Turn edges up and seal to vertical surfaces.
 - c. Cover waterproofing with a plastic slip-sheet.
- G. Bentonite Panel Installation



1. General: Install a continuous layer of bentonite waterproofing panels with ends and edges lapped a minimum of 1-1/2 inches (38 mm) unless otherwise indicated. Stagger joints in adjoining panel rows.
 - a. Install a double layer of waterproofing panels, with ends and edges butted instead of lapped and with second layer of joints staggered over first. Staple panels together to hold them in place.
 2. Concrete Walls: Starting at bottom of wall, apply waterproofing panels with ends and edges lapped and with vertical joints staggered. Secure with fasteners or adhesive recommended in writing by manufacturer. Extend to bottom of footing, grade beam, or wall.
 - a. Horizontal-to-Vertical Transitions: Install granular bentonite tubes immediately before backfilling and compact backfill over the joint.
 - b. Termination at Grade: Extend waterproofing panels to within 2 inches (50 mm) of finish grade unless otherwise indicated. Secure top edge with termination bar. Apply sealant to top edge of termination bar.

OR

Termination at Grade: Fasten top edge of waterproofing panels to wall and protect top edge with sheet metal counterflashing.
 - c. Cover waterproofing panels with a lapped course of plastic protection sheets; remove plastic sheets before backfilling.
- H. Molded-Sheet Drainage Panel Installation
1. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate. Use adhesives or mechanical fasteners that do not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
 - a. For vertical applications, install board insulation **OR** protection course, **as directed**, before installing drainage panels.
- I. Insulation Installation
1. Install one or more layers of board insulation to achieve required thickness and insulation drainage panels over waterproofed surfaces. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.
 2. On vertical surfaces, set insulation units in adhesive or tape applied according to manufacturer's written instructions.
 3. On horizontal surfaces, loosely lay insulation units. Stagger end joints and tightly abut insulation units.
- J. Field Quality Control
1. Inspection: Arrange for manufacturer's representative to inspect completed waterproofing installation before covering with other construction and provide written report that installation complies with manufacturer's written instructions.
 - a. Remove and replace applications of bentonite waterproofing where inspection indicates that it does not comply with specified requirements.
 2. Flood Testing: Flood test each deck area for leaks, according to recommendations in ASTM D 5957, after completing waterproofing but before overlaying construction is placed. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
 - a. Flood to an average depth of 2-1/2 inches (64 mm) with a minimum depth of 1 inch (25 mm) but not exceeding a depth of 4 inches (100 mm). Maintain 2 inches (50 mm) of clearance from top of membrane flashings.
 - b. Flood each area for 24 **OR** 48, **as directed**, hours.
 - c. After flood testing, repair leaks, repeat flood test, and make further repairs until waterproofing installation is watertight.
 3. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.



END OF SECTION 07 17 13 00

**SECTION 07 19 13 00 - WATER REPELLENTS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for water repellents. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes penetrating and film-forming water-repellent coatings for the following vertical and horizontal surfaces:
 - a. Concrete (unpainted).
 - b. Cast stone.
 - c. Brick masonry.
 - d. Concrete unit masonry (unpainted and unglazed).
 - e. Portland cement plaster (stucco).
 - f. Stonework.

C. Performance Requirements

1. Performance Testing: Provide water repellents that comply with test-performance requirements indicated, as evidenced by reports of tests performed by manufacturer **OR** based on Project-specific preconstruction testing, **as directed**, by a qualified independent testing agency on manufacturer's standard products applied to substrates simulating those on Project using same application methods to be used for Project.
 - a. Engage testing agency to perform preconstruction tests on laboratory mockups.
 - b. Select sizes and configurations of assemblies to adequately demonstrate capability of water repellents to comply with performance requirements.
 - c. Notify the Owner seven days in advance of the dates and times when assemblies will be constructed.
2. Absorption: Minimum 80 **OR** 90, **as directed**, percent reduction of absorption after 24 hours in comparison of treated and untreated specimens.
 - a. Brick: ASTM C 67.
 - b. Stone: ASTM C 97.
 - c. Concrete Unit Masonry: ASTM C 140.
 - d. Hardened Concrete: ASTM C 642.
3. Water-Vapor Transmission: Maximum 10 percent reduction in rate of vapor transmission in comparison of treated and untreated specimens, per ASTM E 96.
4. Permeability: Minimum 80 percent water-vapor transmission in comparison of treated and untreated specimens, per ASTM D 1653.
5. Water Penetration and Leakage through Masonry: Maximum 90 percent reduction in leakage rate in comparison of treated and untreated specimens, per ASTM E 514.
6. Durability: Maximum 5 percent loss of water repellency after 2500 hours of weathering in comparison to specimens before weathering, per ASTM G 154.
 - a. Reduction of Water Absorption: 80 percent.
 - b. Reduction in Chloride Content: 80 percent.

D. Submittals

1. Product Data: For each type of product indicated.
2. Product test reports.

E. Quality Assurance

1. Installer Qualifications: An employer of workers trained and approved by manufacturer.



F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer and Applicator agree(s) to repair or replace materials that fail to maintain water repellency specified in Part 1.1 "Performance Requirements" Article within specified warranty period.
 - a. Warranty Period: Two **OR** Five, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Penetrating Water Repellents

1. Silane, Penetrating Water Repellent: Clear, monomeric compound containing 20 percent or more solids of alkyltrialkoxysilanes; with alcohol, mineral spirits, water, or other proprietary solvent carrier; and with 3.3 lb/gal. (400 g/L) or less of VOCs.
2. Silane, Penetrating Water Repellent: Clear, monomeric compound containing 20 percent or more solids of alkyltrialkoxysilanes; with alcohol, mineral spirits, water, or other proprietary solvent carrier; and with 5 lb/gal. (600 g/L) or less of VOCs.
3. Silane, Penetrating Water Repellent: Pigmented, monomeric compound containing 20 percent or more solids of alkyltrialkoxysilanes; with alcohol, mineral spirits, water, or other proprietary solvent carrier; and with 5 lb/gal. (600 g/L) or less of VOCs.
4. Silane, Penetrating Water Repellent: Clear, monomeric compound containing 20 percent or more solids of alkyltrialkoxysilanes; with alcohol, mineral spirits, water, or other proprietary solvent carrier; and with more than 5 lb/gal. (600 g/L) of VOCs.
5. Siloxane, Penetrating Water Repellent: Clear, oligomeric alkylalkoxysiloxanes containing 10 percent or more solids; with alcohol, ethanol, mineral spirits, water, or other proprietary solvent carrier; and with 3.3 lb/gal. (400 g/L) or less of VOCs.
6. Siloxane, Penetrating Water Repellent: Clear, oligomeric alkylalkoxysiloxanes containing 10 percent or more solids; with alcohol, ethanol, mineral spirits, water, or other proprietary solvent carrier; and with 5 lb/gal. (600 g/L) or less of VOCs.
7. Siloxane, Penetrating Water Repellent: Clear, oligomeric alkylalkoxysiloxanes containing 10 percent or more solids; with alcohol, ethanol, mineral spirits, water, or other proprietary solvent carrier; and with more than 5 lb/gal. (600 g/L) of VOCs.
8. Silane/Siloxane-Blend, Penetrating Water Repellent: Clear, silane and siloxane blends with 3.3 lb/gal. (400 g/L) or less of VOCs.
9. Silane/Siloxane-Blend, Penetrating Water Repellent: Clear, silane and siloxane blends with 5 lb/gal. (600 g/L) or less of VOCs.
10. Proprietary-Blend, Penetrating Water Repellent: Clear, consisting of 1 or several different resins (silanes or siloxanes), polymers, stearates, or oils plus other compounds or products of components; and with 3.3 lb/gal. (400 g/L) or less of VOCs.
11. Proprietary-Blend, Penetrating Water Repellent: Clear, consisting of 1 or several different resins (silanes or siloxanes), polymers, stearates, or oils plus other compounds or products of components; and with 5 lb/gal. (600 g/L) or less of VOCs.

B. Film-Forming Water Repellents

1. Silicone Sealer, Film-Forming Water Repellent: Clear, polymerized, silicone-resin water repellent for dense substrates; with a solvent- or water-based solution containing not less than 3 and up to 5 percent solids by weight; and with 3.3 lb/gal. (400 g/L) or less of VOCs.
2. Silicone-Sealer, Film-Forming Water Repellent: Clear, polymerized, silicone-resin water repellent for dense substrates; with a solvent- or water-based solution containing not less than 3 and up to 5 percent solids by weight; and with 5 lb/gal. (600 g/L) or less of VOCs.
3. Proprietary-Blend, Film-Forming Water Repellent: Clear, consisting of 1 or several different resins, acrylics, polymers, stearates, or oils plus other compounds or products of components; and with 3.3 lb/gal. (400 g/L) or less of VOCs.
4. Proprietary-Blend, Film-Forming Water Repellent: Clear, consisting of 1 or several different resins, acrylics, polymers, stearates, or oils plus other compounds or products of components; and with 5 lb/gal. (600 g/L) or less of VOCs.



5. Siliconate, Film-Forming Water Repellent: Clear, with 3.3 lb/gal. (400 g/L) or less of VOCs.
6. Acrylic, Film-Forming Water Repellent: Clear **OR** Pigmented, **as directed**, breathing coating of acrylic resins; with a water-based, solvent-based, or acrylic emulsion solution containing less than 15 percent solids by volume; and with 3.3 lb/gal. (400 g/L) or less of VOCs.
 - a. Colors: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
7. Acrylic, Film-Forming Water Repellent: Pigmented, with 5 lb/gal. (600 g/L) or less of VOCs.
 - a. Colors: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.

1.3 EXECUTION

A. Preparation

1. Clean substrate of substances that might interfere with penetration or performance of water repellents. Test for moisture content, according to water-repellent manufacturer's written instructions, to ensure that surface is dry enough.
 - a. Cast-in-Place Concrete: Remove oil, curing compounds, laitance, and other substances that could prevent adhesion or penetration of water repellents.
 - b. Clay Brick Masonry: Clean clay brick masonry per ASTM D 5703.
2. Test for pH level, according to water-repellent manufacturer's written instructions, to ensure chemical bond to silicate minerals.
3. Protect adjoining work, including sealant bond surfaces, from spillage or blow-over of water repellent. Cover adjoining and nearby surfaces of aluminum and glass if there is the possibility of water repellent being deposited on surfaces. Cover live plants and grass.
4. Coordination with Sealants: Do not apply water repellent until sealants for joints adjacent to surfaces receiving water-repellent treatment have been installed and cured.
 - a. Water-repellent work may precede sealant application only if sealant adhesion and compatibility have been tested and verified using substrate, water repellent, and sealant materials identical to those used in the work.
5. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Application

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect the substrate before application of water repellent and to instruct Applicator on the product and application method to be used.
2. Apply a heavy-saturation spray coating of water repellent on surfaces indicated for treatment using low-pressure spray equipment. Comply with manufacturer's written instructions for using airless spraying procedure, unless otherwise indicated.
 - a. Precast Concrete: At Contractor's option, first application of water repellent on precast concrete units may be completed before installing units. Mask sealant-bond surfaces to prevent water repellent from migrating onto joint surfaces.
3. Apply a second saturation spray coating, as directed, repeating first application. Comply with manufacturer's written instructions for limitations on drying time between coats and after rainstorm wetting of surfaces between coats. Consult manufacturer's technical representative if written instructions are not applicable to Project conditions.

C. Cleaning

1. Immediately clean water repellent from adjoining surfaces and surfaces soiled or damaged by water-repellent application as work progresses. Repair damage caused by water-repellent application. Comply with manufacturer's written cleaning instructions.

END OF SECTION 07 19 13 00



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**SECTION 07 21 13 13 - BUILDING INSULATION**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for building insulation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Perimeter insulation under slabs-on-grade.
 - b. Perimeter wall insulation (supporting backfill).
 - c. Cavity-wall insulation.
 - d. Concealed building insulation.
 - e. Exposed building insulation.
 - f. Loose-fill building insulation.
 - g. Self-supported, spray-applied cellulosic insulation.
 - h. Radiant barriers.
 - i. Vapor retarders.
 - j. Sound attenuation insulation.

C. Definitions

1. Mineral-Fiber Insulation: Insulation composed of rock-wool fibers, slag-wool fibers, or glass fibers; produced in boards and blanket with latter formed into batts (flat-cut lengths) or rolls.

D. Performance Requirements

1. Plenum Rating: Provide glass-fiber **OR** slag-wool-fiber/rock-wool-fiber, **as directed**, insulation where indicated in ceiling plenums whose test performance is rated as follows for use in plenums as determined by testing identical products per "Erosion Test" and "Mold Growth and Humidity Test" described in UL 181, or on comparable tests from another standard acceptable to authorities having jurisdiction.
 - a. Erosion Test Results: Insulation shows no visible evidence of cracking, flaking, peeling, or delamination of interior surface of duct assembly, after testing for 4 hours at 2500-fpm (13-m/s) air velocity.
 - b. Mold Growth and Humidity Test Results: Insulation shows no evidence of mold growth, delamination, or other deterioration due to the effects of high humidity, after inoculation with Chaetomium globosum on all surfaces and storing for 60 days at 100 percent relative humidity in the dark.

E. Submittals

1. Product Data: For each type of product indicated.
2. Samples: Full-size units for each type of exposed insulation indicated.
3. LEED Submittal:
 - a. Product Data for Credit MR 4.1 and MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
4. Product test reports.
5. Research/Evaluation Reports: For foam-plastic insulation.

F. Quality Assurance



1. Fire-Test-Response Characteristics: Provide insulation and related materials with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.
 - a. Surface-Burning Characteristics: ASTM E 84.
 - b. Fire-Resistance Ratings: ASTM E 119.
 - c. Combustion Characteristics: ASTM E 136.

G. Delivery, Storage, And Handling

1. Protect insulation materials from physical damage and from deterioration by moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.
2. Protect plastic insulation as follows:
 - a. Do not expose to sunlight, except to extent necessary for period of installation and concealment.
 - b. Protect against ignition at all times. Do not deliver plastic insulating materials to Project site before installation time.
 - c. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.2 PRODUCTS

A. Foam-Plastic Board Insulation

1. Extruded-Polystyrene Board Insulation: ASTM C 578, of type and density indicated below, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively:
 - a. Type IV, 1.60 lb/cu. ft. (26 kg/cu. m), unless otherwise indicated.
 - b. Type X, 1.30 lb/cu. ft. (21 kg/cu. m).
 - c. Type VI, 1.80 lb/cu. ft. (29 kg/cu. m).
 - d. Type VII, 2.20 lb/cu. ft. (35 kg/cu. m).
 - e. Type V, 3.00 lb/cu. ft. (48 kg/cu. m).
2. Extruded-Polystyrene Drainage Panels: ASTM C 578, of type and density indicated below and fabricated with one side having a matrix of drainage and edge channels.
 - a. Type IV, 1.60 lb/cu. ft. (26 kg/cu. m).
 - b. Type VI, 1.80 lb/cu. ft. (29 kg/cu. m).
 - c. Type VII, 2.20 lb/cu. ft. (35 kg/cu. m).
3. Fabric-Faced, Extruded-Polystyrene Drainage Panels: ASTM C 578, Type VI, with a density of 1.80 lb/cu. ft. (29 kg/cu. m), faced with insulation manufacturer's standard nonwoven filtration fabric and fabricated with 1 side having a matrix of drainage and edge channels.
4. Molded-Polystyrene Board Insulation: ASTM C 578, of type and density indicated below, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively:
 - a. Type I, 0.90 lb/cu. ft. (15 kg/cu. m).
 - b. Type VIII, 1.15 lb/cu. ft. (18 kg/cu. m).
 - c. Type II, 1.35 lb/cu. ft. (22 kg/cu. m).
5. Foil-Faced, Polyisocyanurate Board Insulation: ASTM C 1289, Type I, Class 1 **OR** 2, **as directed**, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, based on tests performed on unfaced core on thicknesses up to 4 inches (101 mm).

B. Cellular-Glass Insulation

1. Cellular-Glass Insulation: ASTM C 552 Type I (flat block) **OR** IV (board) faced on both sides with manufacturer's special kraft-paper sheets laminated to glass block with asphalt, **as directed**, with unfaced insulation passing ASTM E 136 for combustion characteristics.

C. Glass-Fiber Board Insulation



1. Unfaced, Flexible Glass-Fiber Board Insulation: ASTM C 612, Type IA; ASTM C 553, Types I, II, and III; or ASTM C 665, Type I; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, passing ASTM E 136 for combustion characteristics; and of the following nominal density and thermal resistivity:
 - a. Nominal density of 1.0 lb/cu. ft. (16 kg/cu. m), thermal resistivity of 3.7 deg F x h x sq. ft./Btu x in. at 75 deg F (25.7 K x m/W at 24 deg C).
 - b. Nominal density of not less than 1.5 lb/cu. ft. (24 kg/cu. m) nor more than 1.7 lb/cu. ft. (27 kg/cu. m), thermal resistivity of 4 deg F x h x sq. ft./Btu x in. at 75 deg F (27.7 K x m/W at 24 deg C).
2. Foil-Faced, Flexible Glass-Fiber Board Insulation: ASTM C 612, Type IA or ASTM C 553, Types I, II, and III; faced on 1 side with foil-scrim-kraft vapor retarder; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; and of the following nominal density and thermal resistivity:
 - a. Nominal density of 1.0 lb/cu. ft. (16 kg/cu. m), thermal resistivity of 3.7 deg F x h x sq. ft./Btu x in. at 75 deg F (25.7 K x m/W at 24 deg C).
 - b. Nominal density of not less than 1.5 lb/cu. ft. (24 kg/cu. m) nor more than 1.7 lb/cu. ft. (27 kg/cu. m), thermal resistivity of 4 deg F x h x sq. ft./Btu x in. at 75 deg F (27.7 K x m/W at 24 deg C).
3. Unfaced, Glass-Fiber Board Insulation: ASTM C 612, Type IA or Types IA and IB; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics; and of the following nominal density and thermal resistivity:
 - a. Nominal density of 2.25 lb/cu. ft. (36 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).
 - b. Nominal density of 3 lb/cu. ft. (48 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).
 - c. Nominal density of 4.25 lb/cu. ft. (68 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).
 - d. Nominal density of 6 lb/cu. ft. (96 kg/cu. m), thermal resistivity of 4.4 deg F x h x sq. ft./Btu x in. at 75 deg F (30.5 K x m/W at 24 deg C).
4. Foil-Faced, Glass-Fiber Board Insulation: ASTM C 612, Type IA or Types IA and IB; faced on 1 side with foil-scrim-kraft or foil-scrim-polyethylene vapor retarder, with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; and of the following nominal density and thermal resistivity:
 - a. Nominal density of 2.25 lb/cu. ft. (36 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).
 - b. Nominal density of 3 lb/cu. ft. (48 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).
 - c. Nominal density of 4.25 lb/cu. ft. (68 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).
 - d. Nominal density of 6 lb/cu. ft. (96 kg/cu. m), thermal resistivity of not less than 4.34 deg F x h x sq. ft./Btu x in. at 75 deg F (30.1 K x m/W at 24 deg C).
5. Glass-Mat-Faced, Glass-Fiber Board Insulation: ASTM C 612, Type IA or Types IA and IB; faced on 1 side with black glass-fiber mat or black polymer finish; maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; and of the following nominal density and thermal resistivity:
 - a. Nominal density of 1.5 lb/cu. ft. (24 kg/cu. m), thermal resistivity of 4.2 deg F x h x sq. ft./Btu x in. at 75 deg F (29.1 K x m/W at 24 deg C).
 - b. Nominal density of 2.25 lb/cu. ft. (36 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).
 - c. Nominal density of 3 lb/cu. ft. (48 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).
 - d. Nominal density of 6 lb/cu. ft. (96 kg/cu. m), thermal resistivity of 4.5 deg F x h x sq. ft./Btu x in. at 75 deg F (31.2 K x m/W at 24 deg C).

D. Slag-Wool-Fiber/Rock-Wool-Fiber Board Insulation



1. Unfaced, Slag-Wool-Fiber/Rock-Wool-Fiber Board Insulation: ASTM C 612, maximum flame-spread and smoke-developed indexes of 15 and 0, respectively; passing ASTM E 136 for combustion characteristics; and of the following nominal density and thermal resistivity:
 - a. Nominal density of 4 lb/cu. ft. (64 kg/cu. m), Types IA and IB, thermal resistivity of 4 deg F x h x sq. ft./Btu x in. at 75 deg F (27.7 K x m/W at 24 deg C).
 - b. Nominal density of 6 lb/cu. ft. (96 kg/cu. m), Type II, thermal resistivity of 4.16 deg F x h x sq. ft./Btu x in. at 75 deg F (28.8 K x m/W at 24 deg C).
 - c. Nominal density of 8 lb/cu. ft. (128 kg/cu. m), Type III, thermal resistivity of 4.35 deg F x h x sq. ft./Btu x in. at 75 deg F (30.2 K x m/W at 24 deg C).
 - d. Fiber Color: Regular color, unless otherwise indicated.
 - e. Fiber Color: Darkened, where indicated.
 2. Foil-Faced, Slag-Wool-Fiber/Rock-Wool-Fiber Board Insulation: ASTM C 612; faced on 1 side with foil-scrim or foil-scrim-polyethylene vapor retarder; with maximum flame-spread and smoke-developed indexes of 25 and 5, respectively; and of the following nominal density and thermal resistivity:
 - a. Nominal density of 4 lb/cu. ft. (64 kg/cu. m), Types IA and IB, thermal resistivity of 4 deg F x h x sq. ft./Btu x in. at 75 deg F (27.7 K x m/W at 24 deg C).
 - b. Nominal density of 6 lb/cu. ft. (96 kg/cu. m), Type II, thermal resistivity of 4.16 deg F x h x sq. ft./Btu x in. at 75 deg F (28.8 K x m/W at 24 deg C).
 - c. Nominal density of 8 lb/cu. ft. (128 kg/cu. m), Type III, thermal resistivity of 4.35 deg F x h x sq. ft./Btu x in. at 75 deg F (30.2 K x m/W at 24 deg C).
- E. Glass-Fiber Blanket Insulation
1. Unfaced, Glass-Fiber Blanket Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.
 2. Faced, Glass-Fiber Blanket Insulation: ASTM C 665, Type III (blankets with reflective membrane facing), Class A (membrane-faced surface with a flame-spread index of 25 or less); Category 1 (membrane is a vapor barrier), faced with foil-scrim-kraft, foil-scrim, or foil-scrim-polyethylene **OR** polypropylene-scrim-kraft, **as directed**, vapor-retarder membrane on 1 face.
 3. Where glass-fiber blanket insulation is indicated by the following thicknesses, provide blankets in batt or roll form with thermal resistances indicated:
 - a. 3-1/2 inches (89 mm) thick with a thermal resistance of 11 deg F x h x sq. ft./Btu at 75 deg F (1.9 K x sq. m/W at 24 deg C) **OR** 13 deg F x h x sq. ft./Btu at 75 deg F (2.3 K x sq. m/W at 24 deg C), **as directed**.
 - b. 3-5/8 inches (92 mm) thick with a thermal resistance of 11 deg F x h x sq. ft./Btu at 75 deg F (1.9 K x sq. m/W at 24 deg C).
 - c. 5-1/2 inches (140 mm) thick with a thermal resistance of 19 deg F x h x sq. ft./Btu at 75 deg F (3.3 K x sq. m/W at 24 deg C).
 - d. 6-1/2 inches (165 mm) thick with a thermal resistance of 21 deg F x h x sq. ft./Btu at 75 deg F (3.7 K x sq. m/W at 24 deg C).
 - e. 9-1/2 inches (241 mm) **OR** 10 inches (254 mm) **OR** 10-1/4 inches (260 mm), **as directed**, thick with a thermal resistance of 30 deg F x h x sq. ft./Btu at 75 deg F (5.2 K x sq. m/W at 24 deg C).
- F. Slag-Wool-Fiber/Rock-Wool-Fiber Blanket Insulation
1. Unfaced, Slag-Wool-Fiber/Rock-Wool-Fiber Blanket Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.
 2. Faced, Slag-Wool-Fiber/Rock-Wool-Fiber Blanket Insulation: ASTM C 665, Type III (blankets with reflective membrane facing), Class A (membrane-faced surface with a flame spread of 25 or less); Category 1 (membrane is a vapor barrier), faced with foil-scrim-kraft, foil-scrim, or foil-scrim-polyethylene vapor-retarder membrane on 1 face.



3. Where slag-wool-fiber/rock-wool-fiber blanket insulation is indicated by the following thicknesses, provide blankets in batt form with thermal resistances indicated:
 - a. 1-1/2 inches (38 mm) thick with a thermal resistance of 6 deg F x h x sq. ft./Btu at 75 deg F (1 K x sq. m/W at 24 deg C).
 - b. 3-1/2 inches (89 mm) thick with a thermal resistance of 13 deg F x h x sq. ft./Btu at 75 deg F (2.3 K x sq. m/W at 24 deg C).
 - c. 4 inches (101 mm) thick with a thermal resistance of 16 deg F x h x sq. ft./Btu at 75 deg F (2.8 K x sq. m/W at 24 deg C).
 - d. 5-1/4 inches (133 mm) thick with a thermal resistance of 19 deg F x h x sq. ft./Btu at 75 deg F (3.3 K x sq. m/W at 24 deg C).
 - e. 6 inches (152 mm) thick with a thermal resistance of 22 deg F x h x sq. ft./Btu at 75 deg F (3.9 K x sq. m/W at 24 deg C).
- G. Loose-Fill Insulation
 1. Cellulosic-Fiber Loose-Fill Insulation: ASTM C 739, chemically treated for flame-resistance, processing, and handling characteristics.
 2. Glass-Fiber Loose-Fill Insulation: ASTM C 764, Type I for pneumatic application or Type II for poured application; with maximum flame-spread and smoke-developed indexes of 5.
- H. Spray-Applied Cellulosic Insulation
 1. Self-Supported, Spray-Applied Cellulosic Insulation: ASTM C 1149, Type I (materials applied with liquid adhesive; suitable for either exposed or enclosed applications), **OR** Type II (materials containing a dry adhesive activated by water during installation; intended only for enclosed or covered applications), **OR** Type III (materials containing an adhesive mixed with water during application; intended for application on attic floors), **as directed**, chemically treated for flame-resistance, processing, and handling characteristics.
- I. Radiant Barriers
 1. Interior Radiation Control Coating: ASTM C 1321. Silver-colored, not thickness-dependent, low-emissivity solvent-based **OR** water-based, **as directed**, coating, formulated for adherence to substrates indicated and with a surface emittance value of 0.25 or less as measured per ASTM C 1371.
 2. Sheet Radiant Barriers: ASTM C 1313 and as follows:
 - a. Sheet Construction: Foil on one side of substrate **OR** Foil on both sides of substrate **OR** Vacuum metallizing on substrate, **as directed**.
 - b. Surface-Burning Characteristics: Maximum flame-spread and smoke-developed indexes of 5 and 10, respectively.
 - c. Water-Vapor Transmission: 1 perm, maximum **OR** 5 perms or greater, **as directed**.
- J. Vapor Retarders
 1. Polyethylene Vapor Retarders: ASTM D 4397, 6 mils (0.15 mm) thick, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
 2. Reinforced-Polyethylene Vapor Retarders: 2 outer layers of polyethylene film laminated to an inner reinforcing layer consisting of either nylon cord or polyester scrim and weighing not less than 25 lb/1000 sq. ft. (12 kg/100 sq. m), with maximum permeance rating of 0.0507 perm (2.9 ng/Pa x s x sq. m).
 3. Fire-Retardant, Reinforced-Polyethylene Vapor Retarders: 2 outer layers of polyethylene film laminated to an inner reinforcing layer consisting of either nonwoven grid of nylon cord or polyester scrim and weighing not less than 22 lb/1000 sq. ft. (10 kg/100 sq. m), with maximum permeance rating of 0.1317 perm (7.56 ng/Pa x s x sq. m) and with flame-spread and smoke-developed indexes of not more than 5 and 60, respectively.
 4. Foil-Polyester-Film Vapor Retarders: 2 layers of 0.5-mil- (0.013-mm-) thick polyester film laminated to an inner layer of 1-mil- (0.025-mm-) thick aluminum foil, with maximum water-vapor transmission rate in flat condition of 0.0 g/h x sq. m and with maximum flame-spread and smoke-developed indexes of 5.



5. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
6. Vapor-Retarder Fasteners: Pancake-head, self-tapping steel drill screws; with fender washers.
7. Single-Component Nonsag Urethane Sealant: ASTM C 920, Type I, Grade NS, Class 25, Use NT related to exposure, and Use O related to vapor-barrier-related substrates.
8. Adhesive for Vapor Retarders: Product recommended by vapor-retarder manufacturer and with demonstrated capability to bond vapor retarders securely to substrates indicated.

K. Auxiliary Insulating Materials

1. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by insulation manufacturers for sealing joints and penetrations in vapor-retarder facings.
2. Adhesive for Bonding Insulation: Product with demonstrated capability to bond insulation securely to substrates indicated without damaging insulation and substrates.
3. Asphalt Coating for Cellular-Glass Block Insulation: Cutback asphalt or asphalt emulsion of type recommended by manufacturer of cellular-glass block insulation.
4. Eave Ventilation Troughs: Preformed, rigid fiberboard or plastic sheets designed and sized to fit between roof framing members and to provide cross ventilation between insulated attic spaces and vented eaves.

L. Insulation Fasteners

1. Adhesively Attached, Spindle-Type Anchors: Plate welded to projecting spindle; capable of holding insulation of thickness indicated securely in position indicated with self-locking washer in place; and complying with the following requirements:
 - a. Plate: Perforated galvanized carbon-steel sheet, 0.030 inch (0.762 mm) thick by 2 inches (50 mm) square.
 - b. Spindle: Copper-coated, low carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation indicated.
2. Adhesively Attached, Angle-Shaped, Spindle-Type Anchors: Angle welded to projecting spindle; capable of holding insulation of thickness indicated securely in position indicated with self-locking washer in place; and complying with the following requirements:
 - a. Angle: Formed from 0.030-inch- (0.762-mm-) thick, perforated, galvanized carbon-steel sheet with each leg 2 inches (50 mm) square.
 - b. Spindle: Copper-coated, low carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation indicated.
3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel sheet, with beveled edge for increased stiffness, sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) square or in diameter.
 - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in the following locations:
 - 1) Crawlspace.
 - 2) Ceiling plenums.
 - 3) Attic spaces.
 - 4) Where indicated.
4. Insulation Standoff: Spacer fabricated from galvanized mild-steel sheet for fitting over spindle of insulation anchor to maintain air space of 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (76 mm), **as directed**, between face of insulation and substrate to which anchor is attached.
5. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrates indicated without damaging insulation, fasteners, and substrates.

1.3 EXECUTION

A. Preparation

1. Clean substrates of substances harmful to insulation or vapor retarders, including removing projections capable of puncturing vapor retarders or of interfering with insulation attachment.



- B. Installation, General
1. Comply with insulation manufacturer's written instructions applicable to products and application indicated.
 2. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed at any time to ice, rain, and snow.
 3. Extend insulation in thickness indicated to envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.
 4. Water-Piping Coordination: If water piping is located within insulated exterior walls, coordinate location of piping to ensure that it is placed on warm side of insulation and insulation encapsulates piping.
 5. For preformed insulating units, provide sizes to fit applications indicated and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units to produce thickness indicated unless multiple layers are otherwise shown or required to make up total thickness.
- C. Installation Of Perimeter And Under-Slab Insulation
1. On vertical surfaces, set insulation units in adhesive applied according to manufacturer's written instructions. Use adhesive recommended by insulation manufacturer.
 - a. If not otherwise indicated, extend insulation a minimum of 24 inches (610 mm) below exterior grade line.
 2. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.
 3. Protect below-grade insulation on vertical surfaces from damage during backfilling by applying protection course with joints butted. Set in adhesive according to insulation manufacturer's written instructions.
 4. Protect top surface of horizontal insulation from damage during concrete work by applying protection course with joints butted.
- D. Installation Of Cavity-Wall Insulation
1. On units of foam-plastic board insulation, install pads of adhesive spaced approximately 24 inches (610 mm) o.c. both ways on inside face, and as recommended by manufacturer. Fit courses of insulation between wall ties and other obstructions, with edges butted tightly in both directions. Press units firmly against inside substrates indicated.
 - a. Supplement adhesive attachment of insulation by securing boards with two-piece wall ties designed for this purpose and specified in Division 04 Section "Unit Masonry".
 2. Install units of cellular-glass insulation with closely fitting joints using method indicated:
 - a. Gob Method: Apply 4 gobs of adhesive per unit and set units firmly against inside wythe of masonry or other construction as shown. Apply gobs at each corner; spread gobs to form pads 4 inches (101 mm) in diameter by 1/4 inch (6 mm) thick.
 - b. Serrated-Trowel Method: Apply adhesive to entire surface of each cellular-glass insulation unit with serrated trowel complying with insulation manufacturer's written instructions.
 - c. Coat edges of insulation units with full bed of adhesive to seal joints between insulation and between insulation and adjoining construction.
 - d. Coat exterior face (cold face) of installed cellular-glass block insulation course with asphalt coating.
- E. Installation Of General Building Insulation
1. Apply insulation units to substrates by method indicated, complying with manufacturer's written instructions. If no specific method is indicated, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.
 2. Seal joints between foam-plastic insulation units by applying adhesive, mastic, or sealant to edges of each unit to form a tight seal as units are shoved into place. Fill voids in completed installation with adhesive, mastic, or sealant as recommended by insulation manufacturer.
 3. Set vapor-retarder-faced units with vapor retarder to warm-in-winter side **OR** in location indicated, **as directed**, of construction, unless otherwise indicated.



- a. Tape joints and ruptures in vapor retarder, and seal each continuous area of insulation to surrounding construction to ensure airtight installation.
4. Install mineral-fiber insulation in cavities formed by framing members according to the following requirements:
 - a. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill cavity, provide lengths that will produce a snug fit between ends.
 - b. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members.
 - c. Maintain 3-inch (76-mm) clearance of insulation around recessed lighting fixtures.
 - d. Install eave ventilation troughs between roof framing members in insulated attic spaces at vented eaves.
 - e. For metal-framed wall cavities where cavity heights exceed 96 inches (2438 mm), support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.
 - f. For wood-framed construction, install mineral-fiber blankets according to ASTM C 1320 and as follows:
 - 1) With faced blankets having stapling flanges, secure insulation by inset, stapling flanges to sides of framing members.
OR
With faced blankets having stapling flanges, lap blanket flange over flange of adjacent blanket to maintain continuity of vapor retarder once finish material is installed over it.
5. Install board insulation on concrete substrates by adhesively attached, spindle-type insulation anchors as follows:
 - a. Fasten insulation anchors to concrete substrates with insulation anchor adhesive according to anchor manufacturer's written instructions. Space anchors according to insulation manufacturer's written instructions for insulation type, thickness, and application indicated.
 - b. Apply insulation standoffs to each spindle to create cavity width indicated between concrete substrate and insulation.
 - c. After adhesive has dried, install board insulation by pressing insulation into position over spindles and securing it tightly in place with insulation-retaining washers, taking care not to compress insulation below indicated thickness.
 - d. Where insulation will not be covered by other building materials, apply capped washers to tips of spindles.
6. Install board insulation in curtain-wall construction where indicated on Drawings according to curtain-wall manufacturer's written instructions.
 - a. Retain insulation in place by metal clips and straps or integral pockets within window frames, spaced at intervals recommended in writing by insulation manufacturer to hold insulation securely in place without touching spandrel glass. Maintain cavity width of dimension indicated between insulation and glass.
 - b. Install insulation where it contacts perimeter fire-containment system to prevent insulation from bowing under pressure from perimeter fire-containment system.
7. Place loose-fill insulation into spaces indicated, by pouring **OR** by machine blowing, **as directed**, to comply with ASTM C 1015. Level horizontal applications to uniform thickness as indicated, lightly settle to uniform density, but do not compact excessively.
 - a. For cellulosic-fiber loose-fill insulation, comply with the Cellulose Insulation Manufacturers Association's Special Report #3, "Standard Practice for Installing Cellulose Insulation."
8. Apply self-supported, spray-applied cellulosic insulation according to manufacturer's written instructions. Do not apply insulation until installation of pipes, ducts, conduits, wiring, and electrical outlets in walls is completed and windows, electrical boxes, and other items not indicated to receive insulation are masked. After insulation is applied, make it flush with face of studs by using method recommended by insulation manufacturer.



9. Stuff glass-fiber loose-fill insulation into miscellaneous voids and cavity spaces where shown. Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft. (40 kg/cu. m).
- F. Installation Of Insulation In Ceilings For Sound Attenuation
1. Install 3-inch- (76-mm-) thick, unfaced glass-fiber **OR** slag-wool-fiber/rock-wool-fiber, **as directed**, blanket insulation over suspended ceilings at partitions in a width that extends insulation 48 inches (1219 mm) on either side of partition.
OR
Install 1-1/2-inch- (38-mm-) thick, unfaced glass-fiber **OR** slag-wool-fiber/rock-wool-fiber, **as directed**, blanket insulation over suspended ceilings so that insulation extends over entire ceiling.
- G. Installation Of Radiant Barriers
1. Install interior radiation control coating system according to ASTM C 1321.
 2. Install sheet radiant barriers in locations indicated according to ASTM C 1158.
- H. Installation Of Vapor Retarders
1. General: Extend vapor retarder to extremities of areas to be protected from vapor transmission. Secure in place with adhesives or other anchorage system as indicated. Extend vapor retarder to cover miscellaneous voids in insulated substrates, including those filled with loose-fiber insulation.
 2. Seal vertical joints in vapor retarders over framing by lapping not less than two wall studs. Fasten vapor retarders to wood framing at top, end, and bottom edges; at perimeter of wall openings; and at lap joints. Space fasteners 16 inches (400 mm) o.c.
 3. Before installing vapor retarder, apply urethane sealant to flanges of metal framing including runner tracks, metal studs, and framing around door and window openings. Seal overlapping joints in vapor retarders with vapor-retarder tape according to vapor-retarder manufacturer's written instructions. Seal butt joints with vapor-retarder tape. Locate all joints over framing members or other solid substrates.
 4. Firmly attach vapor retarders to metal framing and solid substrates with vapor-retarder fasteners as recommended by vapor-retarder manufacturer.
 5. Seal joints caused by pipes, conduits, electrical boxes, and similar items penetrating vapor retarders with vapor-retarder tape to create an airtight seal between penetrating objects and vapor retarder.
 6. Repair tears or punctures in vapor retarders immediately before concealment by other work. Cover with vapor-retarder tape or another layer of vapor retarder.
- I. Protection
1. Protect installed insulation and vapor retarders from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION 07 21 13 13



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**SECTION 07 21 13 13a - MODIFIED BITUMOUS PROTECTED MEMBRANE ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for modified bituminous protected membrane roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes APP-modified and SBS-modified bituminous protected membrane roofing.

C. Definitions

1. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.
2. Hot Roofing Asphalt: Roofing asphalt heated to its equiviscous temperature, the temperature at which its viscosity is 125 centipoise for mop-applied roofing asphalt and 75 centipoise for mechanical spreader-applied roofing asphalt, within a range of plus or minus 25 deg F (14 deg C), measured at the mop cart or mechanical spreader immediately before application.

D. Performance Requirements

1. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.
3. Roofing System Design: If membrane roofing system is to be designed to withstand uplift pressure established by ASCE/SEI 7, provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
 - a. Corner Uplift Pressure: as directed by the Owner.
 - b. Perimeter Uplift Pressure: as directed by the Owner.
 - c. Field-of-Roof Uplift Pressure: as directed by the Owner.
4. FM Approvals Listing: If Project is FM Global insured or if FM Approvals requirements will set a minimum quality standard, provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120, **as directed.**
 - b. Hail Resistance Rating: MH **OR** SH, **as directed.**
5. Energy Performance (if required for LEED-NC Credit SS 7.2): Provide roofing system with initial Solar Reflectance Index not less than 78 when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.
OR
Energy Performance (for roofs that must comply with the DOE's ENERGY STAR requirements): Provide roofing system that is listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low-slope roof products.
OR



Energy Performance (for roofs that must comply with California Energy Commission's CEC-Title 24): Provide roofing system with initial Solar Reflectance not less than 0.70 and Thermal Emittance not less than 0.75 when tested according to CRRC-1.

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Test Reports for Credit SS 7.2: For roof materials, indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.
 - a. Base flashings and membrane terminations.
 - b. Tapered insulation, including slopes.
 - c. Crickets, saddles, and tapered edge strips, including slopes.
4. Samples: For the following products:
 - a. Sheet roofing materials, including base sheet, base-ply sheet, roofing membrane sheet, flashing backer sheet, membrane cap sheet and flashing sheet, of color specified.
 - b. Roof insulation.
 - c. 10 lb (4.5 kg) of aggregate ballast in gradation and color indicated.
 - d. Roof paver, full sized, in each color and texture required.
5. Qualification Data: For qualified Installer and manufacturer.
6. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of compliance with performance requirements.
7. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for components of membrane roofing system.
8. Research/Evaluation Reports: For components of membrane roofing system, from the ICC-ES or applicable model code organization.
9. Maintenance Data: For roofing system to include in maintenance manuals.
10. Warranties: Sample of special warranties.

F. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer that is UL listed **OR** FM Approvals approved, **as directed**, for membrane roofing system identical to that used for this Project.
2. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
3. Source Limitations: Obtain components including roof insulation and fasteners for membrane roofing system from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.
4. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
5. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
6. Preinstallation Roofing Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.



2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing manufacturer. Protect stored liquid material from direct sunlight.
 - a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.

H. Project Conditions

1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

I. Warranty

1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within specified warranty period.
 - a. Special warranty includes membrane roofing, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, roof pavers, and other components of membrane roofing system.
 - b. Warranty Period: 10 **OR** 15, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. APP-Modified Asphalt-Sheet Materials

1. Roofing Membrane Sheet: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
2. Smooth-Surfaced Roofing Membrane Cap Sheet: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
OR
Granule-Surfaced Roofing Membrane Cap Sheet: ASTM D 6222, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified.

B. SBS-Modified Asphalt-Sheet Materials

1. Roofing Membrane Sheet: ASTM D 6164, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
2. Smooth-Surfaced Roofing Membrane Cap Sheet: ASTM D 6164, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.
OR



Granule-Surface Roofing Membrane Cap Sheet: ASTM D 6164, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified.

OR

Metal-Foil-Surfaced Roofing Membrane Cap Sheet: ASTM D 6298, metal-foil surfaced SBS-modified asphalt sheet (reinforced with glass fibers); suitable for application method specified, and as follows:

a. Foil Surfacing: Aluminum **OR** Copper **OR** Stainless steel, **as directed**.

C. Base-Sheet Materials

1. Base Sheet: ASTM D 4601, Type II, SBS-modified asphalt-impregnated and -coated sheet, with glass-fiber-reinforcing mat, dusted with fine mineral surfacing on both sides.

a. Weight: 25 lb/100 sq. ft. (1.2 kg/sq. m) **OR** 40 lb/100 sq. ft. (1.95 kg/sq. m) **OR** 50 lb/100 sq. ft. (2.4 kg/sq. m) **OR** 60 lb/100 sq. ft. (2.9 kg/sq. m) **OR** 75 lb/100 sq. ft. (3.7 kg/sq. m), **as directed**, minimum.

OR

Base Sheet: ASTM D 4601, Type I **OR** Type II, **as directed**, nonperforated, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.

OR

Base Sheet: ASTM D 4897, Type II, venting, nonperforated, heavyweight, asphalt-impregnated and -coated, glass-fiber base sheet with coarse granular surfacing or embossed venting channels on bottom surface.

OR

Base Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.

D. Base-Ply Sheet Materials

1. Glass-Fiber Base-Ply Sheet: ASTM D 2178, Type IV **OR** Type VI, **as directed**, asphalt-impregnated, glass-fiber felt.

E. Base Flashing Sheet Materials

1. Backer Sheet: ASTM D 4601, Type I **OR** Type II, **as directed**, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.

OR

Backer Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.

OR

Backer Sheet: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.

OR

Backer Sheet: ASTM D 6164, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.

2. Smooth-Surfaced Flashing Sheet: ASTM D 6222, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6223, Grade S, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; smooth surfaced; suitable for application method specified.

3. Granule-Surfaced Flashing Sheet (for use with APP-modified roofing membranes): ASTM D 6222, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with polyester



- fabric) **OR** ASTM D 6223, Grade G, Type I or II, APP-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified, and as follows:
- a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.
4. Granule-Surfaced Flashing Sheet (for use with SBS-modified roofing membranes): ASTM D 6164, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with polyester fabric) **OR** ASTM D 6163, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers) **OR** ASTM D 6162, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with a combination of polyester fabric and glass fibers), **as directed**; granular surfaced; suitable for application method specified, and as follows:
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.
 5. Metal-Foil-Surfaced Flashing Sheet: ASTM D 6298, metal-foil surfaced SBS-modified asphalt sheet (reinforced with glass fibers); suitable for application method specified, and as follows:
 - a. Foil Surfacing: Aluminum **OR** Copper **OR** Stainless steel **OR** Aluminum, fluoropolymer coated finish, of color and gloss selected from manufacturer's full range, **as directed**.
 6. Glass-Fiber Fabric: Woven glass-fiber cloth, treated with asphalt, complying with ASTM D 1668, Type I.
- F. Auxiliary Roofing Membrane Materials
1. General: Auxiliary materials recommended by roofing manufacturer for intended use and compatible with roofing membrane.
 - a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
 - b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Multipurpose Construction Adhesives: 70 g/L.
 - 3) Fiberglass Adhesives: 80 g/L.
 - 4) Contact Adhesives: 80 g/L.
 - 5) Other Adhesives: 250 g/L.
 - 6) Nonmembrane Roof Sealants: 300 g/L.
 - 7) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 8) Sealant Primers for Porous Substrates: 775 g/L.
 2. Asphalt Primer: ASTM D 41.
 3. Roofing Asphalt: ASTM D 312, Type III **OR** Type IV **OR** Type III or IV as recommended by roofing manufacturer for application, **as directed**.
OR
Roofing Asphalt: ASTM D 6152, SEBS modified.
 4. Cold-Applied Adhesive: Roofing manufacturer's standard asphalt-based, one- or two-part, asbestos-free, cold-applied adhesive specially formulated for compatibility and use with roofing membrane and base flashings.
 5. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required by roofing manufacturer for application.
 6. Mastic Sealant: Polyisobutylene, plain or modified bitumen, nonhardening, nonmigrating, nonskinning, and nondrying.
 7. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roofing membrane components to substrate, tested by manufacturer for required pullout strength, and acceptable to roofing system manufacturer.
 8. Insulation Cant Strips: ASTM C 728, perlite insulation board.
OR
Insulation Cant Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.
 9. Metal Flashing Sheet: As specified in Division 7 Section "Sheet Metal Flashing and Trim."



10. Roofing Granules: Ceramic-coated **OR** Slate, **as directed**, roofing granules, No. 11 screen size with 100 percent passing No. 8 (2.36-mm) sieve and 98 percent of mass retained on No. 40 (0.425-mm) sieve, color to match roofing membrane.
11. Separator Sheet: Polyethylene sheet, 4 mils (0.1 mm) thick, minimum.
12. Miscellaneous Accessories: Provide those recommended by roofing system manufacturer.

G. Coating Materials

1. Roof Coating: ASTM D 1227, Type II, Class 1, mineral-colloid-emulsified, fibered **OR** Class 2, chemically emulsified, filled or fibered, **as directed**, asphalt emulsion, asbestos free.
OR
Roof Coating: ASTM D 1227, Type III, Class 1, mineral-colloid-emulsified **OR** Class 2, chemically emulsified, **as directed**, asphalt emulsion, nonfibered.
OR
Roof Coating: ASTM D 2824, Type I, nonfibered **OR** Type III, fibered, asbestos-free, **as directed**, aluminum-pigmented asphaltic coating.
OR
Roof Coating: Acrylic elastomer emulsion coating, formulated for use on bituminous roof surfaces and complying with ASTM D 6083.
 - a. Color: White **OR** Gray **OR** Buff, **as directed**.

H. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type VI, 1.8 lb/cu. ft. (29 kg/cu. m) **OR** Type VII, 2.2 lb/cu. ft. (35 kg/cu. m), **as directed**, with two or four edges rabbeted.
3. Mortar-Faced, Extruded-Polystyrene Board Insulation: ASTM C 578, Type VI, 1.8-lb/cu. ft. (29-kg/cu. m) minimum density, with tongue-and-groove edges on long dimension, and latex-modified cement mortar topping, 3/8 inch (9 mm) thick, 4.5 lb/sq. ft. (19.5 kg/sq. m) **OR** 15/16 inch (23 mm) thick, 11 lb/sq. ft. (53.7 kg/sq. m), **as directed**.

I. Insulation Accessories

1. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.
2. Protection Mat: Woven or nonwoven polypropylene, polyolefin, or polyester fabric, water permeable and resistant to UV degradation, type and weight as recommended by roofing system manufacturer for application.
3. Metal Securement System: Perimeter securement flashing and strapping fabricated from stainless steel, a minimum of 0.031 inch (0.8 mm) thick. Provide fasteners as recommended by mortar-faced insulation manufacturer.

J. Ballast

1. Aggregate Ballast: Washed, crushed stone or smooth stone that will withstand weather exposure without significant deterioration and will not contribute to membrane degradation; of the following size:
 - a. Size: ASTM D 448, Size 5, ranging in size from 1/2 to 1 inch (13 to 25 mm).
 - b. Size: ASTM D 448, Size 4, ranging in size from 3/4 to 1-1/2 inches (19 to 38 mm).
 - c. Size: ASTM D 448, Size 2, ranging in size from 1-1/2 to 2-1/2 inches (38 to 63 mm).
2. Interlocking Roof Pavers: Interlocking, lightweight concrete units, specially factory cast for use as roof ballast; grooved back, with four-way drainage capability; beveled, doweled, or otherwise profiled. Size and weight shall be as directed.
 - a. Compressive Strength: 2500 psi (17 MPa) **OR** 5000 psi (34 MPa), **as directed**, minimum.
 - b. Colors and Textures: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.



3. Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 24 by 24 inches (600 by 600 mm). Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: Weight shall be as directed.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum; ASTM C 140.
 - d. Colors and Textures: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - e. Paver Supports: Integral corner pedestals.
OR
Paver Supports: Paver manufacturer's standard SBR rubber, high-density polyethylene, or polyurethane paver support assembly, including fixed-height **OR** adjustable or stackable, **as directed**, pedestals, shims, and spacer tabs for joint spacing of 1/8 inch (3 mm) **OR** 3/16 inch (5 mm) **OR** 1/8 to 3/16 inch (3 to 5 mm), **as directed**.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with the following requirements and other conditions affecting performance of roofing system:
 - a. Verify that roof openings and penetrations are in place and curbs are set and braced and that roof drain bodies are securely clamped in place.
 - b. Verify that wood cants, blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations.
 - c. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
 - d. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
 - 1) Test for moisture by pouring 1 pint (0.5 L) of hot roofing asphalt on deck at start of each day's work and at start of each roof area or plane. Do not proceed with roofing work if test sample foams or can be easily and cleanly stripped after cooling.
 - e. Verify that concrete curing compounds that will impair adhesion of roofing components to roof deck have been removed.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Prime surface of concrete deck with asphalt primer at a rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.

C. Roofing Membrane Installation, General

1. If referencing NRCA's roof assembly identification matrix system, install roofing membrane system according to roofing system manufacturer's written instructions and applicable recommendations in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing."
 - a. Install roofing system MBA **OR** S, **as directed**,-4-C-T **OR** M **OR** L, **as directed**,-P, according to roof assembly identification matrix and roof assembly layout illustrations in NRCA's "The NRCA Roofing and Waterproofing Manual" and requirements in this Section.



2. For roof system that exceeds requirements of NRCA's roof assemblies, install roofing membrane system according to roofing system manufacturer's written instructions and applicable recommendations in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing" and as follows:
 - a. Membrane: A (APP) **OR** S (SBS), **as directed**.
 - b. Deck Type: C (concrete or nonnailable).
 - c. Adhering Method: T (torched) **OR** M (mopped) **OR** L (cold-applied adhesive), **as directed**.
 - d. Base Sheet: One.
 - e. Number of Glass-Fiber Base-Ply Sheets: One.
 - f. Number of Modified Asphalt Sheets: Two.
 - g. Surfacing Type: P (protected).
 3. Start installation of roofing membrane in presence of roofing system manufacturer's technical personnel.
 4. Where roof slope exceeds 1/2 inch per 12 inches (1:24) **OR** 3/4 inch per 12 inches (1:18), **as directed**, install roofing membrane sheets parallel with slope.
 - a. Backnail roofing membrane sheets to nailer strips according to roofing system manufacturer's written instructions.
 5. Cooperate with testing agencies engaged or required to perform services for installing roofing system.
 6. Coordinate installing roofing system so components of the roofing membrane system not permanently exposed are not subjected to precipitation or left uncovered at the end of the workday or when rain is forecast.
 - a. Provide tie-offs at end of each day's work to cover exposed roofing membrane sheets with a course of coated felt set in roofing cement or hot roofing asphalt with joints and edges sealed.
 - b. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system.
 - c. Remove and discard temporary seals before beginning work on adjoining roofing.
 7. Asphalt Heating: Do not raise roofing asphalt temperature above equiviscous temperature range more than one hour before time of application. Do not exceed roofing asphalt manufacturer's recommended temperature limits during roofing asphalt heating. Do not heat roofing asphalt within 25 deg F (14 deg C) of flash point. Discard roofing asphalt maintained at a temperature exceeding finished blowing temperature for more than four hours.
OR
 Asphalt Heating: Heat and apply SEBS-modified roofing asphalt according to roofing system manufacturer's written instructions.
 8. Substrate-Joint Penetrations: Prevent roofing asphalt from penetrating substrate joints, entering building, or damaging roofing system components or adjacent building construction.
- D. Base-Sheet Installation
1. Install lapped base sheet course, extending sheet over and terminating beyond cants. Attach base sheet as follows:
 - a. Spot- or strip-mop to substrate with hot roofing asphalt.
OR
 Adhere to substrate in a solid mopping of hot roofing asphalt **OR** uniform coating of cold-applied adhesive, **as directed**.
- E. Base-Ply Sheet Installation
1. Install glass-fiber base-ply sheets according to roofing system manufacturer's written instructions starting at low point of roofing system. Align glass-fiber base-ply sheets without stretching. Extend glass-fiber base-ply sheets over and terminate beyond cants. Embed each glass-fiber base-ply sheet in a continuous void-free mopping of hot roofing asphalt, to form a uniform membrane without glass-fiber base-ply sheets touching.
- F. Modified Bituminous Membrane Installation



1. Install modified bituminous roofing membrane sheet and cap sheet according to roofing manufacturer's written instructions, starting at low point of roofing system. Extend roofing membrane sheets over and terminate beyond cants.
 - a. Unroll roofing membrane sheets and allow them to relax for minimum time period required by manufacturer.
 2. Laps: Accurately align roofing membrane sheets, without stretching, and maintain uniform side and end laps. Stagger end laps. Completely bond and seal laps, leaving no voids.
 - a. Repair tears and voids in laps and lapped seams not completely sealed.
 - b. Apply roofing granules to cover exuded bead at laps while bead is hot.
 3. Install roofing membrane sheets so side and end laps shed water.
- G. Flashing And Stripping Installation
1. Install base flashing over cant strips and other sloping and vertical surfaces, at roof edges, and at penetrations through roof, and secure to substrates according to roofing system manufacturer's written instructions and as follows:
 - a. Prime substrates with asphalt primer if required by roofing system manufacturer.
 - b. Backer Sheet Application: Mechanically fasten backer sheet to walls or parapets. Adhere backer sheet over roofing membrane at cants in a solid mopping of hot roofing asphalt **OR** cold-applied adhesive, **as directed**.
OR
Backer Sheet Application: Adhere backer sheet to substrate in a solid mopping of hot roofing asphalt **OR** cold-applied adhesive at rate required by roofing system manufacturer, **as directed**.
 - c. Flashing Sheet Application: Adhere flashing sheet to substrate in cold-applied adhesive at rate required by roofing system manufacturer.
OR
Flashing Sheet Application: Adhere flashing sheet to substrate in asphalt roofing cement at rate required by roofing system manufacturer.
OR
Flashing Sheet Application: Torch apply flashing sheet to substrate.
OR
Flashing Sheet Application: Adhere flashing sheet to substrate in a solid mopping of hot roofing asphalt applied at not less than 425 deg F (218 deg C). Apply hot roofing asphalt to back of flashing sheet if recommended by roofing system manufacturer.
 2. Extend base flashing up walls or parapets a minimum of 8 inches (200 mm) above roofing membrane and 4 inches (100 mm) onto field of roofing membrane.
 3. Mechanically fasten top of base flashing securely at terminations and perimeter of roofing.
 - a. Seal top termination of base flashing with a strip of glass-fiber fabric set in asphalt roofing cement, **as directed**.
 4. Install roofing membrane cap-sheet stripping where metal flanges and edgings are set on membrane roofing according to roofing system manufacturer's written instructions.
 5. Roof Drains: Set 30-by-30-inch (760-by-760-mm) metal flashing in bed of roofing-manufacturer-approved asphaltic adhesive on completed roofing membrane. Cover metal flashing with roofing membrane cap-sheet stripping and extend a minimum of 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, beyond edge of metal flashing onto field of roofing membrane. Clamp roofing membrane, metal flashing, and stripping into roof-drain clamping ring.
 - a. Install stripping according to roofing system manufacturer's written instructions.
- H. Coating Installation
1. Apply coatings to base flashings according to manufacturer's written instructions, by spray, roller, or other suitable application method.
- I. Insulation Installation
1. Loosely lay separator sheet over cooled roofing membrane, with minimum 2-inch (50-mm) side laps and 4-inch (100-mm) end laps.



2. Loosely lay board insulation units over roofing membrane, with long joints of insulation in continuous straight lines and with end joints staggered between rows. Abut edges and ends between units.
3. Install one or more layers of insulation to achieve required thickness over roofing membrane. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.
 - a. Where overall insulation thickness is 2 inches (50 mm) or more, install required thickness in two or more layers with joints of each succeeding layer staggered over joints of previous layer a minimum of 6 inches (150 mm) in each direction.
4. Install geotextile fabric over insulation, overlapping edges and ends at least 12 inches (300 mm). Do not lap ends of fabric sheets within 72 inches (1800 mm) of roof perimeter. Extend fabric 2 to 3 inches (50 to 75 mm) above ballast at perimeter and penetrations. Apply additional layer of fabric around penetrations to prevent aggregate from getting between penetration and insulation. Do not cover drains or restrict water flow to drains.

J. Ballast Installation

1. To roofed area, apply aggregate ballast uniformly over geotextile fabric at rate required by insulation manufacturer, but not less than the following, carefully spreading aggregate to not damage roofing membrane and base flashings. Install roof-paver ballast according to insulation manufacturer's written instructions, **as directed**. Apply ballast as insulation is installed, leaving roofing membrane insulated and ballasted at end of workday.
 - a. Ballast (Dow's "Standard Design"): 15 lb/sq. ft. (75 kg/sq. m) **OR** 20 lb/sq. ft. (100 kg/sq. m), **as directed**, Size 5 aggregate within 102 inches (2600 mm) of roof perimeter and corners and 24 inches (600 mm) of roof penetrations; 10 lb/sq. ft. (50 kg/sq. m), Size 5 aggregate elsewhere.
 - 1) If partially replacing aggregate ballast with roof pavers, install one row of roof pavers in lieu of aggregate ballast at roof perimeter, corners, and penetrations.
 - b. Ballast (for Dow's "Design #1"): 15 lb/sq. ft. (75 kg/sq. m) **OR** 20 lb/sq. ft. (100 kg/sq. m), **as directed**, Size 4 aggregate within 102 inches (2600 mm) of roof perimeter and corners and 24 inches (600 mm) of roof penetrations; 12 lb/sq. ft. (60 kg/sq. m), Size 4 aggregate elsewhere.
 - c. Ballast (for Dow's "Design #1") (if combining aggregate ballast with roof pavers): 12 lb/sq. ft. (60 kg/sq. m), Size 4 aggregate to field of roof; install two rows of roof pavers at roof perimeter, corners, and penetrations according to insulation manufacturer's written instructions.
 - d. Ballast (for Dow's "Design #2") (for aggregate ballast with roof pavers at corners): 15 lb/sq. ft. (75 kg/sq. m) **OR** 20 lb/sq. ft. (100 kg/sq. m), **as directed**, Size 2 aggregate within 102 inches (2600 mm) of roof perimeter and 24 inches (600 mm) of roof penetrations; 13 lb/sq. ft. (65 kg/sq. m), Size 2 aggregate to field of roof; and install three rows of roof pavers at corners of roof according to insulation manufacturer's written instructions. Mechanically fasten securement strapping to center of first perimeter corner row of roof pavers.
 - e. Ballast (for Dow's "Design #2") (if combining aggregate ballast with roof pavers at roof perimeters, corners, and penetrations): 13 lb/sq. ft. (65 kg/sq. m), Size 2 aggregate to field of roof and install three rows of concrete pavers at roof perimeter, corners, and penetrations according to insulation manufacturer's written instructions. Mechanically fasten securement strapping to center of first perimeter and perimeter corner row of roof pavers.
 - f. Ballast (for Dow's "Design #3"): 15 lb/sq. ft. (75 kg/sq. m) **OR** 20 lb/sq. ft. (100 kg/sq. m), **as directed**, Size 2 aggregate within 24 inches (600 mm) of roof penetrations; 13 lb/sq. ft. (65 kg/sq. m), Size 2 aggregate to field of roof; and install four rows of roof pavers at roof perimeter and corners according to insulation manufacturer's written instructions. Mechanically fasten securement strapping to center of first two perimeter and perimeter corner rows of roof pavers.
2. Walkway Pavers: Install walkways formed from one row **OR** two rows, **as directed**, of roof pavers, loosely laid and butted.



- K. Roof-Paver Installation
1. Interlocking Roof Pavers: Install interlocking roof pavers over roofed area according to manufacturer's written instructions.
 2. For Dow's Technote 508 "Standard Design" and "Design #1", install roof pavers over roofed area according to insulation manufacturer's written instructions.
 3. For Dow's Technote 508 "Standard Design" and "Design #2", install roof pavers over roofed area according to insulation manufacturer's written instructions. Mechanically fasten roof-paver metal straps to center of first perimeter and first perimeter corner row of roof pavers.
 4. For Dow's Technote 508 "Standard Design" and "Design #3", install roof pavers over roofed area according to insulation manufacturer's written instructions. Mechanically fasten roof-paver metal straps to center of first two perimeters and first two perimeter corner rows of roof pavers.
 5. Install roof pavers on pedestals set according to pedestal manufacturer's written instructions.
- L. Mortar-Faced Board Insulation Installation
1. Install mortar-faced board insulation loosely laid, according to manufacturer's written instructions, with tongue-and-groove joints nested. Stagger end joints of adjoining rows and abut insulation.
 - a. Mechanically fasten metal securement strapping at penetrations and at perimeter edges of mortar-faced board insulation.
 - b. Over mortar-faced board insulation, install roof pavers on roof perimeter and corners according to manufacturer's written instructions.
 2. Install one row **OR** two rows, **as directed**, of 24-inch- (600-mm-) wide roof pavers to roof perimeter, corners, and penetrations according to mortar-faced board insulation manufacturer's written instructions.
- M. Field Quality Control
1. Testing Agency: Perform tests and inspections and to prepare reports.
 2. Test Cuts: Test specimens will be removed to evaluate problems observed during quality-assurance inspections of roofing membrane as follows:
 - a. Approximate quantities of components within roofing membrane will be determined according to ASTM D 3617.
 - b. Test specimens will be examined for interply voids according to ASTM D 3617 and to comply with criteria established in Appendix 3 in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing."
 - c. Repair areas where test cuts were made according to roofing system manufacturer's written instructions.
 3. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.
 - a. Notify the Owner and Owner 48 hours in advance of date and time of inspection.
 4. Roofing system will be considered defective if it does not pass tests and inspections.
 - a. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- N. Protecting And Cleaning
1. Protect roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to the Owner and Owner.
 2. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
 3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 21 13 13a



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Task	Specification	Specification Description
07 21 13 13	07 51 13 00	Built-Up Asphalt Roofing
07 21 13 13	07 05 13 00	Built-Up Coal-Tar Roofing
07 21 13 13	07 53 16 00	EPDM Membrane Roofing
07 21 13 13	07 05 13 00a	CSPE Membrane Roofing
07 21 13 13	07 05 13 00b	APP-Modified Bituminous Membrane Roofing
07 21 13 13	07 05 13 00c	SBS-Modified Bituminous Membrane Roofing
07 21 13 16	07 21 13 13	Building Insulation
07 21 13 16	07 51 13 00	Built-Up Asphalt Roofing
07 21 13 16	07 05 13 00	Built-Up Coal-Tar Roofing
07 21 13 16	07 53 16 00	EPDM Membrane Roofing
07 21 13 16	07 05 13 00a	CSPE Membrane Roofing
07 21 13 16	07 05 13 00b	APP-Modified Bituminous Membrane Roofing
07 21 13 16	07 05 13 00c	SBS-Modified Bituminous Membrane Roofing
07 21 13 19	07 21 13 13	Building Insulation
07 21 13 19	07 51 13 00	Built-Up Asphalt Roofing
07 21 13 19	07 05 13 00	Built-Up Coal-Tar Roofing
07 21 13 19	07 53 16 00	EPDM Membrane Roofing
07 21 13 19	07 05 13 00a	CSPE Membrane Roofing
07 21 13 19	07 05 13 00b	APP-Modified Bituminous Membrane Roofing
07 21 13 19	07 05 13 00c	SBS-Modified Bituminous Membrane Roofing
07 21 16 00	07 21 13 13	Building Insulation
07 21 19 00	07 21 13 13	Building Insulation
07 21 23 00	07 21 13 13	Building Insulation
07 21 26 00	07 21 13 13	Building Insulation
07 21 29 00	07 21 13 13	Building Insulation



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**SECTION 07 22 16 00 - FLUID-APPLIED PROTECTED MEMBRANE ROOFING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fluid-applied protected membrane roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show locations and extent of roofing.
 - a. Show locations, extent, and details of roof pavers.
3. Maintenance data.
4. Sample warranties.

C. Quality Assurance

1. Fire-Test-Response Characteristics: Provide hot fluid-applied roofing identical to assemblies tested for fire-test-response characteristics indicated by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Exterior Fire-Test Exposure: Class A; complying with ASTM E 108, for application and slopes indicated.
2. Preinstallation Conference: Conduct conference at Project site.

D. Delivery, Storage, And Handling

1. Deliver materials to Project site in original containers with seals unbroken, labeled with manufacturer's name, product brand name and type, date of manufacture, and directions for storing and mixing with other components.
 - a. Handle and store roofing materials and place equipment in a manner to avoid significant or permanent damage to deck or structural supporting members.
2. Protect roofing insulation materials from damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location.

E. Project Conditions

1. Environmental Limitations: Apply roofing within the range of ambient and substrate temperatures recommended by roofing system manufacturer. Do not apply roofing to a damp or wet substrate or when temperature is below 0 deg F (minus 18 deg C).
 - a. Do not apply roofing in snow, rain, fog, or mist.

F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace roofing that does not remain watertight and base flashing that does not within 10 **OR** 15 **OR** 20, **as directed**, years from date of Final Completion.
 - a. Warranty also includes insulation and roof pavers.

1.2 PRODUCTS

A. Roofing Membrane

1. Hot Fluid-Applied, Rubberized-Asphalt Roofing Membrane: Single component; 100 percent solids; hot fluid-applied, rubberized asphalt.

B. Base Flashing Sheet Materials



1. Elastomeric Flashing Sheet: 50-mil- (1.3-mm-) thick, minimum, uncured sheet neoprene with manufacturer's recommended contact adhesives as follows:
 - a. Tensile Strength: 1400 psi (9.6 MPa) minimum; ASTM D 412, Die C.
 - b. Elongation: 300 percent minimum; ASTM D 412.
 - c. Tear Resistance: 125 psi (860 kPa) minimum; ASTM D 624, Die C.
 - d. Brittleness: Does not break at minus 30 deg F (16 deg C); ASTM D 2137.
2. SBS-Modified Bituminous Flashing Sheet: ASTM D 6164, Grade G, Type I or Type II, polyester-reinforced, SBS-modified asphalt sheet; granular surfaced; suitable for application method specified, white **OR** gray **OR** tan, **as directed**.
 - a. Backer Sheet: ASTM D 6164, Grade S, Type I or Type II, polyester-reinforced, SBS-modified asphalt sheet; smooth surfaced; suitable for application method specified.
3. APP-Modified Bituminous Flashing Sheet: ASTM D 6222, Grade S, smooth **OR** Grade G, granular, **as directed**, surfaced, Type I or Type II, polyester-reinforced, APP-modified asphalt sheet; suitable for application method specified.
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.

C. Auxiliary Materials

1. General: Furnish auxiliary materials recommended by roofing system manufacturer for intended use and compatible with roofing.
 - a. Furnish liquid-type auxiliary materials that meet VOC limits of authorities having jurisdiction.
2. Primer: ASTM D 41, asphaltic primer.
3. Elastomeric Sheet: 50-mil- (1.3-mm-) thick, minimum, uncured sheet neoprene with manufacturer's recommended contact adhesives as follows:
 - a. Tensile Strength: 1400 psi (9.6 MPa) minimum; ASTM D 412, Die C.
 - b. Elongation: 300 percent minimum; ASTM D 412.
 - c. Tear Resistance: 125 psi (860 kPa) minimum; ASTM D 624, Die C.
 - d. Brittleness: Does not break at minus 30 deg F (16 deg C); ASTM D 2137.
4. Metal Termination Bars: Manufacturer's standard, predrilled, stainless-steel or aluminum termination bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.
5. Reinforcing Fabric: Manufacturer's recommended, spun-bonded polyester fabric.
6. Protection Course: Manufacturer's standard, 80-to-90-mil- (2.0-to-2.3-mm-) thick, fiberglass-reinforced rubberized asphalt or modified bituminous sheet.
7. Geotextile Fabric: Woven or nonwoven polypropylene, polyolefin, or polyester geotextile fabric; water permeable and resistant to UV-light degradation; of type and weight recommended by insulation manufacturer for application.
8. Roof-Paver Metal Straps: Securement strapping fabricated from stainless steel, a minimum of 3 inches (75 mm) wide by 0.031 inch (0.8 mm) thick with stainless-steel anchors or other corrosion-resistant, postinstalled expansion anchors approved by insulation manufacturer.

D. Board Insulation

1. Extruded-Polystyrene Board Insulation: ASTM C 578, Type VI, 1.8 lb/cu. ft. (29 kg/cu. m) **OR** Type VII, 2.2 lb/cu. ft. (35 kg/cu. m), **as directed**, with two or four edges rabbeted.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type VI, 1.8 lb/cu. ft. (29 kg/cu. m) **OR** Type VII, 2.2 lb/cu. ft. (35 kg/cu. m), **as directed**, with rabbeted edges and with one side having ribbed drainage channels.

E. Mortar-Faced Board Insulation

1. Mortar-Faced, Extruded-Polystyrene Board Insulation: ASTM C 578, Type VI, 1.8-lb/cu. ft. (29-kg/cu. m) minimum density, with tongue-and-groove edges on long dimension, and latex-modified cement mortar topping, 3/8 inch (9 mm) thick, 4 lb/sq. ft. (19.5 kg/sq. m) **OR** 15/16 inch (23 mm) thick, 11 lb/sq. ft. (53.7 kg/sq. m), **as directed**.
 - a. Metal Securement System: Perimeter securement flashing and strapping fabricated from stainless steel, a minimum of 0.031 inch (0.8 mm) thick, with stainless-steel anchors or



other corrosion-resistant, postinstalled expansion anchors approved by insulation manufacturer.

F. Aggregate Ballast

1. Aggregate Ballast: Washed, crushed stone or smooth stone that will withstand weather exposure without significant deterioration and will not contribute to membrane degradation; of the following size:
 - a. Size:
 - 1) ASTM D 448, Size 5, ranging in size from 1/2 to 1 inch (13 to 25 mm).
 - 2) ASTM D 448, Size 4, ranging in size from 3/4 to 1-1/2 inches (19 to 38 mm).
 - 3) ASTM D 448, Size 2, ranging in size from 1-1/2 to 2-1/2 inches (38 to 63 mm).

G. Roof Pavers

1. Interlocking Roof Pavers: Interlocking, lightweight concrete units, specially factory cast for use as roof ballast; grooved back, with four-way drainage capability; beveled, doweled, or otherwise profiled; and as follows:
 - a. Size: 8 by 16 inches (200 by 400 mm) 12 by 12 inches (300 by 300 mm) 12 by 16-1/2 inches (300 by 420 mm) 12 by 18 inches (300 by 450 mm)
 - b. Weight: At least 10 lb/sq. ft. (50 kg/sq. m) but not exceeding 18 lb/sq. ft. (90 kg/sq. m).
 - c. Compressive Strength: 2500 psi (17 MPa) **OR** 5000 psi (34 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.
2. Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 24 by 24 inches (600 by 600 mm). Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 20 lb/sq. ft. (100 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m) **OR** 24 lb/sq. ft. (120 kg/sq. m), **as directed**, minimum.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum; ASTM C 140.
 - d. Colors and Textures: As selected from manufacturer's full range.
 - e. Paver Supports:
 - 1) Integral corner pedestals.
OR
Paver manufacturer's standard SBR rubber, high-density polyethylene, or polyurethane paver support assembly, including fixed-height **OR** adjustable or stackable, **as directed**, pedestals, shims, and spacer tabs for joint spacing of 1/8 inch (3 mm) **OR** 3/16 inch (5 mm), **as directed**.

1.3 EXECUTION

A. Preparation

1. Clean and prepare substrate according to manufacturer's written recommendations. Provide clean, dust-free, and dry substrate for roofing application.
2. Mask off adjoining surfaces not receiving roofing to prevent spillage from affecting other construction.
3. Protect roof drains and other deck penetrations to prevent spillage and migration of roofing fluids.
4. Remove grease, oil, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.
5. Remove fins, ridges, and other projections and fill honeycomb, aggregate pockets, and other voids.

B. Joints, Cracks, And Terminations



1. Prepare and treat substrates to receive roofing membrane, including joints and cracks, roof drains, and penetrations, according to roofing system manufacturer's written instructions.
 - a. Rout and fill joints and cracks in substrate. Before filling, remove dust and dirt according to ASTM D 4258.
 - b. Adhere strip of elastomeric sheet to substrate in a layer of hot fluid-applied, rubberized asphalt. Extend elastomeric sheet a minimum of 6 inches (150 mm) on each side of moving joints and cracks or joints and cracks exceeding 1/8 inch (3 mm) thick, and beyond roof drains and penetrations. Apply second layer of hot fluid-applied, rubberized asphalt over elastomeric sheet.
 - c. Embed strip of reinforcing fabric into a layer of hot fluid-applied, rubberized asphalt. Extend reinforcing fabric a minimum of 6 inches (150 mm) on each side of nonmoving joints and cracks not exceeding 1/8 inch (3 mm) thick, and beyond roof drains and penetrations.
 - 1) Apply second layer of hot fluid-applied, rubberized asphalt over reinforcing fabric.
2. At expansion joints and discontinuous deck-to-wall or deck-to-deck joints, bridge joints with elastomeric sheet extended a minimum of 6 inches (150 mm) on each side of joints and adhere to substrates in a layer of hot fluid-applied, rubberized asphalt. Apply second layer of hot fluid-applied, rubberized asphalt over elastomeric sheet.

C. Base Flashing Installation

1. Install base flashing at terminations of roofing membrane according to manufacturer's written instructions.
2. Prime substrate with asphalt primer if required by manufacturer.
3. Bond elastomeric flashing sheet in contact adhesive against wall substrate to within 3 inches (75 mm) of deck. Adhere remaining vertical leg and horizontal leg of flashing sheet in a layer of hot fluid-applied, rubberized asphalt.
4. Bond modified bituminous flashing sheet to substrate as follows:
 - a. Adhere SBS-modified bituminous backer sheet and flashing sheet to substrate in a layer of hot fluid-applied, rubberized asphalt.
 - b. Torch apply APP-modified bituminous flashing sheet to substrate.
 - c. Adhere SBS-modified bituminous backer sheet and flashing sheet to substrate in a layer of hot fluid-applied, rubberized asphalt or torch apply APP-modified bituminous flashing sheet to substrate as standard with manufacturer.
5. Extend flashing sheet up walls or parapets a minimum of 8 inches (200 mm) above insulation and 6 inches (150 mm) onto roof deck.
6. Install termination bars and mechanically fasten to top of flashing sheet at terminations and perimeter of roofing.

D. Roofing Membrane Application

1. Apply primer, at manufacturer's recommended rate, over prepared substrate and allow to dry.
2. Heat and apply rubberized asphalt according to manufacturer's written instructions.
 - a. Heat rubberized asphalt in an oil- or air-jacketed melter with mechanical agitator specifically designed for heating rubberized asphalt.
3. Start application with manufacturer's authorized representative present.
4. Unreinforced Membrane: Apply hot rubberized asphalt to area to receive roofing. Spread hot rubberized asphalt to form a uniform, unreinforced, seamless membrane, 180-mil (4.5-mm) minimum thickness **OR** 180-mil (4.5-mm) average thickness, but not less than 125 mil (3.2 mm) thick, **as directed**.
5. Reinforced Membrane: Apply hot fluid-applied, rubberized asphalt to area to receive roofing. Spread a 90-mil- (2.3-mm-) thick layer of hot fluid-applied, rubberized asphalt; embed reinforcing fabric, overlapping sheets 2 inches (50 mm); spread another 125-mil- (3.2-mm-) thick layer of hot fluid-applied, rubberized asphalt to form a uniform, reinforced, seamless membrane, 215 mils (5.5 mm) thick.
6. Apply hot fluid-applied, rubberized asphalt over prepared joints and up wall terminations and vertical surfaces to heights indicated or required by manufacturer.



7. Cover waterproofing with protection course with overlapped joints before membrane is subject construction traffic.
- E. Insulation Installation
1. Loosely lay board insulation units over roofing membrane, with long joints of insulation in continuous straight lines and with end joints staggered between rows. Abut edges and ends between units.
 2. Install one or more layers of insulation to achieve required thickness over roofing membrane. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.
 - a. Where overall insulation thickness is 2 inches (50 mm) or more, install required thickness in two or more layers with joints of each succeeding layer staggered over joints of previous layer a minimum of 6 inches (150 mm) in each direction.
 3. Install geotextile fabric over insulation, overlapping edges and ends at least 12 inches (300 mm). Do not lap ends of fabric sheets within 72 inches (1800 mm) of roof perimeter. Extend fabric 2 to 3 inches (50 to 75 mm) above ballast at perimeter and penetrations. Apply additional layer of fabric around penetrations to prevent aggregate from getting between penetration and insulation. Do not cover drains or restrict water flow to drains.
- F. Ballast Installation
1. To roofed area, apply aggregate ballast uniformly over geotextile fabric at rate required by insulation manufacturer, but not less than the following, carefully spreading aggregate to not damage roofing membrane and base flashings. Install roof-paver ballast according to insulation manufacturer's written instructions. Apply ballast as insulation is installed, leaving roofing membrane insulated and ballasted at end of workday.
 - a. Ballast for Dow's Standard Design: 15 lb/sq. ft. (75 kg/sq. m), Size 5 aggregate within 102 inches (2600 mm) of roof perimeter and corners and 24 inches (600 mm) of roof penetrations; 10 lb/sq. ft. (50 kg/sq. m), Size 5 aggregate elsewhere. Revise ballast loads for roof perimeter, corners, and penetration loads below to 20 lb/sq. ft. (100 kg/sq. m) for insulation 3 inches (75 mm) or thicker.
 - 1) Install one row of roof pavers in lieu of aggregate ballast at roof perimeter, corners, and penetrations if combining aggregate ballast with roof pavers.
 - b. Ballast for Dow's Design #1:
 - 1) 15 lb/sq. ft. (75 kg/sq. m), Size 4 aggregate within 102 inches (2600 mm) of roof perimeter and corners and 24 inches (600 mm) of roof penetrations; 12 lb/sq. ft. (60 kg/sq. m), Size 4 aggregate elsewhere. Revise ballast loads for roof perimeter, corners, and penetration loads below to 20 lb/sq. ft. (100 kg/sq. m) for insulation 3 inches (75 mm) or thicker.

OR

12 lb/sq. ft. (60 kg/sq. m), Size 4 aggregate to field of roof; install two rows of roof pavers at roof perimeter, corners, and penetrations according to insulation manufacturer's written instructions if combining aggregate ballast with roof pavers.
 - c. Ballast for Dow's Design #2:
 - 1) 15 lb/sq. ft. (75 kg/sq. m), Size 2 aggregate within 102 inches (2600 mm) of roof perimeter and 24 inches (600 mm) of roof penetrations; 13 lb/sq. ft. (65 kg/sq. m), Size 2 aggregate to field of roof; and install three rows of roof pavers at corners of roof according to insulation manufacturer's written instructions. Mechanically fasten securement strapping to center of first perimeter corner row of roof pavers. Revise ballast loads for roof perimeter, corners, and penetration loads below to 20 lb/sq. ft. (100 kg/sq. m) for insulation 3 inches (75 mm) or thicker.

OR

13 lb/sq. ft. (65 kg/sq. m), Size 2 aggregate to field of roof and install three rows of concrete pavers at roof perimeter, corners, and penetrations according to insulation manufacturer's written instructions if combining aggregate ballast with roof pavers at roof perimeters, corners, and penetrations. Mechanically fasten securement strapping to center of first perimeter and perimeter corner row of roof pavers.
 - d. Ballast for Dow's Design #3:



- 1) 15 lb/sq. ft. (75 kg/sq. m), Size 2 aggregate within 24 inches (600 mm) of roof penetrations; 13 lb/sq. ft. (65 kg/sq. m), Size 2 aggregate to field of roof; and install four rows of roof pavers at roof perimeter and corners according to insulation manufacturer's written instructions. Mechanically fasten securement strapping to center of first two perimeter and perimeter corner rows of roof pavers. Revise ballast loads for roof perimeter, corners, and penetration loads below to 20 lb/sq. ft. (100 kg/sq. m) for insulation 3 inches (75 mm) or thicker.
- 2) Walkway Pavers: Install walkways formed from one row **OR** two rows, **as directed**, of roof pavers, loosely laid and butted.

G. Roof-Paver Installation

1. Interlocking Roof Pavers: Install interlocking roof pavers over roofed area according to manufacturer's written instructions.
2. Install roof pavers over roofed area according to insulation manufacturer's written instructions.
3. Install roof pavers over roofed area according to insulation manufacturer's written instructions. Mechanically fasten roof-paver metal straps to center of first perimeter and first perimeter corner row of roof pavers.
4. Install roof pavers over roofed area according to insulation manufacturer's written instructions. Mechanically fasten roof-paver metal straps to center of first two perimeters and first two perimeter corner rows of roof pavers.
5. Install roof pavers on pedestals set according to pedestal manufacturer's written instructions.

H. Mortar-Faced Board Insulation Installation

1. Install mortar-faced board insulation loosely laid, according to manufacturer's written instructions, with tongue-and-groove joints nested. Stagger end joints of adjoining rows and abut insulation.
 - a. Mechanically fasten metal securement strapping at penetrations and at perimeter edges of mortar-faced board insulation.
 - b. Over mortar-faced board insulation, install roof pavers on roof perimeter and corners according to manufacturer's written instructions.
2. Install one row **OR** two rows, **as directed**, of 24-inch- (600-mm-) wide roof pavers to roof perimeter, corners, and penetrations according to mortar-faced board insulation manufacturer's written instructions.

I. Cleaning And Protection

1. Protect roofing from damage and wear during remainder of construction period.
2. Protect installed insulation from damage due to UV light, physical abuse, and other causes. Provide temporary coverings where insulation will be subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
3. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

1.4 ROOFING INSTALLER'S WARRANTY

Warranty shall be submitted in the following format:

- A. WHEREAS <Insert name> of <Insert address>, herein called the "Roofing Installer," has performed roofing and associated work ("work") on the following project:
 1. Owner:
 2. Address:
 3. Building Name/Type:
 4. Address:
 5. Area of Work:
 6. Acceptance Date:
 7. Warranty Period:



8. Expiration Date:

- B. AND WHEREAS Roofing Installer has contracted (either directly with the Owner or indirectly as a subcontractor) to warrant said work against leaks and faulty or defective materials and workmanship for designated Warranty Period,
- C. NOW THEREFORE Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period it will, at its own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.
- D. This Warranty is made subject to the following terms and conditions:
 - 1. Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by:
 - a. lightning;
 - b. peak gust wind speeds, as directed by the Owner;
 - c. fire;
 - d. failure of roofing system substrate, including settlement, excessive deflection, deterioration, decomposition, and cracking wider than 1/8 inch (3 mm);
 - e. faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work;
 - f. vapor condensation on bottom of roofing; and
 - g. activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by the Owner.
 - 2. When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by the Owner or by another responsible party so designated.
 - 3. Roofing Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.
 - 4. During Warranty Period, if the Owner allows alteration of work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If the Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void, unless Roofing Installer, before starting said work, shall have notified the Owner in writing, showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.
 - 5. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.
 - 6. the Owner shall promptly notify Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.
 - 7. This Warranty is recognized to be the only warranty of Roofing Installer on said work and shall not operate to restrict or cut off the Owner from other remedies and resources lawfully available to the Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Roofing Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with the Owner or a subcontract with the Owner's General Contractor.



E. IN WITNESS THEREOF, this instrument has been duly executed this **<Insert day>** day of **<Insert month>**, **<Insert year>**.

1. Authorized Signature:
2. Name:
3. Title:

END OF SECTION 07 22 16 00



Task	Specification	Specification Description
07 22 16 00	07 51 13 00	Built-Up Asphalt Roofing
07 22 16 00	07 05 13 00	Built-Up Coal-Tar Roofing
07 22 16 00	07 53 16 00	EPDM Membrane Roofing
07 22 16 00	07 05 13 00a	CSPE Membrane Roofing
07 22 16 00	07 05 13 00b	APP-Modified Bituminous Membrane Roofing
07 22 16 00	07 05 13 00c	SBS-Modified Bituminous Membrane Roofing



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**SECTION 07 26 13 00 - ROUGH CARPENTRY**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for rough carpentry. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Framing with dimension lumber.
 - b. Framing with timber.
 - c. Framing with engineered wood products.
 - d. Rooftop equipment bases and support curbs.
 - e. Wood blocking, cants, and nailers.
 - f. Wood furring and grounds.
 - g. Wood sleepers.
 - h. Utility shelving.
 - i. Plywood backing panels.

C. Definitions

1. Exposed Framing: Framing not concealed by other construction.
2. Dimension Lumber: Lumber of 2 inches nominal (38 mm actual) or greater but less than 5 inches nominal (114 mm actual) in least dimension.
3. Timber: Lumber of 5 inches nominal (114 mm actual) or greater in least dimension.
4. Lumber grading agencies, and the abbreviations used to reference them, include the following:
 - a. NeLMA: Northeastern Lumber Manufacturers' Association.
 - b. NLGA: National Lumber Grades Authority.
 - c. RIS: Redwood Inspection Service.
 - d. SPIB: The Southern Pine Inspection Bureau.
 - e. WCLIB: West Coast Lumber Inspection Bureau.
 - f. WWPA: Western Wood Products Association.

D. Submittals

1. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - a. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
 - b. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
 - c. For fire-retardant treatments specified to be High-Temperature (HT) type, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.
 - d. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
 - e. Include copies of warranties from chemical treatment manufacturers for each type of treatment.
2. LEED Submittals:



- a. Product Data for Credit EQ 4.1: For adhesives, including printed statement of VOC content.
- b. Product Data for Credit EQ 4.4: For composite-wood products, documentation indicating that product contains no urea formaldehyde.
- c. Certificates for Credit MR 7: Chain-of-custody certificates certifying that products specified to be made from certified wood comply with forest certification requirements. Include evidence that mill is certified for chain of custody by an FSC-accredited certification body.
 - 1) Include statement indicating costs for each certified wood product.
3. Material Certificates: For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the ALSC Board of Review.
4. Research/Evaluation Reports: For the following, showing compliance with building code in effect for Project:
 - a. Wood-preservative-treated wood.
 - b. Fire-retardant-treated wood.
 - c. Engineered wood products.
 - d. Power-driven fasteners.
 - e. Powder-actuated fasteners.
 - f. Expansion anchors.
 - g. Metal framing anchors.

E. Quality Assurance

1. Forest Certification: For the following wood products, provide materials produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship":
 - a. Dimension lumber framing.
 - b. Timber.
 - c. Laminated-veneer lumber.
 - d. Parallel-strand lumber.
 - e. Prefabricated wood I-joists.
 - f. Rim boards.
 - g. Miscellaneous lumber.

F. Delivery, Storage, And Handling

1. Stack lumber flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.

1.2 PRODUCTS

A. Wood Products, General

1. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
 - a. Factory mark each piece of lumber with grade stamp of grading agency.
 - b. For exposed lumber indicated to receive a stained or natural finish, mark grade stamp on end or back of each piece or omit grade stamp and provide certificates of grade compliance issued by grading agency.
 - c. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.
 - d. Provide dressed lumber, S4S, unless otherwise indicated.



2. Engineered Wood Products: Provide engineered wood products acceptable to authorities having jurisdiction and for which current model code research or evaluation reports exist that show compliance with building code in effect for Project.
 - a. Allowable Design Stresses: Provide engineered wood products with allowable design stresses, as published by manufacturer, that meet or exceed those indicated. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency.
- B. Wood-Preservative-Treated Lumber
 1. Preservative Treatment by Pressure Process: AWPA C2, except that lumber that is not in contact with the ground and is continuously protected from liquid water may be treated according to AWPA C31 with inorganic boron (SBX).
 - a. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.
 - b. For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not require incising, contain colorants, bleed through, or otherwise adversely affect finishes.
 2. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or does not comply with requirements for untreated material.
 3. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
 - a. For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece or omit marking and provide certificates of treatment compliance issued by inspection agency.
 4. Application: Treat all rough carpentry, unless otherwise indicated, **OR** items indicated on Drawings, and the following, **as directed**:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
 - b. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.
 - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
 - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
 - e. Wood floor plates that are installed over concrete slabs-on-grade.
- C. Fire-Retardant-Treated Materials
 1. General: Comply with performance requirements in AWPA C20 (lumber) and AWPA C27 (plywood).
 - a. Use Exterior type for exterior locations and where indicated.
 - b. Use Interior Type A, High Temperature (HT) for enclosed roof framing, framing in attic spaces, and where indicated.
 - c. Use Interior Type A, unless otherwise indicated.
 2. Identify fire-retardant-treated wood with appropriate classification marking of testing and inspecting agency acceptable to authorities having jurisdiction.
 - a. For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece or omit marking and provide certificates of treatment compliance issued by inspection agency.
 3. For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not bleed through, contain colorants, or otherwise adversely affect finishes.
 4. Application: Treat all rough carpentry, unless otherwise indicated, **OR** items indicated on Drawings, and the following, **as directed**:
 - a. Framing for raised platforms.
 - b. Concealed blocking.
 - c. Framing for non-load-bearing partitions.



- d. Framing for non-load-bearing exterior walls.
- e. Roof construction.
- f. Plywood backing panels.

D. Dimension Lumber Framing

1. Maximum Moisture Content: 15 percent **OR** 19 percent **OR** 15 percent for 2-inch nominal (38-mm actual) thickness or less, 19 percent for more than 2-inch nominal (38-mm actual) thickness **OR** 15 percent for 2-inch nominal (38-mm actual) thickness or less, no limit for more than 2-inch nominal (38-mm actual) thickness **OR** 19 percent for 2-inch nominal (38-mm actual) thickness or less, no limit for more than 2-inch nominal (38-mm actual) thickness, **as directed**.
2. Non-Load-Bearing Interior Partitions: Construction or No. 2 **OR** Construction, Stud, or No. 3 **OR** Standard, Stud, or No. 3, **as directed**, grade of any species.
3. Exterior and Load-Bearing Walls **OR** Framing Other Than Non-Load-Bearing Interior Partitions **OR** Framing Other Than Interior Partitions, **as directed**: Any species and grade with a modulus of elasticity of at least 1,500,000 psi (10 350 MPa) **OR** 1,300,000 psi (8970 MPa) **OR** 1,100,000 psi (7590 MPa) **OR** 1,000,000 psi (6900 MPa) **OR** 900,000 psi (6210 MPa), **as directed**, and an extreme fiber stress in bending of at least 1000 psi (6.9 MPa) **OR** 850 psi (5.86 MPa) **OR** 700 psi (4.83 MPa) **OR** 600 psi (4.14 MPa) **OR** 500 psi (3.45 MPa), **as directed**, for 2-inch nominal (38-mm actual) thickness and 12-inch nominal (286-mm actual) width for single-member use.
4. Ceiling Joists (Non-Load-Bearing): Construction or No. 2 **OR** Construction, Stud, or No. 3 **OR** Standard, Stud, or No. 3, **as directed**, grade of any species.
5. Joists, Rafters, and Other Framing Not Listed Above: Any species and grade with a modulus of elasticity of at least 1,500,000 psi (10 350 MPa) **OR** 1,300,000 psi (8970 MPa) **OR** 1,100,000 psi (7590 MPa) **OR** 1,000,000 psi (6900 MPa) **OR** 900,000 psi (6210 MPa), **as directed**, and an extreme fiber stress in bending of at least 1000 psi (6.9 MPa) **OR** 850 psi (5.86 MPa) **OR** 700 psi (4.83 MPa) **OR** 600 psi (4.14 MPa) **OR** 500 psi (3.45 MPa), **as directed**, for 2-inch nominal (38-mm actual) thickness and 12-inch nominal (286-mm actual) width for single-member use.
6. Exposed Exterior **OR** Interior, **as directed**, Framing Indicated to Receive a Stained or Natural Finish: Provide material hand-selected for uniformity of appearance and freedom from characteristics, on exposed surfaces and edges, that would impair finish appearance, including decay, honeycomb, knot-holes, shake, splits, torn grain, and wane.
 - a. Species and Grade: As indicated above for load-bearing construction of same type.
 - b. Species and Grade: Hem-fir (north), Select Structural **OR** No. 1, **as directed**, grade; NLGA.
 - c. Species and Grade: Southern pine, Select Structural **OR** No. 1 **OR** No. 2, **as directed**, grade; SPIB.
 - d. Species and Grade: Douglas fir-larch; Select Structural **OR** No. 1, **as directed**, grade; WCLIB, or WWPA.
 - e. Species and Grade: Mixed southern pine, Select Structural **OR** No. 1 **OR** No. 2, **as directed**, grade; SPIB.
 - f. Species and Grade: Spruce-pine-fir, Select Structural **OR** No. 1, **as directed**, grade; NLGA.
 - g. Species and Grade: Douglas fir-south; Select Structural **OR** No. 1, **as directed**, grade; WWPA.
 - h. Species and Grade: Hem-fir; Select Structural **OR** No. 1, **as directed**, grade; WCLIB, or WWPA.
 - i. Species and Grade: Douglas fir-larch (north); Select Structural **OR** No. 1, **as directed**, grade; NLGA.
 - j. Species and Grade: Spruce-pine-fir (south), Select Structural **OR** No. 1, **as directed**, grade; NeLMA, WCLIB, or WWPA.
 - k. Species and Grade: Eastern hemlock-balsam fir or eastern hemlock-tamarack; Select Structural **OR** No. 1, **as directed**, grade; NeLMA.
 - l. Species and Grade: Beech-birch-hickory, Select Structural **OR** No. 1, **as directed**, grade; NeLMA.



- m. Species and Grade: Northern red oak, Select Structural **OR** No. 1, **as directed**, grade; NeLMA.
 - n. Species and Grade: Redwood, Clear Heart Structural **OR** Clear Structural **OR** Select Structural **OR** No. 1, **as directed**, grade; RIS.
 - o. Species and Grade: Mixed oak, Select Structural **OR** No. 1, **as directed**, grade; NeLMA.
 - p. Species and Grade: Mixed maple, Select Structural **OR** No. 1, **as directed**, grade; NeLMA.
 - q. Species and Grade: Western cedars, Select Structural **OR** No. 1, **as directed**, grade; WCLIB, or WWPA.
- E. Timber Framing
- 1. Provide timber framing complying with the following requirements, according to grading rules of grading agency indicated:
 - a. Species and Grade: Douglas fir-larch, Douglas fir-larch (north), or Douglas fir-south; Select Structural **OR** No. 1, **as directed**, grade; NLGA, WCLIB, or WWPA.
 - b. Species and Grade: Eastern hemlock, eastern hemlock-tamarack, or eastern hemlock-tamarack (north); Select Structural **OR** No. 1, **as directed**, grade; NeLMA or NLGA.
 - c. Species and Grade: Hem-fir or hem-fir (north), Select Structural **OR** No. 1, **as directed**, grade; NLGA, WCLIB, or WWPA.
 - d. Species and Grade: Mixed maple, Select Structural **OR** No. 1, **as directed**, grade; NeLMA.
 - e. Species and Grade: Mixed oak, Select Structural **OR** No. 1, **as directed**, grade; NeLMA.
 - f. Species and Grade: Southern pine, Select Structural **OR** No. 1, **as directed**, grade; SPIB.
 - g. Maximum Moisture Content: 20 **OR** 23, **as directed**, percent.
 - h. Additional Restriction: Free of heart centers.
- F. Engineered Wood Products
- 1. Laminated-Veneer Lumber: Structural composite lumber made from wood veneers with grain primarily parallel to member lengths, evaluated and monitored according to ASTM D 5456 and manufactured with an exterior-type adhesive complying with ASTM D 2559 and containing no urea formaldehyde.
 - a. Extreme Fiber Stress in Bending, Edgewise: 3100 psi (21.3 MPa) **OR** 2900 psi (20.0 MPa) **OR** 2600 psi (17.9 MPa) **OR** 2250 psi (15.5 MPa), **as directed**, for 12-inch nominal- (286-mm actual-) depth members.
 - b. Modulus of Elasticity, Edgewise: 2,000,000 psi (13 700 MPa) **OR** 1,800,000 psi (12 400 MPa) **OR** 1,500,000 psi (10 300 MPa), **as directed**.
 - 2. Parallel-Strand Lumber: Structural composite lumber made from wood strand elements with grain primarily parallel to member lengths, evaluated and monitored according to ASTM D 5456 and manufactured with an exterior-type adhesive complying with ASTM D 2559 and containing no urea formaldehyde.
 - a. Extreme Fiber Stress in Bending, Edgewise: 2900 psi (20 MPa) for 12-inch nominal- (286-mm actual-) depth members.
 - b. Modulus of Elasticity, Edgewise: 2,200,000 psi (15 100 MPa).
 - 3. Wood I-Joists: Prefabricated units, I-shaped in cross section, made with solid or structural composite lumber flanges and wood-based structural panel webs, let into and bonded to flanges. Provide units complying with material requirements of and with structural capacities established and monitored according to ASTM D 5055.
 - a. Provide I-joists manufactured without urea formaldehyde.
 - b. Web Material: Either oriented strand board or plywood, complying with DOC PS 1 or DOC PS 2, Exposure 1 **OR** Plywood, complying with DOC PS 1 or DOC PS 2, Exposure 1 **OR** Plywood, complying with DOC PS 1, Exterior grade, **as directed**.
 - c. Structural Properties: Provide units with depths and design values not less than those indicated.
 - d. Provide units complying with APA PRI-400, factory marked with APA trademark indicating nominal joist depth, joist class, span ratings, mill identification, and compliance with APA standard.



4. Rim Boards: Product designed to be used as a load-bearing member and to brace wood I-joists at bearing ends, complying with research/evaluation report for I-joists.
 - a. Manufacturer: Provide products by same manufacturer as I-joists.
 - b. Material: All-veneer product **OR** glued-laminated wood **OR** product made from any combination solid lumber, wood strands, and veneers, **as directed**. Provide rim boards made without urea formaldehyde.
 - c. Thickness: 1 inch (25 mm) **OR** 1-1/8 inches (28 mm) **OR** 1-1/4 inches (32 mm), **as directed**.
 - d. Provide performance-rated product complying with APA PRR-401, rim board **OR** rim board plus, **as directed**, grade, factory marked with APA trademark indicating thickness, grade, and compliance with APA standard.

G. Miscellaneous Lumber

1. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - a. Blocking.
 - b. Nailers.
 - c. Rooftop equipment bases and support curbs.
 - d. Cants.
 - e. Furring.
 - f. Grounds.
 - g. Utility shelving.
2. For items of dimension lumber size, provide Construction or No. 2 **OR** Standard, Stud, or No. 3, **as directed**, grade lumber with 15 **OR** 19, **as directed**, percent maximum moisture content of any species.
3. For items of dimension lumber size, provide Construction or No. 2 **OR** Standard, Stud, or No. 3, **as directed**, grade lumber with 15 **OR** 19, **as directed**, percent maximum moisture content and any of the following species:
 - a. Hem-fir (north); NLGA.
 - b. Mixed southern pine; SPIB.
 - c. Spruce-pine-fir; NLGA.
 - d. Hem-fir; WCLIB, or WWPA.
 - e. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.
 - f. Western woods; WCLIB or WWPA.
 - g. Northern species; NLGA.
 - h. Eastern softwoods; NeLMA.
4. For exposed boards, provide lumber with 15 **OR** 19, **as directed**, percent maximum moisture content and any of the following species and grades:
 - a. Eastern white pine, Idaho white, lodgepole, ponderosa, or sugar pine; Premium or 2 Common (Sterling) **OR** Standard or No. 3 Common, **as directed**, grade; NeLMA, NLGA, WCLIB, or WWPA.
 - b. Mixed southern pine, No. 1 **OR** 2, **as directed**, grade; SPIB.
 - c. Hem-fir or hem-fir (north), Select Merchantable or No. 1 Common **OR** Construction or No. 2 Common, **as directed**, grade; NLGA, WCLIB, or WWPA.
 - d. Spruce-pine-fir (south) or spruce-pine-fir, Select Merchantable or No. 1 Common **OR** Construction or No. 2 Common, **as directed**, grade; NeLMA, NLGA, WCLIB, or WWPA.
5. For concealed boards, provide lumber with 15 **OR** 19, **as directed**, percent maximum moisture content and any of the following species and grades:
 - a. Mixed southern pine, No. 2 **OR** 3, **as directed**, grade; SPIB.
 - b. Hem-fir or hem-fir (north), Construction or 2 Common **OR** Standard or 3 Common, **as directed**, grade; NLGA, WCLIB, or WWPA.
 - c. Spruce-pine-fir (south) or spruce-pine-fir, Construction or 2 Common **OR** Standard or 3 Common, **as directed**, grade; NeLMA, NLGA, WCLIB, or WWPA.
 - d. Eastern softwoods, No. 2 **OR** 3, **as directed**, Common grade; NeLMA.
 - e. Northern species, No. 2 **OR** 3, **as directed**, Common grade; NLGA.



- f. Western woods, Construction or No. 2 Common **OR** Standard or No. 3 Common, **as directed**, grade; WCLIB or WWPA.
 6. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.
 7. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.
 8. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.
- H. Plywood Backing Panels
1. Telephone and Electrical Equipment Backing Panels: DOC PS 1, Exposure 1, C-D Plugged, fire-retardant treated, **as directed**, in thickness indicated or, if not indicated, not less than 1/2-inch (13-mm) nominal thickness.
- I. Fasteners
1. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.
 - a. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M **OR** of Type 304 stainless steel, **as directed**.
 2. Nails, Brads, and Staples: ASTM F 1667.
 3. Power-Driven Fasteners: NES NER-272.
 4. Wood Screws: ASME B18.6.1.
 5. Lag Bolts: ASME B18.2.1 (ASME B18.2.3.8M).
 6. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where indicated, flat washers.
 7. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.
 - a. Material:
 - 1) Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.
OR
Stainless steel with bolts and nuts complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2 (ASTM F 738M and ASTM F 836M, Grade A1 or A4).
- J. Metal Framing Anchors
1. Allowable Design Loads: Provide products with allowable design loads, as published by manufacturer, that meet or exceed those indicated **OR** of basis-of-design products, **as directed**. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency.
 2. Galvanized Steel Sheet: Hot-dip, zinc-coated steel sheet complying with ASTM A 653/A 653M, G60 (Z180) coating designation.
 - a. Use for interior locations where stainless steel is not indicated.
 3. Stainless-Steel Sheet: ASTM A 666, Type 304 **OR** 316, **as directed**.
 - a. Use for exterior locations and where indicated.
 4. Joist Hangers: U-shaped joist hangers with 2-inch- (50-mm-) long seat and 1-1/4-inch- (32-mm-) wide nailing flanges at least 85 percent of joist depth.
 5. I-Joist Hangers: U-shaped joist hangers with 2-inch- (50-mm-) long seat and 1-1/4-inch- (32-mm-) wide nailing flanges full depth of joist. Nailing flanges provide lateral support at joist top chord.
 6. Top Flange Hangers: U-shaped joist hangers, full depth of joist, formed from metal strap with tabs bent to extend over and be fastened to supporting member.
 7. Bridging: Rigid, V-section, nailless type, 0.050 inch (1.3 mm) thick, length to suit joist size and spacing.



8. Post Bases: Adjustable-socket type for bolting in place with standoff plate to raise post 1 inch (25 mm) above base and with 2-inch- (50-mm-) minimum side cover, socket 0.062 inch (1.6 mm) thick, and standoff and adjustment plates 0.108 inch (2.8 mm) thick.
9. Joist Ties: Flat straps, with holes for fasteners, for tying joists together over supports.
10. Rafter Tie-Downs: Bent strap tie for fastening rafters or roof trusses to wall studs below, 1-1/2 inches (38 mm) wide by 0.050 inch (1.3 mm) thick. Tie fastens to side of rafter or truss, face of top plates, and side of stud below.
11. Rafter Tie-Downs (Hurricane or Seismic Ties): Bent strap tie for fastening rafters or roof trusses to wall studs below, 2-1/4 inches (57 mm) wide by 0.062 inch (1.6 mm) thick. Tie fits over top of rafter or truss and fastens to both sides of rafter or truss, face of top plates, and side of stud below.
12. Floor-to-Floor Ties: Flat straps, with holes for fasteners, for tying upper floor wall studs to band joists and lower floor studs, 1-1/4 inches (32 mm) wide by 0.050 inch (1.3 mm) thick by 36 inches (914 mm) long.
13. Hold-Downs: Brackets for bolting to wall studs and securing to foundation walls with anchor bolts or to other hold-downs with threaded rods and designed with first of two bolts placed seven bolt diameters from reinforced base.
14. Wall Bracing:
 - a. T-shaped bracing made for letting into studs in saw kerf, 1-1/8 inches (29 mm) wide by 9/16 inch (14 mm) deep by 0.034 inch (0.85 mm) thick with hemmed edges.

OR

Wall Bracing: Angle bracing made for letting into studs in saw kerf, 15/16 by 15/16 by 0.040 inch (24 by 24 by 1 mm) thick with hemmed edges.

K. Miscellaneous Materials

1. Sill-Sealer Gaskets:
 - a. Glass-fiber-resilient insulation, fabricated in strip form, for use as a sill sealer; 1-inch (25-mm) nominal thickness, compressible to 1/32 inch (0.8 mm); selected from manufacturer's standard widths to suit width of sill members indicated.

OR

Closed-cell neoprene foam, 1/4 inch (6.4 mm) thick, selected from manufacturer's standard widths to suit width of sill members indicated.
2. Adhesives for Gluing Furring and Sleepers to Concrete or Masonry: Formulation complying with ASTM D 3498 that is approved for use indicated by adhesive manufacturer.
 - a. Use adhesives that have a VOC content of 70 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Water-Repellent Preservative: NWWDA-tested and -accepted formulation containing 3-iodo-2-propynyl butyl carbamate, combined with an insecticide containing chloropyrifos as its active ingredient.

1.3 EXECUTION

A. Installation, General

1. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.
2. Framing Standard: Comply with AF&PA's "Details for Conventional Wood Frame Construction," unless otherwise indicated.
3. Framing with Engineered Wood Products: Install engineered wood products to comply with manufacturer's written instructions.
4. Metal Framing Anchors: Install metal framing to comply with manufacturer's written instructions.
5. Do not splice structural members between supports, unless otherwise indicated.



6. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.
 - a. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches (406 mm) o.c.
 7. Provide fire blocking in furred spaces, stud spaces, and other concealed cavities as indicated and as follows:
 - a. Fire block furred spaces of walls, at each floor level, at ceiling, and at not more than 96 inches (2438 mm) o.c. with solid wood blocking or noncombustible materials accurately fitted to close furred spaces.
 - b. Fire block concealed spaces of wood-framed walls and partitions at each floor level, at ceiling line of top story, and at not more than 96 inches (2438 mm) o.c. Where fire blocking is not inherent in framing system used, provide closely fitted solid wood blocks of same width as framing members and 2-inch nominal- (38-mm actual-) thickness.
 - c. Fire block concealed spaces between floor sleepers with same material as sleepers to limit concealed spaces to not more than 100 sq. ft. (9.3 sq. m) and to solidly fill space below partitions.
 - d. Fire block concealed spaces behind combustible cornices and exterior trim at not more than 20 feet (6 m) o.c.
 8. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
 9. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.
 - a. Use inorganic boron for items that are continuously protected from liquid water.
 - b. Use copper naphthenate for items not continuously protected from liquid water.
 10. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
 - a. NES NER-272 for power-driven fasteners.
 - b. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code.
 - c. "Nailing Schedule," and Tables in Section 2304, of ICC's International Building Code.
 - d. Table 2306.1, "Fastening Schedule," in SBCCI's Standard Building Code.
 - e. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.
 - f. Table 602.3(1), "Fastener Schedule for Structural Members," and Table 602.3(2), "Alternate Attachments," in ICC's International One- and Two-Family Dwelling Code.
 11. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood; do not countersink nail heads, unless otherwise indicated.
 12. For exposed work, arrange fasteners in straight rows parallel with edges of members, with fasteners evenly spaced, and with adjacent rows staggered.
 - a. Comply with approved **OR** indicated, **as directed**, fastener patterns where applicable. Before fastening, mark fastener locations, using a template made of sheet metal, plastic, or cardboard.
 - b. Use finishing nails, unless otherwise indicated. Do not countersink nail heads **OR** Countersink nail heads and fill holes with wood filler, **as directed**.
- B. Wood Ground, Sleeper, Blocking, And Nailer Installation
1. Install where indicated and where required for screeding or attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.
 2. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated.



3. Provide permanent grounds of dressed, pressure-preservative-treated, key-beveled lumber not less than 1-1/2 inches (38 mm) wide and of thickness required to bring face of ground to exact thickness of finish material. Remove temporary grounds when no longer required.

C. Wood Furring Installation

1. Install level and plumb with closure strips at edges and openings. Shim with wood as required for tolerance of finish work.
2. Furring to Receive Plywood or Hardboard Paneling: Install 1-by-3-inch nominal- (19-by-63-mm actual-) size furring horizontally **OR** vertically **OR** horizontally and vertically, **as directed**, at 24 inches (610 mm) **OR** 600 mm, **as directed**, o.c.
3. Furring to Receive Gypsum Board **OR** Plaster Lath, **as directed**: Install 1-by-2-inch nominal- (19-by-38-mm actual-) size furring vertically at 16 inches (406 mm) **OR** 400 mm, **as directed**, o.c.

D. Wall And Partition Framing Installation

1. General: Provide single bottom plate and double top plates using members of 2-inch nominal (38-mm actual) thickness whose widths equal that of studs, except single top plate may be used for non-load-bearing partitions and for load-bearing partitions where framing members bearing on partition are located directly over studs. Fasten plates to supporting construction, unless otherwise indicated.
 - a. For exterior walls, provide 2-by-6-inch nominal- (38-by-140-mm actual-) **OR** 2-by-4-inch nominal- (38-by-89-mm actual-), **as directed**, size wood studs spaced 24 inches (610 mm) **OR** 16 inches (406 mm) **OR** 600 mm **OR** 400 mm, **as directed**, o.c., unless otherwise indicated.
 - b. For interior partitions and walls, provide 2-by-6-inch nominal- (38-by-140-mm actual-) **OR** 2-by-4-inch nominal- (38-by-89-mm actual-) **OR** 2-by-3-inch nominal- (38-by-64-mm actual-), **as directed**, size wood studs spaced 24 inches (610 mm) **OR** 16 inches (406 mm) **OR** 600 mm **OR** 400 mm, **as directed**, o.c., unless otherwise indicated.
 - c. Provide continuous horizontal blocking at midheight of partitions more than 96 inches (2438 mm) high, using members of 2-inch nominal (38-mm actual) thickness and of same width as wall or partitions.
2. Construct corners and intersections with three or more studs, except that two studs may be used for interior non-load-bearing partitions.
3. Frame openings with multiple studs and headers. Provide nailed header members of thickness equal to width of studs. Support headers on jamb studs.
 - a. For non-load-bearing partitions, provide double-jamb studs and headers not less than 4-inch nominal (89-mm actual) depth for openings 48 inches (1200 mm) and less in width, 6-inch nominal (140-mm actual) depth for openings 48 to 72 inches (1200 to 1800 mm) in width, 8-inch nominal (184-mm actual) depth for openings 72 to 120 inches (1800 to 3000 mm) in width, and not less than 10-inch nominal (235-mm actual) depth for openings 10 to 12 feet (3 to 3.6 m) in width.
 - b. For load-bearing walls, provide double-jamb studs for openings 60 inches (1500 mm) and less in width, and triple-jamb studs for wider openings. Provide headers of depth indicated or, if not indicated, according to Table R502.5(1) or Table R502.5(2), as applicable, in ICC's International Residential Code for One- and Two-Family Dwellings.
4. Provide diagonal bracing in exterior walls, at both walls of each external corner **OR** walls, at locations indicated, **as directed**, at 45-degree angle, full-story height, unless otherwise indicated. Use 1-by-4-inch nominal- (19-by-89-mm actual-) size boards, let-in flush with faces of studs **OR** metal wall bracing, let into studs in saw kerf, **as directed**.

E. Floor Joist Framing Installation

1. General: Install floor joists with crown edge up and support ends of each member with not less than 1-1/2 inches (38 mm) of bearing on wood or metal, or 3 inches (76 mm) on masonry. Attach floor joists as follows:
 - a. Where supported on wood members, by toe nailing or by using metal framing anchors.



- b. Where framed into wood supporting members, by using wood ledgers as indicated or, if not indicated, by using metal joist hangers.
 2. Fire Cuts: At joists built into masonry, bevel cut ends 3 inches (76 mm) and do not embed more than 4 inches (102 mm).
 3. Frame openings with headers and trimmers supported by metal joist hangers; double headers and trimmers where span of header exceeds 48 inches (1200 mm).
 4. Do not notch in middle third of joists; limit notches to one-sixth depth of joist, one-third at ends. Do not bore holes larger than 1/3 depth of joist; do not locate closer than 2 inches (50 mm) from top or bottom.
 5. Provide solid blocking of 2-inch nominal (38-mm actual) thickness by depth of joist at ends of joists unless nailed to header or band.
 6. Lap members framing from opposite sides of beams, girders, or partitions not less than 4 inches (102 mm) or securely tie opposing members together. Provide solid blocking of 2-inch nominal (38-mm actual) thickness by depth of joist over supports.
 7. Anchor members paralleling masonry with 1/4-by-1-1/4-inch (6.4-by-32-mm) metal strap anchors spaced not more than 96 inches (2438 mm) o.c., extending over and fastening to 3 joists. Embed anchors at least 4 inches (102 mm) into grouted masonry with ends bent at right angles and extending 4 inches (102 mm) beyond bend.
 8. Provide solid blocking between joists under jamb studs for openings.
 9. Under non-load-bearing partitions, provide double joists separated by solid blocking equal to depth of studs above.
 - a. Provide triple joists separated as above, under partitions receiving ceramic tile and similar heavy finishes or fixtures.
 10. Provide bridging of type indicated below, at intervals of 96 inches (2438 mm) o.c., between joists.
 - a. Diagonal wood bridging formed from bevel-cut, 1-by-3-inch nominal- (19-by-64-mm actual-) size lumber, double-crossed and nailed at both ends to joists.
 - b. Steel bridging installed to comply with bridging manufacturer's written instructions.
- F. Ceiling Joist And Rafter Framing Installation
 1. Ceiling Joists: Install ceiling joists with crown edge up and complying with requirements specified above for floor joists. Face nail to ends of parallel rafters.
 - a. Where ceiling joists are at right angles to rafters, provide additional short joists parallel to rafters from wall plate to first joist; nail to ends of rafters and to top plate and nail to first joist or anchor with framing anchors or metal straps. Provide 1-by-8-inch nominal- (19-by-184-mm actual-) size or 2-by-4-inch nominal- (38-by-89-mm actual-) size stringers spaced 48 inches (1200 mm) o.c. crosswise over main ceiling joists.
 2. Rafters: Notch to fit exterior wall plates and toe nail or use metal framing anchors. Double rafters to form headers and trimmers at openings in roof framing, if any, and support with metal hangers. Where rafters abut at ridge, place directly opposite each other and nail to ridge member or use metal ridge hangers.
 - a. At valleys, provide double-valley rafters of size indicated or, if not indicated, of same thickness as regular rafters and 2 inches (50 mm) deeper. Bevel ends of jack rafters for full bearing against valley rafters.
 - b. At hips, provide hip rafter of size indicated or, if not indicated, of same thickness as regular rafters and 2 inches (50 mm) deeper. Bevel ends of jack rafters for full bearing against hip rafter.
 3. Provide collar beams (ties) as indicated or, if not indicated, provide 1-by-6-inch nominal- (19-by-140-mm actual-) size boards between every third pair of rafters, but not more than 48 inches (1219 mm) o.c. Locate below ridge member, at third point of rafter span. Cut ends to fit roof slope and nail to rafters.
 4. Provide special framing as indicated for eaves, overhangs, dormers, and similar conditions, if any.
- G. Timber Framing Installation



1. Install timber with crown edge up and provide not less than 4 inches (102 mm) of bearing on supports. Provide continuous members, unless otherwise indicated; tie together over supports as indicated if not continuous.
2. Where beams or girders are framed into pockets of exterior concrete or masonry walls, provide 1/2-inch (13-mm) air space at sides and ends of wood members.
3. Install wood posts using metal anchors indicated.
4. Treat ends of timber beams and posts exposed to weather by dipping in water-repellent preservative for 15 minutes.

H. Stair Framing Installation

1. Provide stair framing members of size, space, and configuration indicated or, if not indicated, to comply with the following requirements:
 - a. Stringer Size: 2-by-12-inch nominal- (38-by-286-mm actual-) size, minimum.
 - b. Stringer Material: Laminated-veneer lumber **OR** parallel-strand lumber **OR** solid lumber, **as directed**.
 - c. Notching: Notch stringers to receive treads, risers, and supports; leave at least 3-1/2 inches (89 mm) of effective depth.
 - d. Stringer Spacing: At least 3 stringers for each 36-inch (914-mm) clear width of stair.
2. Provide stair framing with no more than 3/16-inch (4.7-mm) variation between adjacent treads and risers and no more than 3/8-inch (9.5-mm) variation between largest and smallest treads and risers within each flight.

I. Protection

1. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.
2. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION 07 26 13 00

**SECTION 07 41 13 00 - METAL ROOF PANELS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for metal roof panels. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Exposed-fastener, lap-seam metal roof panels.
 - b. Concealed-fastener, lap-seam metal roof panels.
 - c. Standing-seam metal roof panels.
 - d. Batten-seam metal roof panels.
 - e. Horizontal-seam (Bermuda-type) metal roof panels.
 - f. Foamed-insulation-core metal roof panels.
 - g. Metal soffit panels.

C. Definitions

1. Metal Roof Panel Assembly: Metal roof panels, attachment system components, miscellaneous metal framing, thermal insulation, and accessories necessary for a complete weathertight roofing system.

D. Performance Requirements

1. General Performance: Metal roof panels shall comply with performance requirements without failure due to defective manufacture, fabrication, installation, or other defects in construction.
2. Delegated Design: Design metal roof panel assembly, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Air Infiltration: Air leakage through assembly of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) of roof area when tested according to ASTM E 1680 at the following test-pressure difference:
 - a. Test-Pressure Difference (for roofs with slopes of 30 degrees or less): Negative 1.57 lbf/sq. ft. (75 Pa).
 - b. Test-Pressure Difference (for roofs with slopes steeper than 30 degrees): Positive and negative 1.57 lbf/sq. ft. (75 Pa).
 - c. Positive Preload Test-Pressure Difference: Greater than or equal to 15.0 lbf/sq. ft. (720 Pa) and the greater of 75 percent of building live load or 50 percent of building design positive wind-pressure difference.
 - d. Negative Preload Test-Pressure Difference: 50 percent of design wind-uplift-pressure difference.
4. Water Penetration: No water penetration when tested according to ASTM E 1646 at the following test-pressure difference:
 - a. Test-Pressure Difference (for roofs with slopes of 30 degrees or less): 2.86 lbf/sq. ft. (137 Pa).
 - b. Test-Pressure Difference (for roofs with slopes steeper than 30 degrees): 20 percent of positive design wind pressure, but not less than 6.24 lbf/sq. ft. (300 Pa) and not more than 12.0 lbf/sq. ft. (575 Pa).
 - c. Positive Preload Test-Pressure Difference: Greater than or equal to 15.0 lbf/sq. ft. (720 Pa) and the greater of 75 percent of building live load or 50 percent of building design positive wind-pressure difference.
 - d. Negative Preload Test-Pressure Difference: 50 percent of design wind-uplift-pressure difference.



5. Hydrostatic-Head Resistance: No water penetration when tested according to ASTM E 2140.
6. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for wind-uplift-resistance class indicated.
 - a. Uplift Rating: UL 30 **OR** UL 60 **OR** UL 90, **as directed**.
7. FMG Listing: Provide metal roof panels and component materials that comply with requirements in FMG 4471 as part of a panel roofing system and that are listed in FMG's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FMG markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120, **as directed**.
 - b. Hail Resistance: MH **OR** SH, **as directed**.
8. Structural Performance: Provide metal roof panel assemblies capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated, based on testing according to ASTM E 1592:
 - a. Wind Loads: Determine loads based on the following minimum design wind pressures:
 - 1) Uniform pressure of 20 lbf/sq. ft. (957 Pa) **OR** 30 lbf/sq. ft. (1436 Pa), **as directed**, acting inward or outward.
OR
Uniform pressure as indicated on Drawings.
 - b. Snow Loads: 25 lbf/sq. ft. (1197 Pa) **OR** 30 lbf/sq. ft. (1436 Pa) **OR** 35 lbf/sq. ft. (1676 Pa), **as directed**.
 - c. Deflection Limits: Metal roof panel assemblies shall withstand wind and snow loads with vertical deflections no greater than 1/180 **OR** 1/240, **as directed**, of the span.
9. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
10. Thermal Performance: Provide insulated metal roof panel assemblies with thermal-resistance value (R-value) indicated when tested according to ASTM C 518.
11. Energy Performance
 - a. Provide roof panels with solar reflectance index not less than 78 **OR** 29, **as directed**, when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.
OR
Energy Performance: Provide roof panels that are listed on the U.S. Department of Energy's ENERGY STAR Roof Products Qualified Product List for low-slope **OR** steep-slope, **as directed**, roof products.
OR
Energy Performance: Provide roof panels with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC-1.

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Test Reports for Credit SS 7.2: For roof panels, indicating that panels comply with solar reflectance index requirement.
 - b. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: Indicating percentages by weight of postconsumer and preconsumer recycled content for products having recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
3. Shop Drawings: Show fabrication and installation layouts of metal roof panels; details of edge conditions, side-seam and endlap joints, panel profiles, corners, anchorages, trim, flashings, closures, and accessories; and special details. Distinguish between factory- and field-assembled work.
4. Samples: For each type of exposed finish required.



5. Delegated-Design Submittal: For metal roof panel assembly indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Snow Retention System Calculations: Include calculation of number and location of snow guards based on snow load, roof slope, panel length and finish, and seam type and spacing.
 6. Coordination Drawings: Roof plans, drawn to scale, based on input from installers of the items involved.
 7. Manufacturer Certificates: Signed by manufacturer certifying that roof panels comply with energy performance requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of meeting performance requirements.
 8. Product test reports.
 9. Field quality-control reports.
 10. Maintenance data.
 11. Warranties: Samples of special warranties.
- F. Quality Assurance
1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
 2. Surface-Burning Characteristics: Provide metal roof panels having insulation core material with the following surface-burning characteristics as determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 450 or less.
 3. Fire-Resistance Ratings: Where indicated, provide metal roof panels identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.
 - b. Combustion Characteristics: ASTM E 136.
 4. Preinstallation Conference: Conduct conference at Project site.
- G. Delivery, Storage, And Handling
1. Deliver components, sheets, metal roof panels, and other manufactured items so as not to be damaged or deformed. Package metal roof panels for protection during transportation and handling.
 2. Unload, store, and erect metal roof panels in a manner to prevent bending, warping, twisting, and surface damage.
 3. Stack metal roof panels on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal roof panels to ensure dryness. Do not store metal roof panels in contact with other materials that might cause staining, denting, or other surface damage.
 4. Protect strippable protective covering on metal roof panels from exposure to sunlight and high humidity, except to extent necessary for period of metal roof panel installation.
 5. Protect foam-plastic insulation as follows:
 - a. Do not expose to sunlight, except to extent necessary for period of installation and concealment.
 - b. Protect against ignition at all times. Do not deliver foam-plastic insulation materials to Project site before installation time.
 - c. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.
- H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace metal roof panel assemblies that fail in materials or workmanship within two years from date of Final Completion.



2. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal roof panels that show evidence of deterioration of factory-applied finishes within 10 **OR** 20, **as directed**, years from date of Final Completion.
3. Special Weathertightness Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace metal roof panel assemblies that fail to remain weathertight, including leaks, within five **OR** 10, **as directed**, years from date of Final Completion.
4. Special Weathertightness Warranty for Standing-Seam Metal Roof Panels: Manufacturer's standard form in which manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that fail to remain weathertight, including leaks, within 20 years from date of Final Completion.

1.2 PRODUCTS

A. Panel Materials

1. Metallic-Coated Steel Sheet: Restricted flatness steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Recycled Content: Provide steel sheet with average recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
 - b. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - c. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - d. Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 - e. Exposed Coil-Coated Finish:
 - 1) 2-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) 3-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) 4-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 4) Mica Fluoropolymer: AAMA 621. 2-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 5) Metallic Fluoropolymer: AAMA 621. 3-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 6) FEVE Fluoropolymer: AAMA 621. 2-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 7) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mil (0.97 mm) for topcoat.



- f. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
2. Aluminum Sheet: Coil-coated sheet, ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.
 - a. Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 - b. Exposed Coil-Coated Finish:
 - 1) 2-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) 3-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) 4-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 4) Mica Fluoropolymer: AAMA 620. 2-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 5) Metallic Fluoropolymer: AAMA 620. 3-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 6) FEVE Fluoropolymer: AAMA 620. 2-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 7) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mil (0.97 mm) for topcoat.
 - c. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
3. Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 temper.
 - a. Exposed Finish: Apply the following finish, as specified or indicated on Drawings:
 - 1) Natural finish.
 - 2) Brushed Satin: CDA M32-06x (Mechanical Finish: directionally textured, medium satin; Coating: clear organic, air drying, as specified below):
 - 3) Mirror Polished: CDA M22-06x (Mechanical Finish: buffed, specular; Coating: clear organic, air drying, as specified below):
 - a) Clear, Organic Coating: Clear, air-drying, acrylic lacquer specially developed for coating copper-alloy products, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
 - 4) Pre-patinated: ASTM B 882. Copper sheets artificially aged by chemical reaction to convert surface to inorganic crystalline structure with color range and durability of naturally formed patina.
4. Panel Sealants:



- a. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
- b. Joint Sealant: ASTM C 920; elastomeric polyurethane, polysulfide, or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal roof panels and remain weathertight; and as recommended in writing by metal roof panel manufacturer.
- c. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

B. Field-Installed Thermal Insulation

1. Polyethylene Vapor Retarders: ASTM D 4397, 6 mils (0.15 mm) thick, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
2. Unfaced, Polyisocyanurate Board Insulation: ASTM C 591, Type II, compressive strength of 35 psi (240 kPa), with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, based on tests performed.
3. Faced, Polyisocyanurate Board Insulation: ASTM C 1289, Type I, Class 1 aluminum foil **OR** Type II, Class 1 or 2 felt or glass-fiber mat, Grade 3 **OR** Type V, oriented-strand-board facing, **as directed**, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, based on tests performed on unfaced core.
4. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.60-lb/cu. ft. (26-kg/cu. m) minimum density unless otherwise indicated; with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively.
5. Molded-Polystyrene Board Insulation: ASTM C 578, Type I, 0.9 lb/cu. ft. (15 kg/cu. m) **OR** Type II, 1.35 lb/cu. ft. (22 kg/cu. m), **as directed**, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively.
6. Unfaced, Glass-Fiber Board Insulation: ASTM C 612, Type IA or Types IA and IB; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; and with a nominal density of 3 lb/cu. ft. (48 kg/cu. m).
7. Mineral-Fiber-Blanket Insulation: ASTM C 665, type indicated below; consisting of fibers manufactured from glass, slag wool, or rock wool.
 - a. Type I (blankets without membrane covering), passing ASTM E 136 for combustion characteristics.
 - b. Type II (blankets with nonreflective membrane covering), Category 1 (membrane is a vapor retarder), Class A (membrane-faced surface with a flame-spread index of 25 or less).
 - c. Type III (blankets with reflective membrane covering), Category 1 (membrane is a vapor retarder), Class A (membrane-faced surface with a flame-spread index of 25 or less).
8. Metal Building Insulation: ASTM C 991, Type I, or NAIMA 202 **OR** ASTM C 991, Type II, **as directed**, glass-fiber-blanket insulation; 0.5-lb/cu. ft. (8-kg/cu. m) density; 2-inch- (50-mm-) wide, continuous, vapor-tight edge tabs; and with a flame-spread index of 25 or less.
 - a. Vapor-Retarder Facing: ASTM C 1136, with permeance not greater than 0.02 perm (1.15 ng/Pa x s x sq. m) when tested according to ASTM E 96, Desiccant Method:
 - 1) Composition: Polypropylene faced, scrim reinforced, and kraft-paper backing **OR** Foil faced, scrim reinforced, and kraft-paper backing with vapor-retarder coating **OR** Polypropylene faced, scrim reinforced, and foil backing **OR** Vinyl faced, scrim reinforced, and foil backing **OR** Vinyl faced, scrim reinforced, and polyester backing, **as directed**.
 - b. Insulation Retainer Strips: 0.019-inch- (0.48-mm-) thick, formed, galvanized-steel or PVC retainer clips colored to match insulation facing.
 - c. Thermal Spacer Blocks: Fabricated from extruded polystyrene, 1 inch (25 mm) thick.

C. Underlayment Materials

1. Self-Adhering, High-Temperature Sheet: 30 to 40 mils (0.76 to 1.0 mm) thick minimum, consisting of slip-resisting, polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
 - a. Thermal Stability: Stable after testing at 240 deg F (116 deg C); ASTM D 1970.



- b. Low-Temperature Flexibility: Passes after testing at minus 20 deg F (29 deg C); ASTM D 1970.
 2. Felts: ASTM D 226, Type II (No. 30) **OR** Type I (No. 15), **as directed**, asphalt-saturated organic felts.
 3. Slip Sheet: Manufacturer's recommended slip sheet, of type required for application.
- D. Substrate Boards
1. Gypsum Board: Type X, of thickness indicated, with water-resistant-treated core and with water-repellent paper bonded to core's face, back, and long edges. ASTM C 1396/C 1396M.
 2. Glass-Mat Gypsum Sheathing Board: ASTM C 1177/C 1177M; Regular, 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**.
 3. Perlite Board: ASTM C 728, 1 inch (25 mm) thick.
 4. Substrate-Board Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FMG 4470, designed for fastening substrate board to substrate.
- E. Miscellaneous Metal Framing
1. Miscellaneous Metal Framing, General: ASTM C 645, cold-formed metallic-coated steel sheet, ASTM A 653/A 653M, G40 (Z120) hot-dip galvanized **OR** ASTM A 653/A 653M, G60 (Z180) hot-dip galvanized, **as directed**, or coating with equivalent corrosion resistance unless otherwise indicated.
 2. Hat-Shaped, Rigid Furring Channels:
 - a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.025 inch (0.64 mm) **OR** 0.040 inch (1.02 mm), **as directed**.
 - b. Depth: As indicated **OR** 7/8 inch (22 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 3. Cold-Rolled Furring Channels: Minimum 1/2-inch- (13-mm-) wide flange.
 - a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.064 inch (1.63 mm), **as directed**.
 - b. Depth: As indicated **OR** 3/4 inch (19 mm), **as directed**.
 - c. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with nominal thickness of 0.040 inch (1.02 mm).
 - d. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.57-mm-) diameter wire, or double strand of 0.048-inch- (1.22-mm-) diameter wire.
 4. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches (32 mm), wall attachment flange of 7/8 inch (22 mm), and depth required to fit insulation thickness indicated.
 - a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.025 inch (0.64 mm), **as directed**.
 5. Fasteners for Miscellaneous Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten miscellaneous metal framing members to substrates.
- F. Miscellaneous Materials
1. Panel Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide exposed fasteners with heads matching color of metal roof panels by means of plastic caps or factory-applied coating. Provide EPDM, PVC, or neoprene sealing washers.
 2. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil (0.4-mm) dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.
- G. Exposed-Fastener, Lap-Seam Metal Roof Panels
1. General: Provide factory-formed metal roof panels designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps. Include accessories required for weathertight installation.
 2. Corrugated-Profile, Exposed-Fastener Metal Roof Panels: Formed with alternating curved ribs spaced at 2.67 inches (68 mm) o.c. across width of panel.



- a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by Architect from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by Architect from manufacturer's full range.
 - d. Panel Coverage: 21.3 inches (541 mm) **OR** 29.3 inches (744 mm) **OR** 34.67 inches (881 mm) **OR** 37.3 inches (947 mm) **OR** 42.67 inches (1084 mm) **OR** 45.3 inches (1151 mm), **as directed**.
 - e. Panel Height: 0.5 inch (13 mm) **OR** 0.875 inch (22 mm), **as directed**.
3. Tapered-Rib-Profile, Exposed-Fastener Metal Roof Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major ribs.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Major-Rib Spacing: 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** 9 inches (229 mm) **OR** 12 inches (305 mm), **as directed**, o.c.
 - f. Panel Coverage: 24 inches (610 mm) **OR** 36 inches (914 mm), **as directed**.
 - g. Panel Height: 0.625 inch (16 mm) **OR** 0.75 inch (19 mm) **OR** 1.0 inch (25 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.



4. Vee-Rib-Profile, Exposed-Fastener Metal Roof Panels: Formed with raised, V-shaped ribs and recesses that are approximately same size, evenly spaced across panel width, and with rib/recess sides angled at approximately 45 degrees.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Rib Spacing: 5.3 inches (135 mm) **OR** 7.2 inches (183 mm) **OR** 12 inches (305 mm), **as directed**, o.c.
 - e. Panel Coverage: 30 inches (762 mm) **OR** 32 inches (813 mm) **OR** 36 inches (914 mm) **OR** 40 inches (1016 mm), **as directed**.
 - f. Panel Height: 1.375 inches (35 mm) **OR** 1.5 inches (38 mm) **OR** 1.75 inches (44 mm) **OR** 2.0 inches (51 mm) **OR** 3.0 inches (76 mm), **as directed**.
5. Box-Rib-Profile, Exposed-Fastener Metal Roof Panels: Formed with raised, box-shaped ribs that are wider than recesses, evenly spaced across panel width, and with rib/recess sides angled 60 degrees or more.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Rib Spacing: 2.67 inches (68 mm) **OR** 4.0 inches (102 mm) **OR** 5.3 inches (135 mm) **OR** 6.0 inches (152 mm), **as directed**, o.c.
 - e. Panel Coverage: 24 inches (610 mm) **OR** 28 inches (711 mm) **OR** 30 inches (762 mm) **OR** 32 inches (813 mm) **OR** 36 inches (914 mm), **as directed**.



- f. Panel Height: 0.625 inch (16 mm) **OR** 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 2.0 inches (51 mm), **as directed**.
6. Deep-Box-Rib-Profile, Exposed-Fastener Metal Roof Panels: Formed with raised, box-shaped ribs that are wider than recesses, evenly spaced across panel width, and with rib/recess sides angled more than 60 degrees.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
- b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
- c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
- d. Rib Spacing: 12 inches (305 mm), **as directed**, o.c.
- e. Panel Coverage: 24 inches (610 mm), **as directed**.
- f. Panel Height: 3 inches (76 mm) **OR** 4 inches (102 mm), **as directed**.
- H. Concealed-Fastener, Lap-Seam Metal Roof Panels
1. General: Provide factory-formed metal roof panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for weathertight installation.
 2. Tapered-Rib-Profile, Concealed-Fastener Metal Roof Panels: Formed with raised, trapezoidal major rib at panel edge and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major rib and panel edge.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
- b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
- c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.



- d. Panel Coverage: 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm), **as directed**.
- e. Panel Height: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 1.75 inches (44 mm), **as directed**.
- 3. Standing-Seam-Profile, Concealed-Fastener Metal Roof Panels: Formed with raised, curved-top, standing-seam-shaped major rib at panel edge and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major rib and panel edge.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Panel Coverage: 10 inches (254 mm) **OR** 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm), **as directed**.
 - f. Panel Height: 1.0 inch (25 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.
- 4. Batten-Seam-Profile, Concealed-Fastener Metal Roof Panels: Formed with raised, batten-seam-shaped major rib at panel edge and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major rib and panel edge.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Panel Coverage: 10 inches (254 mm) **OR** 12 inches (305 mm) **OR** 14 inches (356 mm) **OR** 15 inches (381 mm) **OR** 18 inches (457 mm) **OR** 24 inches (610 mm) **OR** 36 inches (914 mm), **as directed**.



- e. Panel Height: 0.75 inch (19 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.
- f. Batten Width: 1.5 inches (38 mm) **OR** 2.0 inches (51 mm), **as directed**.

I. Standing-Seam Metal Roof Panels

1. General: Provide factory-formed metal roof panels designed to be installed by lapping and interconnecting raised side edges of adjacent panels with joint type indicated and mechanically attaching panels to supports using concealed clips in side laps. Include clips, cleats, pressure plates, and accessories required for weathertight installation.
 - a. Steel Panel Systems: Unless more stringent requirements are indicated, comply with ASTM E 1514.
 - b. Aluminum Panel Systems: Unless more stringent requirements are indicated, comply with ASTM E 1637.
2. Vertical-Rib, Snap-Joint, Standing-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels, and snapping panels together.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**,.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Batten: Same material, finish, and color as roof panels.
 - f. Clips: Fixed **OR** Floating to accommodate thermal movement, **as directed**.
 - 1) Material: 0.028-inch- (0.71-mm-) **OR** 0.064-inch- (1.63-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 2) Material: 0.025-inch- (0.64-mm-) **OR** 0.062-inch- (1.59-mm-), **as directed**, thick, stainless-steel sheet.
 - g. Panel Coverage: 10 inches (254 mm) **OR** 12 inches (305 mm) **OR** 14 inches (356 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**.
 - h. Panel Height: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 1.75 inches (44 mm), **as directed**.
3. Vertical-Rib, Seamed-Joint, Standing-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels, and mechanically seaming panels together.



- a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Batten: Same material, finish, and color as roof panels.
 - f. Clips: Fixed **OR** Floating to accommodate thermal movement, **as directed**.
 - 1) Material: 0.028-inch- (0.71-mm-) **OR** 0.064-inch- (1.63-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 2) Material: 0.025-inch- (0.64-mm-) **OR** 0.062-inch- (1.59-mm-), **as directed**, thick, stainless-steel sheet.
 - g. Joint Type: Single folded **OR** Double folded **OR** As standard with manufacturer, **as directed**.
 - h. Panel Coverage: 12 inches (305 mm) **OR** 14 inches (356 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm) **OR** 20 inches (508 mm) **OR** 24 inches (610 mm), **as directed**.
 - i. Panel Height: 1.5 inches (38 mm) **OR** 2.0 inches (51 mm) **OR** 2.5 inches (64 mm), **as directed**.
4. Trapezoidal-Rib, Snap-Joint, Standing-Seam Metal Roof Panels: Formed with raised trapezoidal ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels, and snapping panels together.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 28-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Clips: Fixed **OR** Floating to accommodate thermal movement, **as directed**.
 - 1) Material: 0.028-inch- (0.71-mm-) **OR** 0.064-inch- (1.63-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.



- d. Panel Coverage: 12 inches (305 mm) **OR** 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**.
- e. Panel Height: 3 inches (76 mm).
- 5. Trapezoidal-Rib, Seamed-Joint, Standing-Seam Metal Roof Panels: Formed with raised trapezoidal ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels, and mechanically seaming panels together.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Clips: Fixed **OR** Floating to accommodate thermal movement, **as directed**.
 - 1) Material: 0.028-inch- (0.71-mm-) **OR** 0.064-inch- (1.63-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - d. Joint Type: Single folded **OR** Double folded **OR** As standard with manufacturer, **as directed**.
 - e. Panel Coverage: 12 inches (305 mm) **OR** 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**.
 - f. Panel Height: 2.7 inches (69 mm) **OR** 3.0 inches (76 mm), **as directed**.
- 6. Integral-Standing-Seam Metal Roof Panels: Formed with integral ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and lapping and interconnecting side edges of adjacent panels.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Clips: Fixed **OR** Floating to accommodate thermal movement, **as directed**.



- 1) Material: 0.028-inch- (0.71-mm-) **OR** 0.064-inch- (1.63-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 2) Material: 0.025-inch- (0.64-mm-) **OR** 0.062-inch- (1.59-mm-), **as directed**, thick, stainless-steel sheet.
 - f. Panel Coverage: 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm), **as directed**.
 - g. Panel Height: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 2.0 inches (51 mm), **as directed**.
- J. Batten-Seam Metal Roof Panels
1. General: Provide factory-formed metal roof panel assembly designed to be installed by covering vertical side edges of adjacent panels with battens and mechanically attaching panels to supports using concealed clips. Include battens and accessories required for weathertight installation.
 2. Narrow-Profile, Snap-on-Batten-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for independent installation by mechanically attaching panels to supports using concealed clips located under 1 side of panels and engaging opposite edge of adjacent panels, and installation of 3/8-to-1/2-inch- (10-to-13-mm-) wide, snap-on battens over panel joints.
 - a. Panel Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Panel Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Panel Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Panel Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Batten Material: Same material, finish, and color as roof panels.
 - f. Clips: One **OR** Two, **as directed**, piece.
 - 1) Material: 0.028-inch- (0.71-mm-) **OR** 0.064-inch- (1.63-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 2) Material: 0.025-inch- (0.64-mm-) **OR** 0.062-inch- (1.59-mm-), **as directed**, thick, stainless-steel sheet.
 - g. Sealant: Factory applied in top **OR** on each side, **as directed**, of battens.
 - h. Panel Coverage: 12 inches (305 mm) **OR** 14 inches (356 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm) **OR** 20 inches (508 mm), **as directed**.
 - i. Batten Height: 1.0 inch (25 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm) **OR** 1.75 inches (44 mm) **OR** 2.0 inches (51 mm), **as directed**.
 3. Wide-Profile, Snap-on-Batten-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for independent installation by mechanically attaching panels to supports using concealed clips located between and engaging edges of adjacent panels, and installing snap-on battens over panel joints.



- a. Panel Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Panel Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Panel Material: Aluminum sheet, 0.024 inch (0.061 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Panel Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Batten Material: Same material, finish, and color as roof panels.
 - f. Clips: One piece.
 - 1) Material: 0.028-inch- (0.71-mm-) **OR** 0.064-inch- (1.63-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 2) Material: 0.025-inch- (0.64-mm-) **OR** 0.062-inch- (1.59-mm-), **as directed**, thick, stainless-steel sheet.
 - g. Sealant: Factory applied on each side of battens.
 - h. Panel Coverage: 12 inches (305 mm) **OR** 14 inches (356 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm) **OR** 22 inches (559 mm) **OR** 24 inches (610 mm), **as directed**.
 - i. Batten Height: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 1.75 inches (44 mm) **OR** 1.88 inches (48 mm) **OR** 2.0 inches (51 mm), **as directed**.
4. Seamed-Batten Metal Roof Panels: Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** smooth, flat pan, **as directed**, between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels, and installing mechanically seamed battens over panel joints.
- a. Panel Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Panel Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Panel Material: Aluminum sheet, 0.024 inch (0.061 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.



- d. Panel Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Batten Material: Same material, finish, and color as roof panels.
 - f. Clips: One **OR** Two, **as directed**, piece.
 - 1) Material: 0.028-inch- (0.71-mm-) **OR** 0.064-inch- (1.63-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 2) Material: 0.025-inch- (0.64-mm-) **OR** 0.062-inch- (1.59-mm-), **as directed**, thick, stainless-steel sheet.
 - g. Sealant: Factory applied on each side of clips under battens.
 - h. Panel Coverage: 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm), **as directed**.
 - i. Batten Height: 2.0 inches (51 mm) **OR** 2.375 inches (60 mm) **OR** 3.0 inches (76 mm), **as directed**.
- K. Horizontal-Seam (Bermuda-Type) Metal Roof Panels
- 1. Horizontal-Seam (Bermuda-Type) Metal Roof Panels: Formed with horizontal seam at panel edges and smooth, flat pan; designed to be installed in sequential installation by engaging lower edge of each panel to upper edge of panel below and mechanically attaching panels to supports using concealed clips located under upper edge of panels.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer, **as directed**.
 - 2) Color: As selected by the Owner from manufacturer's full range.
 - d. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - e. Clips: One piece.
 - 1) Material: 0.028-inch- (0.71-mm-) nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 2) Material: 0.025-inch- (0.64-mm-) thick, stainless-steel sheet.
 - f. Seal: Factory-applied sealant or vinyl weatherseal in seam.
 - g. Exposure: 9.5 inches (241 mm) **OR** 11 inches (279 mm), **as directed**, nominal.
 - h. Seam Height: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm), **as directed**.
- L. Foamed-Insulation-Core Metal Roof Panels
- 1. General: Provide factory-formed and -assembled metal roof panels fabricated from two sheets of metal with insulation core foamed-in-place during fabrication with joints between panels designed to form weathertight seals. Include accessories required for weathertight installation.
 - a. Panel Performance:
 - 1) Flatwise Tensile Strength: 30 psi (200 kPa) when tested according to ASTM C 297/C 297M.



- 2) Humid Aging: Volume increase not greater than 6.0 percent and no delamination or metal corrosion when tested for 7 days at 140 deg F (60 deg C) and 100 percent relative humidity according to ASTM D 2126.
- 3) Heat Aging: Volume increase not greater than 2.0 percent and no delamination, surface blistering, or permanent bowing when tested for 7 days at 200 deg F (93 deg C) according to ASTM D 2126.
- 4) Cold Aging: Volume decrease not more than 1.0 percent and no delamination, surface blistering, or permanent bowing when tested for 7 days at minus 20 deg F (29 deg C) according to ASTM D 2126.
- 5) Fatigue: No evidence of delamination, core cracking, or permanent bowing when tested to a 20-lbf/sq. ft. (958-kPa) positive and negative wind load and with deflection of L/180 for 2 million cycles.
- 6) Autoclave: No delamination when exposed to 2-psi (13.8-kPa) pressure at a temperature of 212 deg F (100 deg C) for 2-1/2 hours.
- 7) Fire-Test-Response Characteristics: Class A according to ASTM E 108.
- b. Insulation Core: Modified isocyanurate or polyurethane foam using a non-CFC blowing agent, with maximum flame-spread and smoke-developed indexes of 25 and 450, respectively.
 - 1) Closed-Cell Content: 90 percent when tested according to ASTM D 2856.
 - 2) Density: 2.0 to 2.6 lb/cu. ft. (32 to 42 kg/cu. m) when tested according to ASTM D 1622.
 - 3) Compressive Strength: Minimum 20 psi (140 kPa) when tested according to ASTM D 1621.
 - 4) Shear Strength: 26 psi (179 kPa) when tested according to ASTM C 273.
2. Lap-Seam-Profile, Foamed-Insulation-Core Metal Roof Panels: Formed for lapping side edges of adjacent panels and mechanically attaching to supports using exposed fasteners in side laps.
 - a. Facings: Fabricate panel with exterior and interior facings of same material and thickness.
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 3) Exterior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - a) Color: As selected by the Owner from manufacturer's full range.
 - 4) Interior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - a) Color: As selected by the Owner from manufacturer's full range.
 - b. Batten: Same material, finish, and color as exterior facings of roof panels.
 - c. Panel Coverage: 24 inches (610 mm) **OR** 30 inches (762 mm) **OR** 36 inches (914 mm) **OR** 39.6 inches (1000 mm) **OR** 40 inches (1016 mm) **OR** 44.5 inches (1130 mm), **as directed**.
 - d. Panel Thickness: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 2.0 inches (51 mm) **OR** 2.5 inches (64 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm) **OR** 5.0 inches (127 mm) **OR** 6.0 inches (152 mm), **as directed**.
3. Standing-Seam-Profile, Foamed-Insulation-Core Metal Roof Panels: Formed with vertical tongue-and-groove ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by interlocking tongue-and-groove panel edges and mechanically attaching panels to supports using concealed clips located between and engaging edges of adjacent panels, and mechanically seaming panels together.
 - a. Facings: Fabricate panel with exterior and interior facings of same material and thickness.
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.



- 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 3) Exterior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - a) Color: As selected by the Owner from manufacturer's full range.
 - 4) Interior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - a) Color: As selected by the Owner from manufacturer's full range.
 - b. Joint Type: Single folded **OR** Double folded **OR** As standard with manufacturer, **as directed**.
 - c. Panel Coverage: 36 inches (914 mm) **OR** 42 inches (1067 mm), **as directed**.
 - d. Panel Thickness: 2.0 inches (51 mm) **OR** 2.5 inches (64 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm) **OR** 5.0 inches (127 mm) **OR** 6.0 inches (152 mm), **as directed**.
4. Batten-Seam-Profile, Foamed-Insulation-Core Metal Roof Panels: Formed with vertical or tapered tongue-and-groove ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by interlocking tongue-and-groove panel edges and mechanically attaching panels to supports using concealed clips located between and engaging edges of adjacent panels, and installing snap-on battens over panel joints.
- a. Facings: Fabricate panel with exterior and interior facings of same material and thickness.
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) nominal thickness.
 - 3) Exterior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - a) Color: As selected by the Owner from manufacturer's full range.
 - 4) Interior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - a) Color: As selected by the Owner from manufacturer's full range.
 - b. Batten: Same material, finish, and color as exterior facings of roof panels.
 - c. Clips: One piece; 0.064-inch- (1.63-mm-) **OR** 0.097-inch- (2.50-mm-), **as directed**, nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - d. Panel Coverage: 36 inches (914 mm) **OR** 39.6 inches (1000 mm), **as directed**.
 - e. Panel Thickness: 1.75 inches (44 mm) **OR** 2.0 inches (51 mm) **OR** 2.5 inches (64 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm) **OR** 5.0 inches (127 mm) **OR** 6.0 inches (152 mm), **as directed**.

M. Metal Soffit Panels

1. General: Provide factory-formed metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for weathertight installation.
2. Metal Soffit Panels: Match profile and material of metal roof panels.
 - a. Finish: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As indicated on Drawings, **as directed**.
 - b. Sealant: Factory applied within interlocking joint.
3. Flush-Profile Metal Soffit Panels: Solid **OR** Perforated, **as directed**, panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with flush joint between panels.
 - a. Material: Same material, finish, and color as metal roof panels.



- b. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.
- c. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.
- d. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.
- e. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
- 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
- f. Panel Coverage: 8 inches (203 mm) **OR** 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 20 inches (508 mm), **as directed**.
- g. Panel Height: 0.875 inch (22 mm) **OR** 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 3.0 inches (76 mm), **as directed**.
- h. Sealant: Factory applied within interlocking joint.
4. Reveal-Joint-Profile Metal Soffit Panels: Solid **OR** Perforated, **as directed**, panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with recessed reveal joint between panels.
- a. Material: Same material, finish, and color as metal roof panels.
 - b. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.
 - c. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.



- d. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.
- e. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
- f. Panel Coverage: 8 inches (203 mm) **OR** 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 20 inches (508 mm), **as directed**.
- g. Panel Height: 0.75 inch (19 mm) **OR** 1.0 inch (25 mm) **OR** 1.5 inches (38 mm), **as directed**.
- 5. V-Groove-Profile Metal Soffit Panels: Solid **OR** Perforated, **as directed**, panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), flat pan, **as directed**, between panel edges; with V-groove joint between panels.
 - a. Material: Same material, finish, and color as metal roof panels.
 - b. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.
 - c. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.
 - d. Material: Aluminum sheet, 0.024 inch (0.65 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As selected by the Owner from manufacturer's full range, **as directed**.
 - e. Panel Coverage: 6 inches (152 mm) **OR** 12 inches (305 mm) **OR** 14 inches (356 mm), **as directed**.
 - f. Panel Height: 0.375 inch (10 mm) **OR** 0.44 inch (11 mm) **OR** 0.50 inch (13 mm) **OR** 0.625 inch (16 mm), **as directed**.

N. Accessories

- 1. Roof Panel Accessories: Provide components approved by roof panel manufacturer and as required for a complete metal roof panel assembly including trim, copings, fasciae, corner units, ridge closures, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels unless otherwise indicated.
 - a. Closures: Provide closures at eaves and ridges, fabricated of same metal as metal roof panels.



- b. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal roof panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
 - c. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 2. Flashing and Trim: Formed from same material as roof panels, prepainted with coil coating, minimum 0.018 inch (0.45 mm) thick. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers. Finish flashing and trim with same finish system as adjacent metal roof panels.
 3. Gutters: Formed from same material as roof panels. Match profile of gable trim, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96-inch- (2400-mm-) long sections, of size and metal thickness according to SMACNA's "Architectural Sheet Metal Manual." Furnish gutter supports spaced a maximum of 36 inches (900 mm) o.c., fabricated from same metal as gutters. Provide wire ball strainers of compatible metal at outlets. Finish gutters to match metal roof panels **OR** roof fascia and rake trim, **as directed**.
 4. Downspouts: Formed from same material as roof panels. Fabricate in 10-foot- (3-m-) long sections, complete with formed elbows and offsets, of size and metal thickness according to SMACNA's "Architectural Sheet Metal Manual". Finish downspouts to match gutters.
 5. Roof Curbs: Fabricated from same material as roof panels, minimum 0.048 inch (1.2 mm) thick; with bottom of skirt profiled to match roof panel profiles, and welded top box and integral full-length cricket. Fabricate curb subframing of minimum 0.0598-inch- (1.5-mm-) thick, angle-, C-, or Z-shaped steel sheet. Fabricate curb and subframing to withstand indicated loads, of size and height indicated. Finish roof curbs to match metal roof panels.
 - a. Insulate roof curb with 1-inch- (25-mm-) thick, rigid insulation.
- O. Snow Guards
 1. Snow Guards: Prefabricated, noncorrosive units designed to be installed without penetrating metal roof panels, and complete with predrilled holes, clamps, or hooks for anchoring.
 - a. Surface-Mounted, Plastic, Stop-Type Snow Guards: Clear **OR** Integral color, **as directed**, polycarbonate stops designed for attachment to pan surface of metal roof panels using construction adhesive, silicone or polyurethane sealant, or adhesive tape.
 - b. Surface-Mounted, Metal, Stop-Type Snow Guards: Cast-aluminum stops designed for attachment to pan surface of metal roof panel using construction adhesive, silicone or polyurethane sealant, or adhesive tape.
 - c. Surface-Mounted, Copper, Stop-Type Snow Guards: Bronze-alloy stops designed for attachment to pan surface of copper roof panel using solder.
 - d. Seam-Mounted, Stop-Type Snow Guards: Cast-aluminum **OR** Malleable-iron **OR** Clear polycarbonate **OR** Colored polycarbonate, **as directed**, stops designed for attachment to vertical ribs of standing-seam metal roof panels with stainless-steel set screws.
 - e. Seam-Mounted, Bar-Type Snow Guards: Aluminum **OR** stainless-steel, **as directed**, rods or bars held in place by stainless-steel clamps attached to vertical ribs of standing-seam metal roof panels.
 - 1) Aluminum Finish: Mill **OR** Clear anodized, **as directed**.
 - 2) Stainless-Steel Finish: Mill **OR** No. 2B **OR** No. 4, **as directed**.
- P. Fabrication
 1. Fabricate and finish metal roof panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes and as necessary to fulfill indicated performance requirements. Comply with indicated profiles and with dimensional and structural requirements.
 2. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.



3. Fabricate metal roof panel side laps with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, in a manner that will seal weathertight and minimize noise from movements within panel assembly.
4. Sheet Metal Accessories: Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of item indicated.
 - a. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
 - b. End Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
 - c. End Seams for Other Than Aluminum: Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 - d. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.
 - e. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
 - f. Fabricate cleats and attachment devices of size and metal thickness recommended by SMACNA's "Architectural Sheet Metal Manual" or by metal roof panel manufacturer for application, but not less than thickness of metal being secured.

Q. Finishes

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

1.3 EXECUTION

A. Preparation

1. Clean substrates of substances harmful to insulation, including removing projections capable of interfering with insulation attachment.
2. Substrate Board: Install substrate boards over roof deck **OR** sheathing, **as directed**, on entire roof surface. Attach with substrate-board fasteners.
 - a. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - b. Comply with UL **OR** FMG, **as directed**, requirements for fire-rated construction.
3. Miscellaneous Framing: Install subpurlins, eave angles, furring, and other miscellaneous roof panel support members and anchorage according to metal roof panel manufacturer's written instructions.
 - a. Soffit Framing: Wire tie or clip furring channels to supports, as required to comply with requirements for assemblies indicated.

B. Underlayment Installation

1. Self-Adhering Sheet Underlayment: Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply at locations indicated below **OR** on Drawings, **as directed**, wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses. Overlap side edges not less than 3-1/2 inches (90 mm). Extend underlayment into gutter trough. Roll laps with roller. Cover underlayment within 14 days.
 - a. Roof perimeter for a distance up from eaves of 24 inches (600 mm) **OR** 36 inches (914 mm), **as directed**, beyond interior wall line.



- b. Valleys, from lowest point to highest point, for a distance on each side of 18 inches (460 mm), **as directed**. Overlap ends of sheets not less than 6 inches (150 mm).
 - c. Rake edges for a distance of 18 inches (460 mm).
 - d. Hips and ridges for a distance on each side of 12 inches (300 mm).
 - e. Roof to wall intersections for a distance from wall of 18 inches (460 mm).
 - f. Around dormers, chimneys, skylights, and other penetrating elements for a distance from element of 18 inches (460 mm).
2. Felt Underlayment: Apply at locations indicated below **OR** on Drawings, **as directed**, in shingle fashion to shed water, and with lapped joints of not less than 2 inches (50 mm).
 - a. Apply over entire roof surface.
 - b. Apply on roof not covered by self-adhering sheet underlayment. Lap over edges of self-adhering sheet underlayment not less than 3 inches (75 mm), in shingle fashion to shed water.
 3. Apply slip sheet over underlayment before installing metal roof panels.
 4. Install flashings to cover underlayment to comply with requirements specified in Division 07 Section "Sheet Metal Flashing And Trim".

C. Thermal Insulation Installation

1. Polyethylene Vapor Retarder: Extend vapor retarder to extremities of areas to be protected from vapor transmission. Repair tears or punctures immediately before concealment by other work.
2. Board Insulation: Extend insulation in thickness indicated to cover entire roof. Comply with installation requirements in Division 07 Section "Thermal Insulation".
 - a. Erect insulation and hold in place with Z-shaped furring members spaced 24 inches (610 mm) **OR** 600 mm, **as directed**, o.c. Securely attach narrow flanges of furring members to roof deck with screws spaced 24 inches (600 mm) o.c.
3. Blanket Insulation: Install insulation concurrently with metal roof panel installation, in thickness indicated to cover entire roof, according to manufacturer's written instructions and as follows:
 - a. Set vapor-retarder-faced units with vapor retarder to warm side **OR** in location indicated, **as directed**, of construction unless otherwise indicated. Do not obstruct ventilation spaces.
 - b. Tape joints and ruptures in vapor retarder and seal each continuous area of insulation to surrounding construction to ensure airtight installation.
 - c. Install blankets straight and true in one-piece lengths with both sets of facing tabs sealed. Comply with the following installation method:
 - 1) Over-Framing Installation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing members. Hold in place by panels fastened to secondary framing.
 - 2) Between-Purlin Installation: Extend insulation and vapor retarder between purlins. Carry vapor-retarder facing tabs up and over purlin, overlapping adjoining facing of next insulation course maintaining continuity of retarder. Hold in place with bands and crossbands below insulation.
 - 3) Over-Purlin-with-Spacer-Block Installation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing members. Install layer of filler insulation over first layer to fill space formed by roof panel standoffs. Hold in place by panels fastened to standoffs.
 - 4) Two-Layers-between-Purlin-with-Spacer-Block Installation: Extend insulation and vapor retarder between purlins. Carry vapor-retarder facing tabs up and over purlins, overlapping adjoining facing of next insulation course maintaining continuity of retarder. Install layer of filler insulation over first layer to fill space between purlins formed by thermal spacer blocks. Hold in place with bands and crossbands below insulation.
 - d. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.
 - e. Thermal Spacer Blocks: Where metal roof panels attach directly to purlins, install thermal spacer blocks.



D. Metal Roof Panel Installation, General

1. Provide metal roof panels of full length from eave to ridge unless otherwise indicated or restricted by shipping limitations.
2. Thermal Movement. Rigidly fasten metal roof panels to structure at one and only one location for each panel. Allow remainder of panel to move freely for thermal expansion and contraction. Predrill panels for fasteners.
 - a. Point of Fixity: Fasten each panel along a single line of fixing located at eave **OR** ridge **OR** center of panel length **OR** locations indicated on Drawings, **as directed**.
 - b. Avoid attaching accessories through roof panels in a manner that will inhibit thermal movement.
3. Install metal roof panels as follows:
 - a. Commence metal roof panel installation and install minimum of 300 sq. ft. (27.8 sq. m.) in presence of factory-authorized representative.
 - b. Field cutting of metal panels by torch is not permitted.
 - c. Install panels perpendicular to purlins.
 - d. Locate and space fastenings in uniform vertical and horizontal alignment.
 - e. Provide metal closures at rake edges **OR** rake walls, **as directed**, and each side of ridge **OR** ridge and hip, **as directed**, caps.
 - f. Flash and seal metal roof panels with weather closures at eaves, rakes, and perimeter of all openings.
 - g. Install ridge **OR** ridge and hip, **as directed**, caps as metal roof panel work proceeds.
 - h. End Splices: Locate panel end splices over, but not attached to, structural supports. Stagger panel end splices to avoid a four-panel splice condition.
 - i. Install metal flashing to allow moisture to run over and off metal roof panels.
4. Fasteners:
 - a. Steel Roof Panels: Use stainless-steel fasteners for surfaces exposed to the exterior and galvanized-steel fasteners for surfaces exposed to the interior.
 - b. Aluminum Roof Panels: Use aluminum or stainless-steel fasteners for surfaces exposed to the exterior and aluminum or galvanized-steel fasteners for surfaces exposed to the interior.
 - c. Copper Roof Panels: Use copper, stainless-steel, or hardware-bronze fasteners.
5. Anchor Clips: Anchor metal roof panels and other components of the Work securely in place, using manufacturer's approved fasteners according to manufacturers' written instructions.
6. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.
 - a. Coat back side of roof panels with bituminous coating where roof panels will contact wood, ferrous metal, or cementitious construction.
7. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal roof panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by metal roof panel manufacturer.
 - a. Seal metal roof panel end laps with double beads of tape or sealant, full width of panel. Seal side joints where recommended by metal roof panel manufacturer.
 - b. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants".

E. Metal Roof Panel Installation

1. Lap-Seam Metal Roof Panels: Fasten metal roof panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.
 - a. Apply panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.
 - b. Lap ribbed or fluted sheets one full rib corrugation.
 - c. Provide metal-backed neoprene or EPDM washers under heads of exposed fasteners bearing on weather side of metal roof panels.



- d. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 - e. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
 - f. Provide sealant tape at lapped joints of metal roof panels and between panels and protruding equipment, vents, and accessories.
 - g. Apply a continuous ribbon of sealant tape to weather-side surface of fastenings on end laps, and on side laps of nesting-type panels; on side laps of corrugated nesting-type, ribbed, or fluted panels; and elsewhere as needed to make panels weatherproof to driving rains.
 - h. At panel end splices, nest panels with minimum 6-inch (150-mm) end lap, sealed with butyl-rubber sealant and fastened together by interlocking clamping plates.
2. Standing-Seam Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended by manufacturer.
 - a. Install clips to supports with self-tapping fasteners.
 - b. Install pressure plates at locations indicated in manufacturer's written installation instructions.
 - c. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.
 - d. Seamed Joint: Crimp standing seams with manufacturer-approved, motorized seamer tool so clip, metal roof panel, and factory-applied sealant are completely engaged.
 3. Batten-Seam Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each batten-seam joint at location, spacing, and with fasteners recommended by manufacturer.
 - a. Install clips to supports with self-drilling fasteners.
 - b. Apply battens to metal roof panel seams, fully engaged to provide weathertight joints.
 4. Horizontal-Seam (Bermuda-Type) Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each horizontal-seam joint at location, spacing, and with fasteners recommended by manufacturer. Start at eave and work upward toward ridge.
 - a. Install clips to supports with self-drilling fasteners.
- F. Foamed-Insulation-Core Metal Roof Panel Installation
1. General: Apply continuous ribbon of sealant to panel joint on concealed side of insulated metal roof panels as vapor seal; apply sealant to panel joint on exposed side of panels for weather seal.
 2. Lap-Seam, Foamed-Insulation-Core Metal Roof Panels: Fasten insulated metal roof panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.
 - a. Lap ribbed or fluted sheets one full rib corrugation. Apply panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.
 - b. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of insulated metal roof panels.
 - c. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 - d. Provide sealant tape at lapped joints of insulated metal roof panels and between panels and protruding equipment, vents, and accessories.
 - e. Apply a continuous ribbon of sealant tape to panel side laps and elsewhere as needed to make panels weatherproof to driving rains.
 - f. Apply snap-on battens to insulated metal roof panel seams to conceal fasteners.
 3. Standing-Seam, Foamed-Insulation-Core Metal Roof Panels: Fasten insulated metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended by manufacturer.
 - a. Install clips to supports with self-tapping fasteners.



- b. Seamed Joint: Crimp standing seams with manufacturer-approved, motorized seamer tool so cleat, insulated metal roof panel, and factory-applied side-lap sealant are completely engaged.
 - 4. Batten-Seam, Foamed-Insulation-Core Metal Roof Panels: Fasten insulated metal roof panels to supports with concealed clips at each batten-seam joint at location, spacing, and with fasteners recommended by manufacturer.
 - a. Apply battens to insulated metal roof panel seams, fully engaged to provide weathertight joints.
- G. Metal Soffit Panel Installation
 - 1. In addition to complying with requirements in "Metal Roof Panel Installation, General" Article, install metal soffit panels to comply with requirements in this article.
 - 2. Metal Soffit Panels: Provide metal soffit panels full width of soffits. Install panels perpendicular to support framing.
 - a. Flash and seal panels with weather closures where metal soffit panels meet walls and at perimeter of all openings.
 - 3. Metal Fascia Panels: Align bottom of panels and fasten with blind rivets, bolts, or self-tapping screws. Flash and seal panels with weather closures where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.
- H. Accessory Installation
 - 1. General: Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.
 - a. Install components required for a complete metal roof panel assembly including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
 - 2. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - a. Install exposed flashing and trim that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
 - b. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (600 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).
 - 3. Gutters: Join sections with riveted and soldered or lapped and sealed joints. Attach gutters to eave with gutter hangers spaced not more than 36 inches (914 mm) o.c. using manufacturer's standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.
 - 4. Downspouts: Join sections with telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch (25 mm) away from walls; locate fasteners at top and bottom and at approximately 60 inches (1500 mm) o.c. in between.
 - a. Provide elbows at base of downspouts to direct water away from building.
 - b. Connect downspouts to underground drainage system indicated.
 - 5. Roof Curbs: Install curbs at locations indicated on Drawings. Install flashing around bases where they meet metal roof panels.
 - 6. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to metal roof panels as recommended by manufacturer.
- I. Snow Guard Installation



1. Stop-Type Snow Guards: Attach snow guards to metal roof panels with adhesive, sealant, or adhesive tape, as recommended by manufacturer. Do not use fasteners that will penetrate metal roof panels.
 - a. Provide rows of snow guards, at locations indicated on Drawings, spaced apart, beginning from gutter, with each snow guard centered between panel ribs.
 2. Bar-Type Snow Guards: Attach bar supports to vertical ribs of standing-seam metal roof panels with clamps or set screws. Do not use fasteners that will penetrate metal roof panels.
 - a. Provide rows of snow guards, at locations indicated on Drawings, spaced apart, beginning from gutter.
- J. Erection Tolerances
1. Installation Tolerances: Shim and align metal roof panel units within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.
- K. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect metal roof panel installation, including accessories. Report results in writing.
 2. Remove and replace applications of metal roof panels where inspections indicate that they do not comply with specified requirements.
 3. Additional inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- L. Cleaning
1. Remove temporary protective coverings and strippable films, if any, as metal roof panels are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of metal roof panel installation, clean finished surfaces as recommended by metal roof panel manufacturer. Maintain in a clean condition during construction.
 2. Replace metal roof panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 41 13 00

**SECTION 07 41 13 00a - SHEET METAL ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for sheet metal roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Flat-seam metal roofing, custom fabricated.
 - b. Standing-seam metal roofing, custom fabricated **OR** on-site, roll formed, **as directed**.
 - c. Batten-seam metal roofing, custom fabricated **OR** on-site, roll formed, **as directed**.
 - d. Horizontal-seam (Bermuda-type) metal roofing, custom fabricated.

C. Performance Requirements

1. General Performance: Sheet metal roofing system including, but not limited to, metal roof panels, cleats, clips, anchors and fasteners, sheet metal flashing integral with sheet metal roofing, fascia panels, trim, battens, **as directed**, underlayment, and accessories shall comply with requirements indicated without failure due to defective manufacture, fabrication, installation, or other defects in construction. Sheet metal roofing shall remain watertight.
2. Thermal Movements: Provide sheet metal roofing that allows for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
3. Energy Performance: Provide metal roofing with solar reflectance index not less than 78 **OR** 29, **as directed**, when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Test Reports for Credit SS 7.2: For roof panels, indicating that panels comply with Solar Reflectance Index requirement.
3. Shop Drawings: Show fabrication and installation layouts of sheet metal roofing, including plans, elevations, expansion joint locations, and keyed details. Distinguish between shop- and field-assembled work.
 - a. Include details for forming, joining, and securing sheet metal roofing, including pattern of seams, termination points, fixed points, expansion joints, roof penetrations, edge conditions, special conditions, connections to adjoining work, and details of accessory items.
4. Samples: For each exposed product and for each finish specified.
5. Coordination Drawings: Roof plans drawn to scale with coordinated details for penetrations and roof-mounted items.
6. Portable Roll-Forming Equipment Certificate: Issued by UL for equipment manufacturer's portable roll-forming equipment capable of producing panels that comply with UL requirements.
7. Product test reports.
8. Maintenance data.
9. Warranties: Sample of special warranties.

E. Quality Assurance



1. Roll-Formed Sheet Metal Roofing Fabricator Qualifications: Fabricator authorized by portable roll-forming equipment manufacturer to fabricate and install sheet metal roofing units required for this Project, and who maintains current UL certification of its portable roll-forming equipment.
2. UL-Certified, Portable Roll-Forming Equipment: UL-certified, portable roll-forming equipment capable of producing roofing panels for sheet metal roofing assemblies that comply with UL 580 for Class 30 **OR** Class 60 **OR** Class 90, **as directed**, wind-uplift resistance. Maintain UL certification of portable roll-forming equipment for duration of sheet metal roofing work.
3. Sheet Metal Roofing Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" unless more stringent requirements are specified or shown on Drawings.
4. Copper Roofing Standard: Comply with CDA's "Copper in Architecture Handbook." Conform to dimensions and profiles shown unless more stringent requirements are indicated.
5. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Do not store sheet metal roofing materials in contact with other materials that might cause staining, denting, or other surface damage. Store sheet metal roofing materials away from uncured concrete and masonry.
2. Protect strippable protective covering on sheet metal roofing from exposure to sunlight and high humidity, except to the extent necessary for the period of sheet metal roofing installation.

G. Warranty

1. Special Warranty: Warranty form at the end of this Section in which Installer agrees to repair or replace components of sheet metal roofing that fail in materials or workmanship within two years from date of Final Completion.
2. Special Warranty on Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace sheet metal roofing that shows evidence of deterioration of factory-applied finishes within 20 **OR** 10, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Roofing Sheet Metals

1. General: Protect mechanical and other finishes on exposed surfaces from damage by applying a strippable, temporary protective film before shipping.
2. Metallic-Coated Steel Sheet: Restricted flatness steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - b. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - c. Thickness: Nominal 0.022 inch (0.56 mm) **OR** 0.028 inch (0.71 mm), **as directed**, unless otherwise indicated.
 - 1) Batten Caps: Nominal 0.028 inch (0.71 mm) thick.
 - d. Surface: Smooth, flat **OR** Embossed, **as directed**.
 - e. Exposed Coil-Coated Finish:
 - 1) Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) Four-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat,



- and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
- 4) Mica Fluoropolymer: AAMA 621. Two-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 5) Metallic Fluoropolymer: AAMA 621. Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 6) FEVE Fluoropolymer: AAMA 621. Two-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 7) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mils (0.97 mm) for topcoat.
- f. Color: As selected from manufacturer's full range.
 - g. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
3. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer for finish required, with temper as required to suit forming operations and performance required.
- a. Thickness: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, unless otherwise indicated.
 - 1) Batten Caps: 0.050 inch (1.27 mm) thick.
 - b. As-Milled Finish: Mill **OR** One-side bright mill **OR** Standard one-side bright **OR** Standard two-side bright, **as directed**, finish.
 - c. Alclad Finish: Metallurgically bonded surfacing to both sides, forming a composite aluminum sheet with reflective luster.
 - d. Surface: Smooth, flat **OR** Embossed, **as directed**.
 - e. Factory Prime Coating: Where painting after installation is indicated, pretreat with white or light-colored, factory-applied, baked-on epoxy primer coat; minimum dry film thickness of 0.2 mil (0.005 mm).
 - f. Exposed Coil-Coated Finish:
 - 1) Two-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) Three-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) Four-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 4) Mica Fluoropolymer: AAMA 620. Two-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 5) Metallic Fluoropolymer: AAMA 620. Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight



- in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
- 6) FEVE Fluoropolymer: AAMA 620. Two-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 7) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mil (0.97 mm) for topcoat.
- g. Color: As selected from manufacturer's full range.
 - h. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
4. Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 temper, 16 oz./sq. ft. (0.55 mm thick) **OR** 20 oz./sq. ft. (0.70 mm thick), **as directed**, unless otherwise indicated.
 - a. Batten Caps: 20 oz./sq. ft. (0.70 mm thick).
 - b. Non-Patinated Exposed Finish: Mill
 - c. Non-Patinated Exposed, Lacquered Finish: Finish designations for copper alloys comply with the system defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
 - 1) Brushed Satin (Lacquered): M32-06x (Mechanical Finish: directionally textured, medium satin; with clear organic coating); coating of "Incralac" waterborne **OR** solvent-borne, **as directed**, methyl methacrylate copolymer lacquer with UV inhibitor, applied by air spray in two coats per manufacturer's written instructions to a total thickness of 1 mil (0.025 mm).
 - 2) Mirror Polished (Lacquered): M22-06x (Mechanical Finish: buffed, specular; with clear organic coating); coating of "Incralac" waterborne **OR** solvent-borne, **as directed**, air-drying, methyl methacrylate copolymer lacquer with UV inhibitor, applied by air spray in two coats per manufacturer's written instructions to a total thickness of 1 mil (0.025 mm).
 - d. Pre-Patinated Copper-Sheet Finish: Dark brown **OR** Verdigris, **as directed**, pre-patinated according to ASTM B 882.
 5. Zinc-Tin Alloy-Coated Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 temper, coated on both sides with a zinc-tin alloy (50 percent zinc, 50 percent tin).
 - a. Weight (Thickness): 16-oz./sq. ft. (0.55-mm) **OR** 20-oz./sq. ft. (0.70-mm), **as directed**, uncoated weight (thickness), with 0.787-mil (0.020-mm) coating thickness applied to each side.
 - 1) Batten Caps: 20-oz./sq. ft. (0.70-mm) uncoated weight (thickness), with 0.787-mil (0.020-mm) coating thickness applied to each side unless otherwise indicated.
 6. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304, dead soft, fully annealed.
 - a. Thickness: 0.016 inch (0.40 mm) **OR** 0.019 inch (0.48 mm), **as directed**, unless otherwise indicated.
 - 1) Batten Caps: 0.019 inch (0.48 mm) thick.
 - b. Surface: Smooth, flat **OR** Embossed, **as directed**.
 - c. Finish: 2D (dull, cold rolled) **OR** 2B (bright, cold rolled) **OR** 3 (coarse, polished directional satin) **OR** 4 (polished directional satin), **as directed**.
 - 1) Remove tool and die marks and stretch lines or blend into finish.
 - 2) Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
 - 3) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.



7. Zinc-Tin Alloy-Coated Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304, dead-soft, fully annealed stainless-steel sheet, coated on both sides with a zinc-tin alloy (50 percent zinc, 50 percent tin), with factory-applied gray preweathering.
 - a. Thickness: 0.015-inch (0.38-mm) **OR** 0.018-inch (0.46-mm) **OR** 0.024-inch (0.61-mm), **as directed**, minimum uncoated thickness, with 0.787-mil (0.020-mm) coating thickness applied to each side.
 - 1) Batten Caps: 0.018-inch- (0.46-mm-) minimum uncoated thickness, with 0.787-mil (0.020-mm) coating thickness applied to each side unless otherwise indicated.
 8. Zinc-Tin Alloy-Coated Steel Sheet: ASTM A 625/A 625M; single-reduced, black-steel sheet, coated on both sides with a zinc-tin alloy (50 percent zinc, 50 percent tin), with factory-applied shop coat, **as directed**.
 - a. Thickness: 0.012-inch (0.31-mm) **OR** 0.014-inch (0.36-mm), **as directed**, uncoated thickness, with 0.787-mil (0.020-mm) coating thickness applied to each side.
 - 1) Batten Caps: 0.014-inch (0.36-mm) uncoated thickness, with 0.787-mil (0.020-mm) coating thickness applied to each side unless otherwise indicated.
 - b. Exposed Coil-Coated Finish: Manufacturer's standard two-coat fluoropolymer complying with performance requirements in AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 1) Color: As selected from manufacturer's full range.
 - c. Field-Applied Finish: Manufacturer's standard waterborne acrylic emulsion paint primer and finish coat.
 - 1) Color: As selected from manufacturer's full range.
 9. Zinc Sheet: Zinc, 99 percent pure, alloyed with a maximum of 1 percent copper and titanium; with manufacturer's standard factory-applied, flexible, protective back coating.
 - a. Thickness: 0.027 inch (0.70 mm) **OR** 0.032 inch (0.80 mm), **as directed**, unless otherwise indicated.
 - 1) Batten Caps: 0.032 inch (0.80 mm) thick.
 - b. Finish: Bright rolled **OR** Preweathered gray **OR** Preweathered black, **as directed**.
 10. Titanium Sheet: ASTM B 265, Grade 1.
 - a. Thickness: 0.015 inch (0.38 mm) **OR** 0.020 inch (0.51 mm), **as directed**, unless otherwise indicated.
 - 1) Batten Caps: 0.020 inch (0.51 mm) thick.
 - b. Surface: Smooth, flat **OR** Embossed, **as directed**.
 - c. Finish: Low **OR** Medium, **as directed**, matte.
 - d. Color Anodic Finish (Light-Interference Phenomenon): Silver **OR** Gold **OR** Purple **OR** Blue **OR** Match sample **OR** As selected from manufacturer's full range of colors and color densities, **as directed**.
- B. Underlayment Materials
1. Polyethylene Sheet: 6-mil- (0.15-mm-) thick polyethylene sheet complying with ASTM D 4397.
 2. Felts: ASTM D 226, Type II (No. 30) **OR** Type I (No. 15), **as directed**, asphalt-saturated organic felts.
 3. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils (0.76 to 1.0 mm) thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
 - a. Thermal Stability: ASTM D 1970; stable after testing at 240 deg F (116 deg C).
 - b. Low-Temperature Flexibility: ASTM D 1970; passes after testing at minus 20 deg F (29 deg C).
 4. Slip Sheet: Building paper, 3-lb/100 sq. ft. (0.16-kg/sq. m) minimum, rosin sized.
- C. Miscellaneous Materials



1. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for a complete roofing system and as recommended by fabricator for sheet metal roofing.
2. Wood Battens: Lumber complying with requirements in Division 05 Section(s) "Maintenance Of Decorative Metal" OR Division 06 Section(s) "Miscellaneous Rough Carpentry", **as directed**, and treated with exterior-type fire retardant.
3. Snap-On Seams: Provide snap-on seams integrated with panel-edge profile as recommended by portable roll-forming equipment manufacturer to produce sheet metal roofing assemblies that comply with UL 580 for wind-uplift resistance classification specified in "Quality Assurance" Article.
4. Snap-on Batten Caps: Provide batten clips integrated with snap-on caps as recommended by portable roll-forming equipment manufacturer to produce sheet metal roofing assemblies that comply with UL 580 for wind-uplift resistance classification specified in "Quality Assurance" Article.
5. Fasteners: Wood screws, annular-threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads.
 - a. General:
 - 1) Exposed Fasteners: Heads matching color of sheet metal roofing using plastic caps or factory-applied coating.
 - 2) Fasteners for Flashing and Trim: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
 - 3) Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.
 - b. Fasteners for Zinc-Coated **OR** Aluminum-Zinc Alloy-Coated, **as directed**, Steel Sheet: Hot-dip galvanized steel according to ASTM A 153/A 153M, ASTM F 2329, or Series 300 stainless steel.
 - c. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
 - d. Fasteners for Copper **OR** Zinc-Tin Alloy-Coated Copper, **as directed**, Sheet: Copper, hardware bronze, or Series 300 stainless steel.
 - e. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.
 - f. Fasteners for Zinc-Tin Alloy-Coated Steel **OR** Stainless-Steel, **as directed**, Sheet: Series 300 stainless steel.
 - g. Fasteners for Zinc Sheet: Hot-dip galvanized steel according to ASTM A 153/A 153M, ASTM F 2329, or Series 300 stainless steel.
 - h. Fasteners for Titanium Sheet: Titanium or Series 300 stainless steel.
6. Solder:
 - a. For Zinc-Coated (Galvanized) Steel: ASTM B 32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead.
 - b. For Copper: ASTM B 32, Grade Sn50, 50 percent tin and 50 percent lead.
 - c. For Stainless Steel: ASTM B 32, Grade Sn60, with an acid flux of type recommended by stainless-steel sheet manufacturer.
 - d. For Zinc-Tin Alloy-Coated Steel **OR** Stainless Steel **OR** Copper, **as directed**: ASTM B 32, 100 percent tin.
 - e. For Zinc: ASTM B 32, 40 percent tin and 60 percent lead with low antimony, as recommended by manufacturer.
7. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
8. Elastomeric Sealant: ASTM C 920, elastomeric polyurethane **OR** polysulfide **OR** silicone, **as directed**, polymer sealant as recommended by portable roll-forming equipment manufacturer for installation indicated, **as directed**; low modulus; of type, grade, class, and use classifications required to seal joints in sheet metal roofing and remain watertight.
9. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.



10. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

D. Accessories

1. Sheet Metal Accessories: Provide components required for a complete sheet metal roofing assembly including trim, copings, fasciae, corner units, clips, flashings, sealants, gaskets, fillers, metal closures, closure strips, and similar items. Match material and finish of sheet metal roofing unless otherwise indicated.
 - a. Provide accessories as recommended by portable roll-forming equipment manufacturer to produce sheet metal roofing assemblies that comply with UL 580 for wind-uplift resistance classification specified in "Quality Assurance" Article.
 - b. Cleats: For mechanically seaming into joints and formed from the following materials:
 - 1) Metallic-Coated Steel **OR** Aluminum, **as directed**, Roofing: 0.0250-inch- (0.64-mm-), **as directed**, thick stainless steel.
 - 2) Copper **OR** Zinc-Tin Alloy-Coated Copper, **as directed**, Roofing: 16-oz./sq. ft. (0.55-mm), **as directed**, copper sheet.
 - 3) Stainless-Steel **OR** Titanium, **as directed**, Roofing: 0.0250-inch- (0.64-mm-), **as directed**, thick stainless steel.
 - 4) Zinc-Tin Alloy-Coated Stainless-Steel **OR** Zinc-Tin Alloy-Coated Steel, **as directed**, Roofing: Manufacturer's preformed cleats or cleats fabricated from manufacturer's thickest flat-stock sheet.
 - 5) Zinc Roofing: Manufacturer's preformed stainless-steel cleats.
 - c. Clips: Minimum 0.0625-inch- (1.6-mm-) thick, stainless-steel panel clips designed to withstand negative-load requirements.
 - d. Backing Plates: Plates at roofing splices, fabricated from material recommended by SMACNA.
 - e. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible-closure strips; cut or premolded to match sheet metal roofing profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
 - f. Flashing and Trim: Formed from same material and with same finish as sheet metal roofing, minimum 0.018 inch (0.46 mm) thick.
2. Pipe Flashing: Premolded, EPDM pipe collar with flexible aluminum ring bonded to base.
3. Roof Curbs: Fabricated from same material and finish as sheet metal roofing, minimum thickness matching the sheet metal roofing; with bottom of skirt profiled to match roof panel profiles; with weatherproof top box and integral full-length cricket. Fabricate curb subframing of nominal 0.062-inch- (1.59-mm-) thick, angle-, C-, or Z-shaped galvanized steel or stainless-steel sheet. Fabricate curb and subframing to withstand indicated loads of size and height indicated. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.
 - a. Insulate curbs with 1-inch- (25-mm-) thick, rigid insulation.
 - b. Install wood nailers at tops of curbs.

E. Snow Guards

1. Snow Guards, General: Prefabricated, noncorrosive units designed to be installed without penetrating sheet metal roofing; complete with predrilled holes, clamps, or hooks for anchoring.
2. Surface-Mounted, Plastic, Stop-Type Snow Guards: Clear **OR** Integral-color, **as directed**, polycarbonate stops designed for attachment to panel surface of sheet metal roofing using construction adhesive, silicone or polyurethane sealant, or adhesive tape.
3. Surface-Mounted, Metal, Stop-Type Snow Guards: Cast-aluminum stops designed for attachment to panel surface of sheet metal roofing using construction adhesive, silicone or polyurethane sealant, or adhesive tape.
4. Surface-Mounted, Copper, Stop-Type Snow Guards: Bronze-alloy stops designed for attachment to panel surface of copper roofing using solder.
5. Seam-Mounted, Stop-Type Snow Guards: Cast-aluminum **OR** Malleable-iron **OR** Clear polycarbonate **OR** Colored polycarbonate, **as directed**, stops designed for attachment to vertical ribs of standing-seam sheet metal roofing with stainless-steel set screws.



6. Seam-Mounted, Bar-Type Snow Guards: Rail- or fence-type assembly consisting of aluminum or stainless-steel rods, bars, or pipe held in place by stainless-steel clamps attached to vertical ribs of standing-seam sheet metal roofing.
 - a. Aluminum Finish: Mill **OR** Clear anodized, **as directed**.
 - b. Stainless-Steel Finish: Mill **OR** Enamel, **as directed**.

F. Fabrication

1. General: Custom fabricate sheet metal roofing to comply with details shown and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions (panel width and seam height), geometry, metal thickness, and other characteristics of installation indicated. Fabricate sheet metal roofing and accessories at the shop to greatest extent possible.
 - a. Flat-Seam Roofing: Form flat-seam panels from metal sheets 20 by 28 inches (510 by 710 mm) with 1/2-inch (13-mm) notched and folded edges.
 - b. Standing-Seam Roofing: Form standing-seam panels with finished seam height of 1 inch (25 mm) **OR** of 1-1/2 inches (38 mm) **OR** as indicated, **as directed**.
 - c. Batten-Seam Roofing: Form batten-seam panels with sides turned up 2-1/8 inches (54 mm) **OR** as indicated, **as directed**, with 1/2-inch (13-mm) flange turned toward center of pan.
 - d. Horizontal-Seam (Bermuda-Type) Roofing: Form horizontal-seam (Bermuda-type) panels with upper edges turned up and extending above batten 1/2 inch (13 mm).
2. General: Fabricate roll-formed sheet metal roofing panels with UL-certified, portable roll-forming equipment capable of producing roofing panels for sheet metal roofing assemblies that comply with UL 580 for wind-uplift resistance classification specified in "Quality Assurance" Article. Fabricate roll-formed sheet metal according to equipment manufacturer's written instructions and to comply with details shown.
3. Fabrication Tolerances: Fabricate sheet metal roofing that is capable of installation to a tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.
4. Fabrication Tolerances: Fabricate sheet metal roofing that is capable of installation to tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."
5. Form exposed sheet metal work to fit substrates without excessive oil canning, buckling, and tool marks; true to line and levels indicated; and with exposed edges folded back to form hems.
 - a. Lay out sheet metal roofing so transverse seams, if required, are made in direction of flow with higher panels overlapping lower panels.
 - b. Offset transverse seams from each other 12 inches (300 mm) minimum.
 - c. Fold and cleat eaves and transverse seams in the shop.
 - d. Form and fabricate sheets, seams, strips, cleats, valleys, ridges, edge treatments, integral flashings, and other components of metal roofing to profiles, patterns, and drainage arrangements shown on Drawings and as required for leakproof construction.
6. Expansion Provisions: Fabricate sheet metal roofing to allow for expansion in running work sufficient to prevent leakage, damage, and deterioration of the Work. Where lapped expansion provisions cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with butyl sealant concealed within joints.
7. Sealant Joints: Where movable, nonexpansion-type joints are indicated or required to produce weathertight seams, form metal to provide for proper installation of elastomeric sealant in compliance with SMACNA standards.
8. Metal Protection: Where dissimilar metals will contact each other, protect against galvanic action by painting contact surfaces with bituminous coating, by applying self-adhering sheet underlayment to each contact surface, or by other permanent separation as recommended by fabricator of sheet metal roofing or manufacturers of the metals in contact.
9. Sheet Metal Accessories: Custom fabricate flashings and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated. Obtain field measurements for accurate fit before shop fabrication.



- a. Form exposed sheet metal accessories without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.
 - b. Seams:
 - 1) Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.
OR
Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength, **as directed**.
 - c. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant.
 - d. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
 - e. Fabricate cleats and attachment devices of sizes as recommended by SMACNA's "Architectural Sheet Metal Manual" for application, but not less than thickness of metal being secured.
10. Do not use graphite pencils to mark metal surfaces.

1.3 EXECUTION

A. Preparation

1. Lay out and nail battens to wood sheathing **OR** screw battens to wood sheathing **OR** screw battens to metal deck, **as directed**, before installation of sheet metal roofing.
 - a. Space fasteners not more than 18 inches (457 mm) o.c.
 - b. Space fasteners as required by portable roll-forming equipment manufacturer for specified UL classification for wind-uplift resistance.
2. Zinc-Tin Alloy-Coated Steel Roofing: For roofing with 3:12 slopes or less, paint underside of shop-coated, zinc-tin alloy-coated steel, before installation, with zinc-tin alloy-coated steel primer, applied at a dry film thickness of not less than 2.5 mils (0.06 mm). Comply with manufacturer's written instructions. This is in addition to the shop coating.

B. Underlayment Installation

1. Polyethylene Sheet: Install polyethylene sheet on roof sheathing under sheet metal roofing. Use adhesive for anchorage to minimize use of mechanical fasteners under sheet metal roofing. Apply at locations indicated on Drawings, in shingle fashion to shed water, with lapped and taped joints of not less than 2 inches (50 mm).
2. Felt Underlayment: Install felt underlayment on roof sheathing under sheet metal roofing. Use adhesive for temporary anchorage to minimize use of mechanical fasteners under sheet metal roofing. Apply at locations indicated, in shingle fashion to shed water, with lapped joints of not less than 2 inches (50 mm).
 - a. Apply from eave to ridge.
OR
Apply on roof not covered by self-adhering sheet underlayment. Lap edges of self-adhering sheet underlayment not less than 3 inches (75 mm), in shingle fashion to shed water.
3. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free, on roof sheathing under sheet metal roofing. Apply primer if required by underlayment manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation; use primer rather than nails for installing underlayment at low temperatures. Apply over entire roof **OR** at locations indicated, **as directed**, in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps with roller. Cover underlayment within 14 days.
 - a. Roof perimeter for a distance up from eaves of 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**, beyond interior wall line.



- b. Valleys, from lowest to highest point, for a distance on each side of 18 inches (460 mm). Overlap ends of sheets not less than 6 inches (150 mm).
 - c. Rake edges for a distance of 18 inches (460 mm).
 - d. Hips and ridges for a distance on each side of 12 inches (300 mm).
 - e. Roof to wall intersections for a distance from wall of 18 inches (460 mm).
 - f. Around dormers, chimneys, skylights, and other penetrating elements for a distance from element of 18 inches (460 mm).
4. Install flashings to cover underlayment to comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim".
 5. Apply slip sheet before installing sheet metal roofing.

C. Installation, General

1. General: Anchor sheet metal roofing and other components of the Work securely in place, with provisions for thermal and structural movement. Install fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for a complete roofing system and as recommended by fabricator for sheet metal roofing.
 - a. Field cutting of sheet metal roofing by torch is not permitted.
 - b. Provide metal closures at peaks, rake edges, rake walls, eaves, and each side of ridge and hip caps, **as directed**.
 - c. Flash and seal sheet metal roofing with closure strips at eaves, rakes, and perimeter of all openings. Fasten with self-tapping screws.
 - d. Locate and space fastenings in uniform vertical and horizontal alignment. Predrill panels for fasteners.
 - e. Install ridge **OR** ridge and hip, **as directed**, caps as sheet metal roofing work proceeds.
 - f. Locate roofing splices over, but not attached to, structural supports. Stagger roofing splices and end laps to avoid a four-panel lap splice condition. Install backing plates at roofing splices.
 - g. Install sealant tape where indicated.
 - h. Lap metal flashing over sheet metal roofing to allow moisture to run over and off the material.
 - i. Do not use graphite pencils to mark metal surfaces.
2. Thermal Movement. Rigidly fasten metal roof panels to structure at only one location for each panel. Allow remainder of panel to move freely for thermal expansion and contraction.
 - a. Point of Fixity: Fasten each panel along a single line of fixing located at eave **OR** ridge **OR** center of panel length **OR** locations indicated on Drawings, **as directed**.
 - b. Avoid attaching accessories through roof panels in a manner that will inhibit thermal movement.
3. Fasteners: Use fasteners of sizes that will penetrate wood sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood screws **OR** metal decking not less than recommended by fastener manufacturer to achieve maximum pull-out resistance, **as directed**.
4. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating, by applying self-adhering sheet underlayment to each contact surface, or by other permanent separation as recommended by SMACNA.
 - a. Coat back side of uncoated aluminum and stainless-steel sheet metal roofing with bituminous coating where roofing will contact wood, ferrous metal, or cementitious construction.
5. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.
6. Fasciae: Align bottom of sheet metal roofing and fasten with blind rivets, bolts, or self-tapping screws. Flash and seal sheet metal roofing with closure strips where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.



D. Custom-Fabricated Sheet Metal Roofing Installation

1. Fabricate and install work with lines and corners of exposed units true and accurate. Form exposed faces flat and free of buckles, excessive waves, and avoidable tool marks, considering temper and reflectivity of metal. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant. Fold back sheet metal to form a hem on concealed side of exposed edges unless otherwise indicated.
 - a. Install cleats to hold sheet metal panels in position. Attach each cleat with two fasteners to prevent rotation.
 - b. Fasten cleats not more than 12 inches (300 mm) o.c. Bend tabs over fastener head.
 - c. Provide expansion-type cleats and clips for roof panels that exceed 30 feet (9.1 m) in length.
2. Seal joints as shown and as required for watertight construction. For roofing with 3:12 slopes or less, use cleats at transverse seams.
 - a. Where sealant-filled joints are used, embed hooked flanges of joint members not less than 1 inch (25 mm) into sealant. Form joints to completely conceal sealant. When ambient temperature at time of installation is moderate, between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F (4 deg C).
 - b. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants".
3. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter. Pre-tin edges of sheets to be soldered to a width of 1-1/2 inches (38 mm), except reduce pre-tinning where pre-tinned surface would show in completed Work.
 - a. Do not solder metallic-coated steel **OR** aluminum **OR** titanium sheet.
 - b. Do not pre-tin zinc-tin alloy-coated stainless steel **OR** zinc-tin alloy-coated copper.
 - c. Do not use torches for soldering. Heat surfaces to receive solder and flow solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.
 - d. Stainless-Steel Roofing: Tin edges of uncoated sheets, using solder for stainless steel and acid flux. Promptly remove acid flux residue from metal after tinning and soldering. Comply with solder manufacturer's recommended methods for cleaning and neutralization.
 - e. Copper Roofing: Tin edges of uncoated copper sheets, using solder for copper.
4. Rivets: Rivet joints in uncoated aluminum **OR** zinc, **as directed**, where indicated and where necessary for strength.
5. Flat-Seam Roofing: Attach flat-seam metal panels to substrate with cleats, starting at eave and working upward toward ridge. After panels are in place, mallet seams and solder.
 - a. Attach roofing panels with cleats spaced not more than 24 inches (610 mm) o.c.. Lock and solder panels to base flashing.
 - b. Attach edge flashing to face of roof edge with continuous cleat fastened to roof substrate at 12 inches (305 mm) o.c. Lock panels to edge flashing and solder **OR** apply sealant, **as directed**.
6. Standing-Seam Roofing: Attach standing-seam metal panels to substrate with cleats, double fastened at 12 inches (305 mm) o.c. Install panels reaching from eave to ridge before moving to adjacent panels. Before panels are interlocked, apply continuous bead of sealant to top of flange of lower panel. Lock standing seams by folding over twice so cleat and panel edges are completely engaged.
 - a. Lock each panel to panel below with soldered **OR** sealed, **as directed**, transverse seam.
 - b. Loose-lock panels at eave edges to continuous cleats and flanges at roof edge at gutters.
OR
Loose-lock panels at eave edges to continuous edge flashing exposed 24 inches (610 mm) from roof edge. Attach edge flashing to face of roof edge with continuous cleat fastened to roof substrate at 12 inches (305 mm) o.c. Lock panels to edge flashing.
 - c. Leave seams upright **OR** Fold over seams, **as directed**, after locking at ridges and hips.
7. Batten-Seam Roofing: Attach batten-seam metal panels to substrate with cleats, starting at eave and working upward toward ridge. Hold cleats in place with battens and fold edges of cleats over to hold panels. After panels are in place and before batten cap is installed, apply continuous



bead of sealant to top of flanges of each panel. Install batten cap covering batten and panel edges and fold batten cap and panel together so batten cap and panel edges are completely engaged.

- a. Hook each panel to panel below with soldered **OR** sealed, **as directed**, transverse seam.
- b. Splay upturned edges of panels away from base of battens to provide expansion capability.
- c. Close batten ends with metal closures. Fold together with panel edges and end of batten cap.
- d. Loose-lock panels at eave edges to continuous cleats and flanges at roof edge at gutters.

OR

Loose-lock panels at eave edges to continuous edge flashing exposed 24 inches (610 mm) from roof edge. Attach edge flashing to face of roof edge with continuous cleat fastened to roof substrate at 12 inches (305 mm) o.c. Lock panels to edge flashing.

8. Horizontal-Seam (Bermuda-Type) Roofing: Attach horizontal-seam metal panels to substrate with cleats, starting at eave and working upward toward ridge. Attach cleats to battens, spaced at 8 inches (203 mm) o.c. Lock lower edge of each panel to upper edge of panel below, folding seam over to engage cleat and panel edges. After first fold, mallet seams against batten, leaving joint slightly angled to form drip.
 - a. Hook end of each panel to adjacent panel with soldered **OR** sealed, **as directed**, cross seam.
 - b. Hook panel at eave edge to continuous cleat.
 - c. Join ridges and hips with a standing seam and leave seams upright **OR** fold over seams, **as directed**, after locking.
9. Field Painting: Paint exposed surfaces of zinc-tin alloy-coated steel with one coat of zinc-tin alloy-coated steel primer and one coat of zinc-tin alloy-coated steel finish coat as soon as possible after installation; apply each coat at a dry film thickness of not less than 2.5 mils (0.06 mm). Comply with manufacturer's written instructions.

E. On-Site, Roll-Formed Sheet Metal Roofing Installation

1. General: Install on-site, roll-formed sheet metal roofing fabricated from UL-certified equipment to comply with equipment manufacturer's written instructions for UL wind-uplift resistance class indicated. Provide sheet metal roofing of full length from eave to ridge unless otherwise restricted by on-site or shipping limitations.
2. Standing-Seam Sheet Metal Roofing: Fasten sheet metal roofing to supports with concealed clips at each standing-seam joint at location, at spacing, and with fasteners recommended by manufacturer of portable roll-forming equipment.
 - a. Install clips to substrate with self-tapping fasteners.
 - b. Install pressure plates at locations indicated in equipment manufacturer's written installation instructions.
 - c. Before panels are joined, apply continuous bead of sealant to top of flange of lower panel.
 - d. Snap-On Seam: Nest standing seams and fasten together by interlocking and completely engaging field-applied sealant.

OR

Seamed Joint: Crimp standing seams with manufacturer-approved motorized seamer tool so cleat, sheet metal roofing, and field-applied sealant are completely engaged.
3. Batten-Seam Sheet Metal Roofing: Fasten sheet metal roofing to supports with concealed clips at each batten-seam joint at location, at spacing, and with fasteners recommended by manufacturer of portable roll-forming equipment.
 - a. Install clips to substrate with self-drilling fasteners.
 - b. After panels are in place and before batten cap is installed, apply continuous bead of sealant to top of flange of each panel.
 - c. Apply snap-on batten caps to sheet metal roofing seams, fully engaged to provide weathertight joints.
4. Seal joints as shown and as required for watertight construction. For roofing with 3:12 slopes or less, use cleats at transverse seams.



- a. Where sealant-filled joints are used, embed hooked flanges of joint members not less than 1 inch (25 mm) into sealant. Form joints to completely conceal sealant. When ambient temperature at time of installation is moderate, between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement either way. Adjust setting proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F (4 deg C).
- b. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants".

F. Accessory Installation

1. General: Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.
 - a. Install components required for a complete sheet metal roofing assembly including trim, copings, seam covers, flashings, sealants, gaskets, fillers, metal closures, closure strips, and similar items.
 - b. Install accessories integral to sheet metal roofing that are specified in Division 07 Section "Sheet Metal Flashing And Trim" to comply with that Section's requirements.
2. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - a. Install flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers.
 - b. Install continuous strip of self-adhering underlayment at edge of continuous flashing overlapping self-adhering underlayment, where "continuous seal strip" is indicated in SMACNA's "Architectural Sheet Metal Manual," and where indicated on Drawings.
 - c. Install exposed flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
 - d. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (600 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, and filled with butyl sealant concealed within joints.
3. Pipe Flashing: Form flashing around pipe penetration and sheet metal roofing. Fasten and seal to sheet metal roofing as recommended by SMACNA.
4. Roof Curbs: Install curbs at locations indicated on Drawings. Install flashing around bases where they meet sheet metal roofing.
5. Stop-Type Snow Guards: Attach snow guards to sheet metal roofing with adhesive or adhesive tape, as recommended by manufacturer. Do not use fasteners that will penetrate sheet metal roofing.
 - a. Provide rows of snow guards, at locations indicated on Drawings, spaced apart, beginning up from roof edge at gutter, with each snow guard centered between sheet metal roofing ribs, **as directed**.
6. Bar-Type Snow Guards: Attach bar supports to vertical ribs of standing-seam sheet metal roofing with clamps or set screws. Do not use fasteners that will penetrate sheet metal roofing.
 - a. Provide rows of snow guards, at locations indicated on Drawings, spaced apart, beginning up from roof edge at gutter.

G. Erection Tolerances

1. Installation Tolerances: Shim and align sheet metal roofing within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.



OR

Installation Tolerances: Shim and align sheet metal roofing within installed tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."

H. Cleaning And Protection

1. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
2. Clean and neutralize flux materials. Clean off excess solder.
3. Clean off excess sealants.
4. Remove temporary protective coverings and strippable films as sheet metal roofing is installed unless otherwise indicated in manufacturer's written installation instructions. On completion of sheet metal roofing installation, clean finished surfaces as recommended by sheet metal roofing manufacturer. Maintain sheet metal roofing in a clean condition during construction.
5. Replace sheet metal roofing components that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 41 13 00a



Task	Specification	Specification Description
07 41 33 00	07 41 13 00	Metal Roof Panels



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**SECTION 07 42 13 19 - GLAZING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for glazing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes glazing for the following products and applications, including those specified in other Sections where glazing requirements are specified by reference to this Section:
 - a. Windows.
 - b. Doors.
 - c. Glazed curtain walls.
 - d. Storefront framing.
 - e. Glazed entrances.
 - f. Sloped glazing.
 - g. Skylights.
 - h. Interior borrowed lites.

C. Definitions

1. Glass Manufacturers: Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.
2. Glass Thicknesses: Indicated by thickness designations in millimeters according to ASTM C 1036.
3. Interspace: Space between lites of an insulating-glass unit.

D. Performance Requirements

1. General: Installed glazing systems shall withstand normal thermal movement and wind and impact loads (where applicable) without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, or installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.
2. Delegated Design: Design glass, including comprehensive engineering analysis according to ASTM E 1300 **OR** ICC's 2003 International Building Code, **as directed**, by a qualified professional engineer, using the following design criteria:
 - a. Design Wind Pressures: As indicated on Drawings.
OR
Design Wind Pressures: Determine design wind pressures applicable to Project according to ASCE/SEI 7, based on heights above grade indicated on Drawings.
 - 1) Basic Wind Speed: 85 mph (38 m/s) **OR** 90 mph (40 m/s) **OR** 100 mph (44 m/s) **OR** 110 mph (49 m/s), **as directed**.
 - 2) Importance Factor.
 - 3) Exposure Category: **B OR C OR D, as directed**.
 - b. Design Snow Loads: As indicated on Drawings, **as directed**.
 - c. Vertical Glazing: For glass surfaces sloped 15 degrees or less from vertical, design glass to resist design wind pressure based on glass type factors for short-duration load.
 - d. Sloped Glazing: For glass surfaces sloped more than 15 degrees from vertical, design glass to resist each of the following combinations of loads:
 - 1) Outward design wind pressure minus the weight of the glass. Base design on glass type factors for short-duration load.
 - 2) Inward design wind pressure plus the weight of the glass plus half of the design snow load. Base design on glass type factors for short-duration load.



- 3) Half of the inward design wind pressure plus the weight of the glass plus the design snow load. Base design on glass type factors for long-duration load.
 - e. Glass Type Factors for Wired, Patterned, and Sandblasted Glass:
 - 1) Short-Duration Glass Type Factor for Wired Glass: 0.5.
 - 2) Long-Duration Glass Type Factor for Wired Glass: 0.3.
 - 3) Short-Duration Glass Type Factor for Patterned Glass: 1.0.
 - 4) Long-Duration Glass Type Factor for Patterned Glass: 0.6.
 - 5) Short-Duration Glass Type Factor for Sandblasted Glass: 0.5.
 - f. Thickness of Patterned Glass: Base design of patterned glass on thickness at thinnest part of the glass.
 - g. Probability of Breakage for Sloped Glazing: For glass surfaces sloped more than 15 degrees from vertical, design glass for a probability of breakage not greater than 0.001.
 - h. Maximum Lateral Deflection: For glass supported on all four edges, limit center-of-glass deflection at design wind pressure to not more than 1/50 times the short-side length or 1 inch (25 mm), whichever is less.
 - i. Differential Shading: Design glass to resist thermal stresses induced by differential shading within individual glass lites.
 3. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on glass framing members and glazing components.
 - a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- E. Preconstruction Testing
1. Preconstruction Adhesion and Compatibility Testing: Test each glazing material type, tape sealant, gasket, glazing accessory, and glass-framing member for adhesion to and compatibility with elastomeric glazing sealants.
 - a. Testing will not be required if data are submitted based on previous testing of current sealant products and glazing materials matching those submitted.
 - b. Use ASTM C 1087 to determine whether priming and other specific joint-preparation techniques are required to obtain rapid, optimum adhesion of glazing sealants to glass, tape sealants, gaskets, and glazing channel substrates.
 - c. Test no fewer than eight Samples of each type of material, including joint substrates, shims, sealant backings, secondary seals, and miscellaneous materials.
 - d. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
 - e. For materials failing tests, submit sealant manufacturer's written instructions for corrective measures including the use of specially formulated primers.
- F. Submittals
1. Product Data: For each glass product and glazing material indicated.
 2. LEED Submittals:
 - a. Product Data for Credit EQ 4.1: For glazing sealants used inside of the weatherproofing system, including printed statement of VOC content.
 3. Glass Samples: For each type of glass product other than clear monolithic vision glass **OR** the following products, **as directed**; 12 inches (300 mm) square.
 - a. Tinted glass.
 - b. Patterned glass.
 - c. Coated glass.
 - d. Wired glass.
 - e. Fire-resistive glazing products.
 - f. Laminated glass with colored interlayer.
 - g. Insulating glass.
 4. Glazing Accessory Samples: For gaskets, sealants and colored spacers, in 12-inch (300-mm) lengths. Install sealant Samples between two strips of material representative in color of the adjoining framing system, **as directed**.



5. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.
6. Delegated-Design Submittal: For glass indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
7. Qualification Data: For installers, manufacturers of insulating-glass units with sputter-coated, low-e coatings, glass testing agency and sealant testing agency.
8. Product Certificates: For glass and glazing products, from manufacturer.
9. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for tinted glass, coated glass, insulating glass, glazing sealants and glazing gaskets.
 - a. For glazing sealants, provide test reports based on testing current sealant formulations within previous 36-month period.
10. Preconstruction adhesion and compatibility test report.
11. Warranties: Sample of special warranties.

G. Quality Assurance

1. Manufacturer Qualifications for Insulating-Glass Units with Sputter-Coated, Low-E Coatings: A qualified insulating-glass manufacturer who is approved and certified, **as directed**, by coated-glass manufacturer.
2. Installer Qualifications: A qualified installer who employs glass installers for this Project who are certified under the National Glass Association's Certified Glass Installer Program.
3. Glass Testing Agency Qualifications: A qualified independent testing agency accredited according to the NFRC CAP 1 Certification Agency Program.
4. Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.
5. Source Limitations for Glass: Obtain ultraclear float glass, tinted float glass, coated float glass, laminated glass and insulating glass from single source from single manufacturer for each glass type.
6. Source Limitations for Glazing Accessories: Obtain from single source from single manufacturer for each product and installation method.
7. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below, unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.
 - a. GANA Publications: GANA's "Laminated Glazing Reference Manual" and GANA's "Glazing Manual."
 - b. AAMA Publications: AAMA GDSG-1, "Glass Design for Sloped Glazing," and AAMA TIR-A7, "Sloped Glazing Guidelines."
 - c. IGMA Publication for Sloped Glazing: IGMA TB-3001, "Guidelines for Sloped Glazing."
 - d. IGMA Publication for Insulating Glass: SIGMA TM-3000, "North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use."
8. Safety Glazing Labeling: Where safety glazing labeling is indicated, permanently mark glazing with certification label of the SGCC **OR** the SGCC or another certification agency acceptable to authorities having jurisdiction **OR** the manufacturer, **as directed**. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.
9. Fire-Protection-Rated Glazing Labeling: Permanently mark fire-protection-rated glazing with certification label of a testing agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, test standard, whether glazing is for use in fire doors or other openings, whether or not glazing passes hose-stream test, whether or not glazing has a temperature rise rating of 450 deg F (250 deg C), and the fire-resistance rating in minutes.
10. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of IGCC.
11. Preinstallation Conference: Conduct conference at Project site.

H. Delivery, Storage, And Handling



1. Protect glazing materials according to manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.
2. Comply with insulating-glass manufacturer's written recommendations for venting and sealing units to avoid hermetic seal ruptures due to altitude change.

I. Project Conditions

1. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.
 - a. Do not install glazing sealants when ambient and substrate temperature conditions are outside limits permitted by sealant manufacturer or below 40 deg F (4.4 deg C).

J. Warranty

1. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer's standard form in which coated-glass manufacturer agrees to replace coated-glass units that deteriorate within specified warranty period. Deterioration of coated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.
 - a. Warranty Period: 10 years from date of Final Completion.
2. Manufacturer's Special Warranty on Laminated Glass: Manufacturer's standard form in which laminated-glass manufacturer agrees to replace laminated-glass units that deteriorate within specified warranty period. Deterioration of laminated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.
 - a. Warranty Period: Five **OR** 10, **as directed**, years from date of Final Completion.
3. Manufacturer's Special Warranty on Insulating Glass: Manufacturer's standard form in which insulating-glass manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass.
 - a. Warranty Period: 10 years from date of Final Completion.

1.2 PRODUCTS

A. Glass Products, General

1. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass lites in thicknesses as needed to comply with requirements indicated.
 - a. Minimum Glass Thickness for Exterior Lites: Not less than 6.0 mm.
 - b. Thickness of Tinted Glass: Provide same thickness for each tint color indicated throughout Project.
2. Strength: Where float glass is indicated, provide annealed float glass, Kind HS heat-treated float glass, or Kind FT heat-treated float glass as needed to comply with "Performance Requirements" Article, **as directed**. Where heat-strengthened glass is indicated, provide Kind HS heat-treated float glass or Kind FT heat-treated float glass as needed to comply with "Performance Requirements" Article, **as directed**. Where fully tempered glass is indicated, provide Kind FT heat-treated float glass.
3. Windborne-Debris-Impact Resistance: Provide exterior glazing that passes basic **OR** enhanced, **as directed**, -protection testing requirements in ASTM E 1996 for Wind Zone 1 **OR** Wind Zone 2 **OR** Wind Zone 3 **OR** Wind Zone 4, **as directed**, when tested according to ASTM E 1886. Test



specimens shall be no smaller in width and length than glazing indicated for use on the Project and shall be installed in same manner as glazing indicated for use on the Project.

- a. Large-Missile Test: For glazing located within 30 feet (9.1 m) of grade.
- b. Small-Missile Test: For glazing located more than 30 feet (9.1 m) above grade.

OR

Large-Missile Test: For all glazing, regardless of height above grade.

4. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:
 - a. For monolithic-glass lites, properties are based on units with lites 6.0 mm thick **OR** of thickness indicated, **as directed**.
 - b. For laminated-glass lites, properties are based on products of construction indicated.
 - c. For insulating-glass units, properties are based on units of thickness indicated for overall unit and for each lite.
 - d. U-Factors: Center-of-glazing values, according to NFRC 100 and based on LBL's WINDOW 5.2 computer program, expressed as Btu/sq. ft. x h x deg F (W/sq. m x K).
 - e. Solar Heat-Gain Coefficient and Visible Transmittance: Center-of-glazing values, according to NFRC 200 and based on LBL's WINDOW 5.2 computer program.
 - f. Visible Reflectance: Center-of-glazing values, according to NFRC 300.

B. Glass Products

1. Float Glass: ASTM C 1036, Type I, Quality-Q3, Class I (clear) unless otherwise indicated.
2. Ultraclear Float Glass: ASTM C 1036, Type I, Quality-Q3, Class I, complying with other requirements specified and with visible light transmission not less than 91 percent and solar heat gain coefficient not less than 0.87, **as directed**.
3. Heat-Treated Float Glass: ASTM C 1048; Type I; Quality-Q3; Class I (clear) unless otherwise indicated; of kind and condition indicated.
 - a. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.
 - b. For uncoated glass, comply with requirements for Condition A.
 - c. For coated vision glass, comply with requirements for Condition C (other coated glass).
4. Pyrolytic-Coated, Self-Cleaning, Low-Maintenance Glass: Clear float glass with a coating on first surface having both photocatalytic and hydrophilic properties that act to loosen dirt and to cause water to sheet evenly over the glass instead of beading.
5. Uncoated Tinted Float Glass: Class 2, complying with other requirements specified.
 - a. Tint Color: Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 - b. Visible Light Transmittance: as directed by the Owner.
6. Polished Wired Glass: ASTM C 1036, Type II, Class 1 (clear), Form 1, Quality-Q6, complying with ANSI Z97.1, Class C.
 - a. Mesh: M1 (diamond) **OR** M2 (square), **as directed**.
7. Film-Faced Polished Wired Glass: ASTM C 1036, Type II, Class 1 (clear), Form 1, Quality-Q6 and complying with testing requirements in 16 CFR 1201 for Category II materials.
 - a. Mesh: M1 (diamond) **OR** M2 (square), **as directed**.
8. Patterned Glass: ASTM C 1036, Type II, Class 1 (clear), Form 3; Quality-Q6, Finish F1 (patterned one side) **OR** Finish F2 (patterned both sides), **as directed**, Pattern P1 (linear) **OR** Pattern P2 (geometric) **OR** Pattern P3 (random) **OR** Pattern P4 (special), **as directed**.
9. Tempered Patterned Glass: ASTM C 1048, Kind FT (fully tempered), Type II, Class 1 (clear), Form 3; Quality-Q6, Finish F1 (patterned one side) **OR** Finish F2 (patterned both sides), **as directed**, Pattern P1 (linear) **OR** Pattern P2 (geometric) **OR** Pattern P3 (random) **OR** Pattern P4 (special), **as directed**.
10. Patterned Wired Glass: ASTM C 1036, Type II, Class 1 (clear), Form 2, Quality-Q6, Finish F1 (patterned one side) **OR** Finish F2 (patterned both sides), **as directed**, Mesh M1 (diamond), Pattern P1 (linear) **OR** Pattern P2 (geometric) **OR** Pattern P3 (random) **OR** Pattern P4 (special), **as directed**.



11. Ceramic-Coated Vision Glass: Heat-treated float glass, Condition C; with ceramic enamel applied by silk-screened process; complying with Specification No. 95-1-31 in GANA's Tempering Division's "Engineering Standards Manual" and with other requirements specified.
 - a. Glass: Clear float **OR** Ultraclear float **OR** Tinted float, **as directed**.
 - b. Tint Color: Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 - c. Ceramic Coating Color and Pattern: As selected from manufacturer's full range.
12. Reflective-Coated Vision Glass: ASTM C 1376, coated by pyrolytic process **OR** vacuum deposition (sputter-coating) process, **as directed**, and complying with other requirements specified.
 - a. Kind: Kind CV (coated vision glass), except that Kind CO (coated overhead glass) may be used where the lower edge of the glass is more than 6 feet (1.8 m) above the adjacent floor level or cannot be approached closer than 10 feet (3.0 m).
 - b. Coating Color: Gold **OR** Pewter **OR** Silver, **as directed**.
 - c. Glass: Clear float **OR** Tinted float, **as directed**.
 - d. Tint Color: Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 - e. Visible Light Transmittance:
 - f. Outdoor Visible Reflectance: as directed by the Owner.
 - g. Self-Cleaning, Low-Maintenance Coating: Pyrolytic coating on first surface.
13. Ceramic-Coated Spandrel Glass: ASTM C 1048, Condition B, Type I, Quality-Q3, and complying with other requirements specified.
 - a. Glass: Clear float **OR** Ultraclear float **OR** Tinted float, **as directed**.
 - b. Tint Color: Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 - c. Ceramic Coating Color: As selected from manufacturer's full range.
14. Silicone-Coated Spandrel Glass: ASTM C 1048, Condition C, Type I, Quality-Q3, and complying with other requirements specified.
 - a. Glass: Clear float **OR** Ultraclear float **OR** Tinted float, **as directed**.
 - b. Tint Color: Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 - c. Silicone Coating Color: As selected from manufacturer's full range.
15. Reflective-Coated Spandrel Glass: ASTM C 1376, Kind CS; coated by pyrolytic process **OR** vacuum deposition (sputter-coating) process, **as directed**, and complying with other requirements specified.
 - a. Coating Color: Gold **OR** Pewter **OR** Silver, **as directed**.
 - b. Glass: Clear float **OR** Ultraclear float **OR** Tinted float, **as directed**.
 - c. Tint Color: Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 - d. Visible Light Transmittance: as directed by the Owner.
 - e. Outdoor Visible Reflectance: as directed by the Owner.

C. Laminated Glass

1. Laminated Glass: ASTM C 1172, and complying with testing requirements in 16 CFR 1201 for Category II materials, and with other requirements specified. Use materials that have a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after fabrication and installation.
 - a. Construction: Laminate glass with polyvinyl butyral interlayer or cast-in-place and cured-transparent-resin interlayer to comply with interlayer manufacturer's written recommendations.
 - b. Interlayer Thickness: Provide thickness not less than that indicated and as needed to comply with requirements.
 - c. Interlayer Color: Clear unless otherwise indicated.
2. Windborne-Debris-Impact-Resistant Laminated Glass: ASTM C 1172, and complying with testing requirements in 16 CFR 1201 for Category II materials, with "Windborne-Debris-Impact Resistance" Paragraph in "Glass Products, General" Article, and with other requirements specified. Use materials that have a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after fabrication and installation.
 - a. Construction: Laminate glass with one of the following to comply with interlayer manufacturer's written recommendations:



- 1) Polyvinyl butyral interlayer.
 - 2) Polyvinyl butyral interlayers reinforced with polyethylene terephthalate film.
 - 3) Ionoplast interlayer.
 - 4) Cast-in-place and cured-transparent-resin interlayer.
 - 5) Cast-in-place and cured-transparent-resin interlayer reinforced with polyethylene terephthalate film.
- b. Interlayer Thickness: Provide thickness not less than that indicated and as needed to comply with requirements.
- c. Interlayer Color: Clear unless otherwise indicated.
3. Glass: Comply with applicable requirements in "Glass Products" Article as indicated by designations in "Laminated-Glass Types" Article.
- D. Insulating Glass
1. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified according to ASTM E 2190, and complying with other requirements specified.
 - a. Sealing System: Dual seal, with manufacturer's standard **OR** polyisobutylene and polysulfide **OR** polyisobutylene and silicone **OR** polyisobutylene and hot-melt butyl **OR** polyisobutylene and polyurethane, **as directed**, primary and secondary.
 - b. Spacer: Manufacturer's standard spacer material and construction **OR** Aluminum with mill or clear anodic finish **OR** Aluminum with black, color anodic finish **OR** Aluminum with bronze, color anodic finish **OR** Aluminum with powdered metal paint finish in color selected **OR** Galvanized steel **OR** Stainless steel **OR** Polypropylene covered stainless steel in color selected **OR** Thermally broken aluminum **OR** Nonmetallic laminate **OR** Nonmetallic tube, **as directed**.
 - c. Desiccant: Molecular sieve or silica gel, or blend of both.
 2. Glass: Comply with applicable requirements in "Glass Products" Article and in "Laminated Glass" Article, **as directed**, as indicated by designations in "Insulating-Glass Types" Article and in "Insulating-Laminated-Glass Types" Article, **as directed**.
- E. Fire-Protection-Rated Glazing
1. Fire-Protection-Rated Glazing, General: Listed and labeled by a testing agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 252 for door assemblies and NFPA 257 for window assemblies.
 2. Monolithic Ceramic Glazing: Clear, ceramic flat glass; 3/16-inch (5-mm) nominal thickness.
 3. Film-Faced Ceramic Glazing: Clear, ceramic flat glass; 3/16-inch (5-mm) nominal thickness; faced on one surface with a clear glazing film; complying with testing requirements in 16 CFR 1201 for Category II materials.
 4. Laminated Ceramic Glazing: Laminated glass made from 2 plies of clear, ceramic flat glass; 5/16-inch (8-mm) total nominal thickness; complying with testing requirements in 16 CFR 1201 for Category II materials.
 5. Fire-Protection-Rated Tempered Glass: 1/4-inch- (6.4-mm-) **OR** 3/8-inch- (9.5-mm-) **OR** 1/2-inch- (12.7-mm-), **as directed**, thick, fire-protection-rated tempered glass, complying with testing requirements in 16 CFR 1201 for Category II materials.
 6. Fire-Protection-Rated Laminated Glass: 5/16-inch- (8-mm-) thick, fire-protection-rated laminated glass, complying with testing requirements in 16 CFR 1201 for Category II materials.
 7. Laminated Glass with Intumescent Interlayers: Laminated glass made from multiple plies of uncoated, clear float glass; with intumescent interlayers; complying with testing requirements in 16 CFR 1201 for Category II materials.
 8. Gel-Filled, Double Glazing Units: Double glazing units made from two lites of uncoated, clear, fully tempered float glass; with a perimeter metal spacer separating lites and dual-edge seal enclosing a cavity filled with clear, fully transparent, heat-absorbing gel; complying with testing requirements in 16 CFR 1201 for Category II materials.
- F. Glazing Gaskets



1. Dense Compression Gaskets: Molded or extruded gaskets of profile and hardness required to maintain watertight seal, made from one of the following:
 - a. Neoprene complying with ASTM C 864.
 - b. EPDM complying with ASTM C 864.
 - c. Silicone complying with ASTM C 1115.
 - d. Thermoplastic polyolefin rubber complying with ASTM C 1115.
2. Soft Compression Gaskets: Extruded or molded, closed-cell, integral-skinned neoprene, EPDM, silicone or thermoplastic polyolefin rubber gaskets complying with ASTM C 509, Type II, black; of profile and hardness required to maintain watertight seal.
 - a. Application: Use where soft compression gaskets will be compressed by inserting dense compression gaskets on opposite side of glazing or pressure applied by means of pressure-glazing stops on opposite side of glazing.
3. Lock-Strip Gaskets: Neoprene extrusions in size and shape indicated, fabricated into frames with molded corner units and zipper lock-strips, complying with ASTM C 542, black.

G. Glazing Sealants

1. General:
 - a. Compatibility: Provide glazing sealants that are compatible with one another and with other materials they will contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
 - b. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
 - c. VOC Content: For sealants used inside of the weatherproofing system, not more than 250 g/L when calculated according to 40 CFR 59, Subpart D.
 - d. Colors of Exposed Glazing Sealants: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
2. Glazing Sealant: Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 100/50, Use NT.
3. Glazing Sealant: Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 50, Use NT.
4. Glazing Sealant: Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use NT.
5. Glazing Sealant: Acid-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use NT.
6. Glazing Sealants for Fire-Rated Glazing Products: Products that are approved by testing agencies that listed and labeled fire-resistant glazing products with which they are used for applications and fire-protection ratings indicated.

H. Glazing Tapes

1. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C 1281 and AAMA 800 for products indicated below:
 - a. AAMA 804.3 tape, where indicated.
 - b. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.
 - c. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.
2. Expanded Cellular Glazing Tapes: Closed-cell, PVC foam tapes; factory coated with adhesive on both surfaces; and complying with AAMA 800 for the following types:
 - a. AAMA 810.1, Type 1, for glazing applications in which tape acts as the primary sealant.
 - b. AAMA 810.1, Type 2, for glazing applications in which tape is used in combination with a full bead of liquid sealant.



- I. Miscellaneous Glazing Materials
1. General: Provide products of material, size, and shape complying with referenced glazing standard, requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.
 2. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.
 3. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.
 4. Spacers: Elastomeric blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.
 5. Edge Blocks: Elastomeric material of hardness needed to limit glass lateral movement (side walking).
 6. Cylindrical Glazing Sealant Backing: ASTM C 1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.
 7. Perimeter Insulation for Fire-Resistive Glazing: Product that is approved by testing agency that listed and labeled fire-resistant glazing product with which it is used for application and fire-protection rating indicated.
- J. Fabrication Of Glazing Units
1. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.
 2. Clean-cut or flat-grind vertical edges of butt-glazed monolithic lites to produce square edges with slight chamfers at junctions of edges and faces.
 3. Grind smooth and polish exposed glass edges and corners.
- K. Monolithic-Glass Types
1. Glass Type: Clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Provide safety glazing labeling.
 2. Glass Type: Ultraclear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Provide safety glazing labeling.
 3. Glass Type: Pyrolytic-coated, self-cleaning, low-maintenance, clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Provide safety glazing labeling.
 4. Glass Type: Tinted float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Winter Nighttime U-Factor: as directed by the Owner.
 - c. Summer Daytime U-Factor: as directed by the Owner.
 - d. Solar Heat Gain Coefficient: as directed by the Owner.
 - e. Provide safety glazing labeling.
 5. Glass Type: Polished wired glass.
 - a. Thickness: 6.0 mm.
 6. Glass Type: Patterned glass.
 - a. Thickness: 4.0 **OR** 5.0 **OR** 6.0, **as directed**, mm.
 7. Glass Type: Tempered patterned glass.
 - a. Thickness: 4.0 **OR** 5.0 **OR** 6.0, **as directed**, mm.
 - b. Provide safety glazing labeling.
 8. Glass Type: Patterned wired glass.
 - a. Thickness: 6.0 mm.



9. Glass Type: Ceramic-coated vision glass, heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Coating Location: Second surface.
 - c. Winter Nighttime U-Factor: as directed by the Owner.
 - d. Summer Daytime U-Factor: as directed by the Owner.
 - e. Solar Heat Gain Coefficient: as directed by the Owner.
 - f. Provide safety glazing labeling.
10. Glass Type: Reflective-coated vision glass, float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Coating Location: First **OR** Second, **as directed**, surface.
 - c. Winter Nighttime U-Factor: as directed by the Owner.
 - d. Summer Daytime U-Factor: as directed by the Owner.
 - e. Solar Heat Gain Coefficient: as directed by the Owner.
 - f. Provide safety glazing labeling.
11. Glass Type: Ceramic-coated spandrel glass, heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Coating Location: Second surface.
 - c. Winter Nighttime U-Factor: as directed by the Owner.
 - d. Summer Daytime U-Factor: as directed by the Owner.
 - e. Fallout Resistance: Passes fallout-resistance test in ASTM C 1048 for an assembly of glass and adhered reinforcing material.
12. Glass Type: Silicone-coated spandrel glass, heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Coating Location: Second surface.
 - c. Winter Nighttime U-Factor: as directed by the Owner.
 - d. Summer Daytime U-Factor: as directed by the Owner.
 - e. Fallout Resistance: Passes fallout-resistance test in ASTM C 1048 for an assembly of glass and adhered reinforcing material.
13. Glass Type: Reflective-coated spandrel glass, heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness: 6.0 mm.
 - b. Coating Location: First **OR** Second, **as directed**, surface.
 - c. Winter Nighttime U-Factor: as directed by the Owner.
 - d. Summer Daytime U-Factor: as directed by the Owner.
 - e. Fallout Resistance: Passes fallout-resistance test in ASTM C 1048 for an assembly of glass and adhered reinforcing material.
 - f. Factory apply manufacturer's standard opacifier of the following material to coated second surface of lites, with resulting products complying with Specification No. 89-1-6 in GANA's Tempering Division's "Engineering Standards Manual":
 - 1) Manufacturer's standard opacifier material.

OR

 Polyester film laminated to glass with solvent-based adhesive.

L. Laminated-Glass Types

1. Glass Type: Clear laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass **OR** ultraclear float glass **OR** ultraclear heat-strengthened float glass **OR** ultraclear fully tempered float glass, **as directed**.
 - a. Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - b. Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.



- c. Provide safety glazing labeling.
2. Glass Type: Antireflective-coated clear laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass **OR** ultraclear float glass **OR** ultraclear heat-strengthened float glass **OR** ultraclear fully tempered float glass, **as directed**.
 - a. Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - b. Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - c. Visible Reflectance: Less than 2 percent.
 - d. Winter Nighttime U-Factor: as directed by the Owner.
 - e. Summer Daytime U-Factor: as directed by the Owner.
 - f.
 - g. Solar Heat Gain Coefficient: as directed by the Owner.
 - h.
 - i. Provide safety glazing labeling.
3. Glass Type: Tinted laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**, with outer ply Class 2 (tinted) and inner ply Class 1 (clear).
 - a. Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - b. Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - c. Winter Nighttime U-Factor: as directed by the Owner.
 - d.
 - e. Summer Daytime U-Factor: as directed by the Owner.
 - f.
 - g. Solar Heat Gain Coefficient: as directed by the Owner.
 - h.
 - i. Provide safety glazing labeling.
4. Glass Type: Tinted laminated glass with two plies of clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**, and tinted interlayer.
 - a. Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - b. Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - c. Interlayer Color: Blue-green **OR** Bronze light **OR** Gray, **as directed**.
 - d. Winter Nighttime U-Factor: as directed by the Owner.
 - e.
 - f. Summer Daytime U-Factor: as directed by the Owner.
 - g.
 - h. Solar Heat Gain Coefficient: as directed by the Owner.
 - i. Provide safety glazing labeling.
5. Glass Type: Ceramic-coated, laminated vision glass with two plies of heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - b. Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - c. Coating Location: Second **OR** Third **OR** Fourth, **as directed**, surface.
 - d. Winter Nighttime U-Factor: as directed by the Owner.
 - e.
 - f. Summer Daytime U-Factor: as directed by the Owner.
 - g.
 - h. Solar Heat Gain Coefficient: as directed by the Owner.
 - i.
 - j. Provide safety glazing labeling.



6. Glass Type: Reflective-coated, laminated vision glass with two plies of heat-strengthened float glass **OR** fully tempered float glass, **as directed**, with inner ply Class 1 (clear).
 - a. Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - b. Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - c. Coating Location: First **OR** Second **OR** Third, **as directed**, surface.
 - d. Winter Nighttime U-Factor: as directed by the Owner.
 - e.
 - f. Summer Daytime U-Factor: as directed by the Owner.
 - g.
 - h. Solar Heat Gain Coefficient: as directed by the Owner.
 - i. Provide safety glazing labeling.
7. Glass Type: Low-e-coated, laminated vision glass with two plies of clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - a. Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - b. Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - c. Low-E Coating: Pyrolytic on second **OR** Pyrolytic on third **OR** Sputtered on second **OR** Sputtered on third **OR** Pyrolytic or sputtered on second or third, **as directed**, surface.
 - d. Visible Light Transmittance: as directed by the Owner.
 - e.
 - f. Winter Nighttime U-Factor: as directed by the Owner.
 - g.
 - h. Summer Daytime U-Factor: as directed by the Owner.
 - i.
 - j. Solar Heat Gain Coefficient: as directed by the Owner.
 - k.
 - l. Provide safety glazing labeling.
8. Glass Type: Reflective-coated, laminated spandrel glass with two plies of heat-strengthened float glass **OR** fully tempered float glass, **as directed**, with inner ply Class 1 (clear).
 - a. Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - b. Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - c. Coating Location: First **OR** Second **OR** Third, **as directed**, surface.
 - d. Winter Nighttime U-Factor: as directed by the Owner.
 - e.
 - f. Summer Daytime U-Factor: as directed by the Owner.
 - g.

M. Insulating-Glass Types

1. Glass Type: Clear insulating glass.
 - a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass, **as directed**.
 - f. Winter Nighttime U-Factor: as directed by the Owner.
 - g.
 - h. Summer Daytime U-Factor: as directed by the Owner.
 - i. Provide safety glazing labeling.



2. Glass Type: Ultraclear insulating glass.
 - a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Ultraclear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Ultraclear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - f. Winter Nighttime U-Factor: as directed by the Owner.
 - g.
 - h. Summer Daytime U-Factor: as directed by the Owner.
 - i.
 - j. Provide safety glazing labeling.
3. Glass Type: Pyrolytic-coated, self-cleaning, low-maintenance, clear insulating glass.
 - a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Pyrolytic-coated, self-cleaning, low-maintenance, clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass, **as directed**.
 - f. Winter Nighttime U-Factor: as directed by the Owner.
 - g. Summer Daytime U-Factor: as directed by the Owner.
 - h. Provide safety glazing labeling.
4. Glass Type: Low-e-coated, clear insulating glass.
 - a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass **OR** Ultraclear float glass **OR** Ultraclear heat-strengthened float glass **OR** Ultraclear fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass **OR** Ultraclear float glass **OR** Ultraclear heat-strengthened float glass **OR** Ultraclear fully tempered float glass, **as directed**.
 - f. Low-E Coating: Pyrolytic on second **OR** Pyrolytic on third **OR** Sputtered on second **OR** Sputtered on third **OR** Pyrolytic or sputtered on second or third, **as directed**, surface.
 - g. Visible Light Transmittance: as directed by the Owner.
 - h. Winter Nighttime U-Factor: as directed by the Owner.
 - i. Summer Daytime U-Factor: as directed by the Owner.
 - j. Solar Heat Gain Coefficient: as directed by the Owner.
 - k. Provide safety glazing labeling.
5. Glass Type: Tinted insulating glass.
 - a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Tinted float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - f. Winter Nighttime U-Factor: as directed by the Owner.
 - g. Summer Daytime U-Factor: as directed by the Owner.
 - h. Solar Heat Gain Coefficient: as directed by the Owner.
 - i. Provide safety glazing labeling.
6. Glass Type: Low-e-coated, tinted insulating glass.
 - a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.



- c. Outdoor Lite: Tinted float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - f. Low-E Coating: Pyrolytic on second **OR** Pyrolytic on third **OR** Sputtered on second **OR** Sputtered on third **OR** Pyrolytic or sputtered on second or third, **as directed**, surface.
 - g. Visible Light Transmittance: as directed by the Owner.
 - h. Winter Nighttime U-Factor: as directed by the Owner.
 - i. Summer Daytime U-Factor: as directed by the Owner.
 - j. Solar Heat Gain Coefficient: as directed by the Owner.
 - k. Provide safety glazing labeling.
7. Glass Type: Ceramic-coated, insulating vision glass.
- a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Heat-strengthened float glass **OR** Fully tempered float glass **OR** Ultraclear heat-strengthened float glass **OR** Ultraclear fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass **OR** Ultraclear float glass **OR** Ultraclear heat-strengthened float glass **OR** Ultraclear fully tempered float glass, **as directed**.
 - f. Coating Location: Second **OR** Third **OR** Fourth, **as directed**, surface.
 - g. Winter Nighttime U-Factor: as directed by the Owner.
 - h. Summer Daytime U-Factor: as directed by the Owner.
 - i. Solar Heat Gain Coefficient: as directed by the Owner.
 - j. Provide safety glazing labeling.
8. Glass Type: Reflective-coated, clear insulating glass.
- a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - f. Coating Location: First **OR** Second **OR** Third, **as directed**, surface.
 - g. Winter Nighttime U-Factor: as directed by the Owner.
 - h. Summer Daytime U-Factor: as directed by the Owner.
 - i. Solar Heat Gain Coefficient: as directed by the Owner.
 - j. Provide safety glazing labeling.
9. Glass Type: Reflective-coated, tinted insulating glass.
- a. Overall Unit Thickness: 1 inch (25 mm) **OR** 5/8 inch (16 mm), **as directed**.
 - b. Thickness of Each Glass Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Tinted float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - f. Coating Location: First **OR** Second **OR** Third, **as directed**, surface.
 - g. Winter Nighttime U-Factor: as directed by the Owner.
 - h. Summer Daytime U-Factor: as directed by the Owner.
 - i. Solar Heat Gain Coefficient: as directed by the Owner.
 - j. Provide safety glazing labeling.
10. Glass Type: Ceramic-coated **OR** Silicone-coated, **as directed**, insulating spandrel glass.
- a. Overall Unit Thickness: 1 inch (25 mm).
 - b. Thickness of Each Glass Lite: 5.0 mm **OR** 6.0 mm, **as directed**.



- c. Outdoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass **OR** Ultraclear float glass **OR** Ultraclear heat-strengthened float glass **OR** Ultraclear fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass **OR** Ultraclear float glass **OR** Ultraclear heat-strengthened float glass **OR** Ultraclear fully tempered float glass, **as directed**.
 - f. Coating Location: Fourth surface.
 - g. Winter Nighttime U-Factor: as directed by the Owner.
 - h. Summer Daytime U-Factor: as directed by the Owner.
11. Glass Type: Ceramic-coated **OR** Silicone-coated, **as directed**, low-e, insulating spandrel glass.
- a. Overall Unit Thickness: 1 inch (25 mm).
 - b. Thickness of Each Glass Lite: 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass **OR** Ultraclear float glass **OR** Ultraclear heat-strengthened float glass **OR** Ultraclear fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Float glass **OR** Heat-strengthened float glass **OR** Fully tempered float glass **OR** Ultraclear float glass **OR** Ultraclear heat-strengthened float glass **OR** Ultraclear fully tempered float glass, **as directed**.
 - f. Low-E Coating: Pyrolytic on second **OR** Pyrolytic on third **OR** Sputtered on second **OR** Sputtered on third **OR** Pyrolytic or sputtered on second or third, **as directed**, surface.
 - g. Opaque Coating Location: Fourth surface.
 - h. Winter Nighttime U-Factor: as directed by the Owner.
 - i. Summer Daytime U-Factor: as directed by the Owner.
12. Glass Type: Ceramic-coated **OR** Silicone-coated, **as directed**, tinted, insulating spandrel glass.
- a. Overall Unit Thickness: 1 inch (25 mm).
 - b. Thickness of Each Glass Lite: 5.0 mm **OR** 6.0 mm.
 - c. Outdoor Lite: Tinted float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - f. Coating Location: Fourth surface.
 - g. Winter Nighttime U-Factor: as directed by the Owner.
 - h. Summer Daytime U-Factor: as directed by the Owner.
- N. Insulating-Laminated-Glass Types
- 1. Glass Type: Clear insulating laminated glass.
 - a. Overall Unit Thickness: 1-3/16 inch (30 mm) **OR** 1 inch (25 mm) **OR** 3/4 inch (19 mm), **as directed**.
 - b. Thickness of Outdoor Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Heat-strengthened float glass **OR** Fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - 1) Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - 2) Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - f. Winter Nighttime U-Factor: as directed by the Owner.
 - g. Summer Daytime U-Factor: as directed by the Owner.
 - h. Solar Heat Gain Coefficient: as directed by the Owner.
 - i. Provide safety glazing labeling.
 - 2. Glass Type: Low-e-coated, clear insulating laminated glass.



- a. Overall Unit Thickness: 1-3/16 inch (30 mm) **OR** 1 inch (25 mm) **OR** 3/4 inch (19 mm), **as directed**.
 - b. Thickness of Outdoor Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Heat-strengthened float glass **OR** Fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - 1) Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - 2) Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - f. Low-E Coating: Pyrolytic on second **OR** Pyrolytic on third **OR** Sputtered on second **OR** Sputtered on third **OR** Pyrolytic or sputtered on second or third, **as directed**, surface.
 - g. Visible Light Transmittance: as directed by the Owner.
 - h. Winter Nighttime U-Factor: as directed by the Owner.
 - i. Summer Daytime U-Factor: as directed by the Owner.
 - j. Solar Heat Gain Coefficient: as directed by the Owner.
 - k. Provide safety glazing labeling.
3. Glass Type: Tinted, insulating laminated glass.
- a. Overall Unit Thickness: 1-3/16 inch (30 mm) **OR** 1 inch (25 mm) **OR** 3/4 inch (19 mm), **as directed**.
 - b. Thickness of Outdoor Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Tinted heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - 1) Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - 2) Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - f. Winter Nighttime U-Factor: as directed by the Owner.
 - g. Summer Daytime U-Factor: as directed by the Owner.
 - h. Solar Heat Gain Coefficient: as directed by the Owner.
 - i. Provide safety glazing labeling.
4. Glass Type: Low-e-coated, tinted, insulating laminated glass.
- a. Overall Unit Thickness: 1-3/16 inch (30 mm) **OR** 1 inch (25 mm) **OR** 3/4 inch (19 mm), **as directed**.
 - b. Thickness of Outdoor Lite: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**.
 - c. Outdoor Lite: Tinted heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - 1) Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - 2) Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - f. Low-E Coating: Pyrolytic on second **OR** Pyrolytic on third **OR** Sputtered on second **OR** Sputtered on third **OR** Pyrolytic or sputtered on second or third, **as directed**, surface.
 - g. Visible Light Transmittance: as directed by the Owner.
 - h. Winter Nighttime U-Factor: as directed by the Owner.
 - i. Summer Daytime U-Factor: as directed by the Owner.
 - j. Solar Heat Gain Coefficient: as directed by the Owner.
 - k. Provide safety glazing labeling.



5. Glass Type: Reflective-coated, clear, insulating laminated glass.
 - a. Overall Unit Thickness: 1-3/16 inch (30 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Thickness of Outdoor Lite: 6.0 mm.
 - c. Outdoor Lite: Clear heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - 1) Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - 2) Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - f. Coating Location: First **OR** Second **OR** Third, **as directed**, surface.
 - g. Winter Nighttime U-Factor: as directed by the Owner.
 - h. Summer Daytime U-Factor: as directed by the Owner.
 - i. Solar Heat Gain Coefficient: as directed by the Owner.
 - j. Provide safety glazing labeling.
 6. Glass Type: Reflective-coated, tinted, insulating laminated glass.
 - a. Overall Unit Thickness: 1-3/16 inch (30 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Thickness of Outdoor Lite: 6.0 mm.
 - c. Outdoor Lite: Tinted heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - d. Interspace Content: Air **OR** Argon, **as directed**.
 - e. Indoor Lite: Clear laminated glass with two plies of float glass **OR** heat-strengthened float glass **OR** fully tempered float glass, **as directed**.
 - 1) Thickness of Each Glass Ply: 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm **OR** As indicated, **as directed**.
 - 2) Interlayer Thickness: 0.030 inch (0.76 mm) **OR** 0.060 inch (1.52 mm) **OR** 0.090 inch (2.29 mm), **as directed**.
 - f. Coating Location: First **OR** Second **OR** Third, **as directed**, surface.
 - g. Winter Nighttime U-Factor: as directed by the Owner.
 - h. Summer Daytime U-Factor: as directed by the Owner.
 - i. Solar Heat Gain Coefficient: as directed by the Owner.
 - j. Provide safety glazing labeling.
- O. Fire-Protection-Rated Glazing Types
1. Glass Type: 20-minute fire-rated glazing without hose-stream test; monolithic ceramic glazing **OR** film-faced ceramic glazing **OR** laminated ceramic glazing **OR** fire-protection-rated tempered glass **OR** fire-protection-rated laminated glass **OR** gel-filled, double glazing units, **as directed**.
 - a. Provide safety glazing labeling.
 2. Glass Type: 20-minute fire-rated glazing with hose-stream test; monolithic ceramic glazing **OR** film-faced ceramic glazing **OR** laminated ceramic glazing **OR** gel-filled, double glazing units, **as directed**.
 - a. Provide safety glazing labeling.
 3. Glass Type: 45-minute **OR** 60-minute **OR** 90-minute **OR** 120-minute, **as directed**, fire-rated glazing; monolithic ceramic glazing **OR** film-faced ceramic glazing **OR** laminated ceramic glazing **OR** laminated glass with intumescent interlayers **OR** gel-filled, double glazing units, **as directed**.
 - a. Provide safety glazing labeling.
 4. Glass Type: 45-minute **OR** 60-minute **OR** 90-minute **OR** 120-minute, **as directed**, fire-rated glazing with 450 deg F (250 deg C) temperature rise limitation; laminated glass with intumescent interlayers **OR** gel-filled, double glazing units, **as directed**.
 - a. Provide safety glazing labeling.



1.3 EXECUTION

A. Examination

1. Examine framing, glazing channels, and stops, with Installer present, for compliance with the following:
 - a. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.
 - b. Presence and functioning of weep systems.
 - c. Minimum required face and edge clearances.
 - d. Effective sealing between joints of glass-framing members.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.
2. Examine glazing units to locate exterior and interior surfaces. Label or mark units as needed so that exterior and interior surfaces are readily identifiable. Do not use materials that will leave visible marks in the completed work.

C. Glazing, General

1. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.
2. Adjust glazing channel dimensions as required by Project conditions during installation to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.
3. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.
4. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.
5. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.
6. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.
7. Provide spacers for glass lites where length plus width is larger than 50 inches (1270 mm).
 - a. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
 - b. Provide 1/8-inch (3-mm) minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.
8. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.
9. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.
10. Set glass lites with proper orientation so that coatings face exterior or interior as specified.
11. Where wedge-shaped gaskets are driven into one side of channel to pressurize sealant or gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.
12. Square cut wedge-shaped gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away; seal corner joints and butt joints with sealant recommended by gasket manufacturer.



- D. Tape Glazing
1. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.
 2. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.
 3. Cover vertical framing joints by applying tapes to heads and sills first and then to jambs. Cover horizontal framing joints by applying tapes to jambs and then to heads and sills.
 4. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.
 5. Do not remove release paper from tape until right before each glazing unit is installed.
 6. Apply heel bead of elastomeric sealant.
 7. Center glass lites in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.
 8. Apply cap bead of elastomeric sealant over exposed edge of tape.
- E. Gasket Glazing (Dry)
1. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.
 2. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.
 3. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.
 4. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.
 5. Install gaskets so they protrude past face of glazing stops.
- F. Sealant Glazing (Wet)
1. Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or spacers and backings in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.
 2. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.
 3. Tool exposed surfaces of sealants to provide a substantial wash away from glass.
- G. Lock-Strip Gasket Glazing
1. Comply with ASTM C 716 and gasket manufacturer's written instructions. Provide supplementary wet seal and weep system unless otherwise indicated.
- H. Cleaning And Protection
1. Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove nonpermanent labels and clean surfaces.
 2. Protect glass from contact with contaminating substances resulting from construction operations. If, despite such protection, contaminating substances do come into contact with glass, remove substances immediately as recommended in writing by glass manufacturer.



3. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains; remove as recommended in writing by glass manufacturer.
4. Remove and replace glass that is broken, chipped, cracked, or abraded or that is damaged from natural causes, accidents, and vandalism, during construction period.
5. Wash glass on both exposed surfaces in each area of Project not more than four days before date scheduled for inspections that establish date of Final Completion. Wash glass as recommended in writing by glass manufacturer.

END OF SECTION 07 42 13 19



Task	Specification	Specification Description
07 42 63 00	01 22 16 00	No Specification Required



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**SECTION 07 46 16 00 - METAL WALL PANELS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for metal wall panels. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Exposed-fastener, lap-seam metal wall panels.
 - b. Concealed-fastener, lap-seam metal wall panels.
 - c. Metal liner panels.
 - d. Metal soffit panels.

C. Definition

1. Metal Wall Panel Assembly: Metal wall panels, attachment system components, miscellaneous metal framing, thermal insulation, and accessories necessary for a complete weathertight wall system.

D. Performance Requirements

1. General Performance: Metal wall panel assemblies shall comply with performance requirements without failure due to defective manufacture, fabrication, installation, or other defects in construction.
2. Delegated Design: Design metal wall panel assembly, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Air Infiltration: Air leakage through assembly of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) of wall area when tested according to ASTM E 283 at the following test-pressure difference:
 - a. Test-Pressure Difference: 1.57 lbf/sq. ft. (75 Pa).
4. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:
 - a. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa) which is equivalent to a 50-mph (80-km/h) wind.
5. Water Penetration under Dynamic Pressure: No evidence of water leakage when tested according to AAMA 501.1 under dynamic pressure equal to 20 percent of inward-acting, wind-load design pressure of not less than 6.24 lbf/sq. ft. (300 Pa) (which is equivalent to a 50-mph (80-km/h) wind) and not more than 12 lbf/sq. ft. (575 Pa).
 - a. Water Leakage: As defined according to AAMA 501.1.
OR
Water Leakage: Uncontrolled water infiltrating the system or appearing on system's normally exposed interior surfaces from sources other than condensation. Water controlled by flashing and gutters that is drained back to the exterior and cannot damage adjacent materials or finishes is not water leakage.
6. Structural Performance: Provide metal wall panel assemblies capable of withstanding the effects the following loads and stresses within limits and under conditions indicated, based on testing according to ASTM E 1592:
 - a. Wind Loads: Determine loads based on the following minimum design wind pressures:
 - 1) Uniform pressure of 20 lbf/sq. ft. (957 Pa) **OR** 30 lbf/sq. ft. (1436 Pa), **as directed**, acting inward or outward.
OR
Uniform pressure as indicated on Drawings.



- b. Deflection Limits: Metal wall panel assemblies shall withstand wind loads with horizontal deflections no greater than 1/180 **OR** 1/240, **as directed**, of the span.
7. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show fabrication and installation layouts of metal wall panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details. Distinguish between factory-, shop- and field-assembled work.
3. Samples: For each type of exposed finish required.
4. Delegated-Design Submittal: For metal wall panel assembly indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Coordination Drawings: Exterior elevations drawn to scale and coordinating penetrations and wall-mounted items.
6. Product Test Reports.
7. Field quality-control reports.
8. Maintenance Data.
9. Warranties: Sample of special warranties.

F. Quality Assurance

1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
2. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
3. Fire-Resistance Ratings: Where indicated, provide metal wall panels identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
4. Preinstallation Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Deliver components, sheets, metal wall panels, and other manufactured items so as not to be damaged or deformed. Package metal wall panels for protection during transportation and handling.
2. Unload, store, and erect metal wall panels in a manner to prevent bending, warping, twisting, and surface damage.
3. Stack metal wall panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal wall panels to ensure dryness, with positive slope for drainage of water. Do not store metal wall panels in contact with other materials that might cause staining, denting, or other surface damage.
4. Retain strippable protective covering on metal wall panel for period of metal wall panel installation.
5. Protect foam-plastic insulation as follows:
 - a. Do not expose to sunlight, except to extent necessary for period of installation and concealment.
 - b. Protect against ignition at all times. Do not deliver foam-plastic insulation materials to Project site before installation time.
 - c. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

H. Warranty



1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal wall panel assemblies that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period: Two years from date of Final Completion.
2. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal wall panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - a. Finish Warranty Period:
 - 1) 20 years from date of Final Completion for fluoropolymer finish.
 - 2) 10 years from date of Final Completion for siliconized polyester.

1.2 PRODUCTS

A. Panel Materials

1. Metallic-Coated Steel Sheet: Restricted flatness steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - b. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - c. Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 - d. Exposed Coil-Coated Finish:
 - 1) 2-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) 3-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) 4-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 4) Mica Fluoropolymer: AAMA 621. 2-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 5) Metallic Fluoropolymer: AAMA 621. 3-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 6) FEVE Fluoropolymer: AAMA 621. 2-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 7) Siliconized-Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mil (0.97 mm) for topcoat.
 - e. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).



2. Aluminum Sheet: Coil-coated sheet, ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.
 - a. Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 - b. Exposed Coil-Coated Finish:
 - 1) 2-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) 3-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) 4-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 4) Mica Fluoropolymer: AAMA 620. 2-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 5) Metallic Fluoropolymer: AAMA 620. 3-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 6) FEVE Fluoropolymer: AAMA 620. 2-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 7) Siliconized-Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mil (0.97 mm) for topcoat.
 - c. Exposed Anodized Finish:
 - 1) Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
 - 2) Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - d. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
3. Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 temper.
 - a. Exposed Finish: Apply the following finish, as specified or indicated on Drawings.
 - 1) Natural finish.
 - 2) Brushed Satin: CDA M32-06x (Mechanical Finish: directionally textured, medium satin; Coating: clear organic, air drying, as specified below):
 - a) Clear, Organic Coating: Clear, air-drying, acrylic lacquer specially developed for coating copper-alloy products, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
 - 3) Mirror Polished: CDA M22-06x (Mechanical Finish: buffed, specular; Coating: clear organic, air drying, as specified below):
 - a) Clear, Organic Coating: Clear, air-drying, acrylic lacquer specially developed for coating copper-alloy products, applied by air spray in two coats per



- manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
- 4) Pre-patinated: ASTM B 882. Copper sheets artificially aged by chemical reaction to convert surface to inorganic crystalline structure with color range and durability of naturally-formed patina.
4. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304 **OR** 316, **as directed**, fully annealed.
 - a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 - b. Polished Finish: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1) Run grain of directional finishes with long dimension of each piece.
 - 2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - 3) Directional Satin Finish: No. 4.
 - c. Bright, Cold-Rolled, Unpolished Finish: No. 2B.
 5. Panel Sealants:
 - a. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
 - b. Joint Sealant: ASTM C 920; elastomeric polyurethane, polysulfide, or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal wall panels and remain weathertight; and as recommended in writing by metal wall panel manufacturer.
 - c. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.
- B. Field-Installed Thermal Insulation
1. Unfaced, Polyisocyanurate Board Insulation: ASTM C 591, Type II, compressive strength of 35 psi (241 kPa), with maximum flame-spread index of 75 and smoke-developed index of 450.
 2. Faced, Polyisocyanurate Board Insulation: ASTM C 1289, Type I (foil facing), Class 1 or 2 **OR** Type II (asphalt felt or glass-fiber mat facing), Class 2 or 3, Grade 3, **as directed**, with maximum flame-spread index of 75 and smoke-developed index of 450, based on tests performed on unfaced core.
 3. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.60-lb/cu. ft. (26-kg/cu. m), with maximum flame-spread index of 75 and smoke-developed index of 450.
 4. Molded-Polystyrene Board Insulation: ASTM C 578, Type I, 0.9 lb/cu. ft. (15 kg/cu. m) **OR** Type II, 1.35 lb/cu. ft. (22 kg/cu. m), **as directed**, with maximum flame-spread index of 75 and smoke-developed index of 450.
 5. Unfaced, Glass-Fiber Board Insulation: ASTM C 612, Type IA or Types IA and IB; with maximum flame-spread index of 25 and smoke-developed index of 50, and with a nominal density of 3 lb/cu. ft. (48 kg/cu. m).
 6. Mineral-Fiber-Blanket Insulation: ASTM C 665, type indicated below; consisting of fibers manufactured from glass **OR** slag or rock wool, **as directed**.
 - a. Type I (blankets without membrane covering), passing ASTM E 136 for combustion characteristics.
 - b. Type II (blankets with nonreflective membrane covering), Category 1 (membrane is a vapor retarder), Class A (membrane-faced surface with a flame-spread index of 25 or less).
 - c. Type III (blankets with reflective membrane covering), Category 1 (membrane is a vapor retarder), Class A (membrane-faced surface with a flame-spread index of 25 or less).
 7. Metal Building Insulation: ASTM C 991, Type I; or NAIMA 202 **OR** ASTM C 991, Type II, **as directed**, glass-fiber-blanket insulation; 0.5-lb/cu. ft. (8-kg/cu. m) density; 2-inch- (50-mm-) wide, continuous, vapor-tight edge tabs; and with a flame-spread index of 25 or less.
 - a. Vapor-Retarder Facing: ASTM C 1136, with permeance not greater than 0.02 perm (1.15 ng/Pa x s x sq. m) when tested according to ASTM E 96, Desiccant Method:
 - 1) Composition: Polypropylene faced, scrim reinforced, and kraft-paper backing **OR** Foil faced, scrim reinforced, and kraft-paper backing with vapor-retarder coating **OR** Polypropylene faced, scrim reinforced, and foil backing **OR** Vinyl faced, scrim reinforced, and foil backing **OR** Vinyl faced, scrim reinforced, and polyester backing, **as directed**.



- b. Insulation Retainer Strips: 0.019-inch- (0.48-mm-) thick, formed galvanized steel or PVC retainer clips colored to match insulation facing.

C. Miscellaneous Metal Framing

1. Miscellaneous Metal Framing, General: ASTM C 645, cold-formed metallic-coated steel sheet, ASTM A 653/A 653M, G40 (Z120) hot-dip galvanized **OR** ASTM A 653/A 653M, G60 (Z180) hot-dip galvanized, **as directed**, or coating with equivalent corrosion resistance unless otherwise indicated.
2. Subgirts: Manufacturer's standard C- or Z-shaped sections, 0.064-inch (1.63-mm) nominal thickness.
3. Zee Clips: 0.079-inch (2.01-mm) nominal thickness.
4. Base or Sill Angles **OR** Channels, **as directed**: 0.079-inch (2.01-mm) nominal thickness.
5. Hat-Shaped, Rigid Furring Channels:
 - a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.025 inch (0.64 mm) **OR** 0.040 inch (1.02 mm), **as directed**.
 - b. Depth: As indicated **OR** 7/8 inch (22 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
6. Cold-Rolled Furring Channels: Minimum 1/2-inch- (13-mm-) wide flange.
 - a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.064 inch (1.63 mm), **as directed**.
 - b. Depth: As indicated **OR** 3/4 inch (19 mm), **as directed**.
 - c. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with 0.040-inch (1.02-mm) nominal thickness.
 - d. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.57-mm-) diameter wire, or double strand of 0.048-inch- (1.22-mm-) diameter wire.
7. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches (32 mm), wall attachment flange of 7/8 inch (22 mm), and depth required to fit insulation thickness indicated.
 - a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.025 inch (0.64 mm), **as directed**.
8. Fasteners for Miscellaneous Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten miscellaneous metal framing members to substrates.

D. Miscellaneous Materials

1. Panel Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide exposed fasteners with heads matching color of metal wall panels by means of plastic caps or factory-applied coating. Provide EPDM, PVC, or neoprene sealing washers.

E. Exposed-Fastener, Lap-Seam Metal Wall Panels

1. General: Provide factory-formed metal wall panels designed to be field assembled by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps. Include accessories required for weathertight installation.
2. Corrugated-Profile, Exposed-Fastener Metal Wall Panels: Formed with alternating curved ribs spaced at 2.67 inches (68 mm) o.c. across width of panel.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.



- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- d. Panel Coverage: 21.3 inches (541 mm) **OR** 29.3 inches (744 mm) **OR** 34.6 inches (881 mm) **OR** 37.3 inches (947 mm) **OR** 42.6 inches (1084 mm) **OR** 45.3 inches (1151 mm), **as directed**.
- e. Panel Height: 0.5 inch (13 mm) **OR** 0.875 inch (22 mm), **as directed**.
3. Tapered-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major ribs.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Major-Rib Spacing: 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** 9 inches (229 mm) **OR** 12 inches (305 mm), **as directed**, o.c.
 - e. Panel Coverage: 24 inches (610 mm) **OR** 36 inches (914 mm), **as directed**.
 - f. Panel Height: 0.625 inch (16 mm) **OR** 0.75 inch (19 mm) **OR** 1.0 inch (25 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.
4. Reverse-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with recessed, trapezoidal major valleys and intermediate stiffening valleys symmetrically spaced **OR** flat pan, **as directed**, between major valleys.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.



- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- c. Major-Rib Spacing: 12 inches (305 mm) o.c.
- d. Panel Coverage: 36 inches (914 mm).
- e. Panel Height: 1.25 inches (32 mm).
5. Vee-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with raised, V-shaped ribs and recesses that are approximately same size, evenly spaced across panel width, and with rib/recess sides angled at approximately 45 degrees.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Rib Spacing: 5.3 inches (135 mm) **OR** 7.2 inches (183 mm) **OR** 12 inches (305 mm), **as directed**, o.c.
 - e. Panel Coverage: 30 inches (762 mm) **OR** 32 inches (813 mm) **OR** 36 inches (914 mm) **OR** 40 inches (1016 mm), **as directed**.
 - f. Panel Height: 1.375 inches (35 mm) **OR** 1.5 inches (38 mm) **OR** 1.75 inches (44 mm) **OR** 2.0 inches (51 mm) **OR** 3.0 inches (76 mm), **as directed**.
6. Box-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with raised, box-shaped ribs, evenly spaced across panel width, and with rib/recess sides angled 60 degrees or more.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.



- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Rib Spacing: 2.67 inches (68 mm) **OR** 4.0 inches (102 mm) **OR** 5.3 inches (135 mm) **OR** 6.0 inches (152 mm), **as directed**, o.c.
 - e. Panel Coverage: 24 inches (610 mm) **OR** 28 inches (711 mm) **OR** 30 inches (762 mm) **OR** 32 inches (813 mm) **OR** 36 inches (914 mm), **as directed**.
 - f. Panel Height: 0.625 inch (16 mm) **OR** 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 2.0 inches (51 mm), **as directed**.
7. Deep-Box-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with raised, box-shaped ribs, evenly spaced across panel width, and with rib/recess sides angled more than 60 degrees.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Rib Spacing: 12 inches (305 mm) o.c.
 - e. Panel Coverage: 24 inches (610 mm).
 - f. Panel Height: 3.0 inches (76 mm) **OR** 4.0 inches (102 mm), **as directed**.



- F. Concealed-Fastener, Lap-Seam Metal Wall Panels
1. General: Provide factory-formed metal wall panels designed to be field assembled by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for weathertight installation.
 2. Flush-Profile, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with flush joint between panels.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Panel Coverage: 12 inches (305 mm), **as directed**.
 - e. Panel Height: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm), **as directed**.
 3. Reveal-Joint, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with narrow reveal joint between panels.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.



- fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- d. Panel Coverage: 12 inches (305 mm).
- e. Panel Height: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm), **as directed**.
4. Wide-Reveal-Joint, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and stepped profile between panel edges resulting in wide reveal joint between panels.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- d. Panel Coverage: 12 inches (305 mm).
- e. Panel Height: 1.5 inches (38 mm).
5. V-Groove-Profile, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- c. Panel Coverage: 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** 12 inches (305 mm), **as directed**.
- d. Panel Height: 0.625 inch (16 mm) **OR** 1.25 inches (32 mm), **as directed**.
6. Tapered-Rib-Profile, Concealed-Fastener Metal Wall Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major ribs.



- a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Panel Coverage: 12 inches (305 mm) **OR** 14 inches (356 mm), **as directed**.
 - d. Panel Height: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm), **as directed**.
7. Curved-Rib-Profile, Concealed-Fastener Metal Wall Panels: Formed with raised, curved-side major ribs and flat pan between major ribs; with reveal joint between panels.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Panel Coverage: 12 inches (305 mm).
 - e. Panel Height: 0.875 inch (22 mm) **OR** 1.5 inches (38 mm), **as directed**.
8. Creased-Profile, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and center-creased pan between panel edges; with flush joint between panels.
- a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.



- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- d. Panel Coverage: 12 inches (305 mm).
- e. Panel Height: 1.5 inches (38 mm).
9. Creased-Rib-Profile, Concealed-Fastener Metal Wall Panels: Formed with raised, center-creased, trapezoidal major ribs; with reveal joint between panels.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Panel Coverage: 12 inches (305 mm).
 - e. Panel Height: 0.875 inch (22 mm) **OR** 1.5 inches (38 mm), **as directed**.
- G. Metal Liner Panels
 1. General: Provide factory-formed metal liner panels designed for interior side of metal wall panel assemblies and field assembled by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for a complete installation.
 2. Flush-Profile Metal Liner Panels: Solid **OR** Perforated, **as directed**, panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with flush joint between panels.
 - a. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.



- 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- b. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- c. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- d. Panel Coverage: 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 24 inches (610 mm) **OR** 36 inches (914 mm), **as directed**.
- e. Panel Height: 1.5 inches (38 mm) **OR** 2.0 inches (51 mm) **OR** 3.0 inches (76 mm), **as directed**.
- f. Acoustical Performance: Where sound-absorption requirement is indicated, fabricate interior liner panels with 1/8-inch- (3-mm-) diameter holes uniformly spaced approximately 1000 holes/sq. ft. (10 750 holes/sq. m).
 - 1) NRC of not less than 0.65 **OR** 0.85 **OR** 1.00, **as directed**, when tested according to ASTM C 423.

H. Metal Soffit Panels

1. General: Provide factory-formed metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for weathertight installation.
2. Metal Soffit Panels: Match profile and material of metal wall panels.
 - a. Finish: Match finish and color of metal wall panels **OR** As indicated on Drawings, **as directed**.
 - b. Sealant: Factory applied within interlocking joint.
3. Flush-Profile Metal Soffit Panels: Solid **OR** Perforated, **as directed**, panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with flush joint between panels.
 - a. Material: Same material, finish, and color as metal wall panels.
 - b. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.



- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - e. Material: Copper sheet, 16-oz./sq. ft. weight (0.55-mm thickness) **OR** 20-oz./sq. ft. weight (0.68-mm thickness), **as directed**.
 - 1) Exterior Finish: Brushed satin (lacquered) **OR** Mirror polished, **as directed**.
 - f. Panel Coverage: 8 inches (203 mm) **OR** 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 20 inches (508 mm), **as directed**.
 - g. Panel Height: 0.875 inch (22 mm) **OR** 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 3.0 inches (76 mm), **as directed**.
 - h. Sealant: Factory applied within interlocking joint.
4. Reveal-Joint-Profile Metal Soffit Panels: Solid **OR** Perforated, **as directed**, panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with recessed reveal joint between panels.
- a. Material: Same material, finish, and color as metal wall panels.
 - b. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - c. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) nominal thickness.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - d. Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - e. Panel Coverage: 8 inches (203 mm) **OR** 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 20 inches (508 mm), **as directed**.



- f. Panel Height: 0.75 inch (19 mm) **OR** 1.0 inch (25 mm) **OR** 1.5 inches (38 mm), **as directed**.
5. V-Groove-Profile Metal Soffit Panels: Solid **OR** Perforated, **as directed**, panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with V-groove joint between panels.
- a. Material: Same material, finish, and color as metal wall panels.
- b. Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- c. Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) nominal thickness.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
- 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- d. Material: Aluminum sheet, 0.024 inch (0.65 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
- 1) Exterior Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**
- 2) Color: Match finish and color of metal wall panels **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- e. Panel Coverage: 6 inches (152 mm) **OR** 12 inches (305 mm) **OR** 14 inches (356 mm), **as directed**.
- f. Panel Height: 0.375 inch (10 mm) **OR** 0.44 inch (11 mm) **OR** 0.50 inch (13 mm) **OR** 0.625 inch (16 mm), **as directed**.
- I. Accessories
1. Wall Panel Accessories: Provide components required for a complete metal wall panel assembly including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal wall panels, unless otherwise indicated.
- a. Closures: Provide closures at eaves and rakes, fabricated of same metal as metal wall panels.
- b. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
- c. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal wall panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
2. Flashing and Trim: Formed from 0.018-inch (0.46-mm) minimum thickness, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal wall panels.



J. Fabrication

1. General: Fabricate and finish metal wall panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
2. Fabricate metal wall panels in a manner that eliminates condensation on interior side of panel and with joints between panels designed to form weathertight seals.
3. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
4. Fabricate metal wall panel joints with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, and that will minimize noise from movements within panel assembly.
5. Sheet Metal Accessories: Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of item indicated.
 - a. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
 - b. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
 - c. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 - d. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.
 - e. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
 - f. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended by metal wall panel manufacturer.
 - 1) Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal wall panel manufacturer for application but not less than thickness of metal being secured.

K. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

1.3 EXECUTION

A. Preparation

1. Miscellaneous Framing: Install subgirts, base angles, sills, furring, and other miscellaneous wall panel support members and anchorages according to ASTM C 754 and metal wall panel manufacturer's written recommendations.
 - a. Soffit Framing: Wire-tie or clip furring channels to supports, as required to comply with requirements for assemblies indicated.

B. Thermal Insulation Installation

1. Board Insulation: Extend insulation in thickness indicated to cover entire wall. Comply with installation requirements in Division 07 Section "Thermal Insulation".



- a. Erect insulation horizontally and hold in place with Z-shaped furring members spaced 24 inches (610 mm) o.c. Attach furring members to substrate with screws spaced 24 inches (610 mm) o.c.
- b. Retain insulation in place by metal clips and straps or integral pockets within panels, spaced at intervals according to insulation manufacturer's instructions. Maintain cavity width between insulation and metal liner panel of dimension indicated.
2. Blanket Insulation: Install insulation concurrently with metal wall panel installation, in thickness indicated to cover entire wall, according to manufacturer's written instructions and as follows:
 - a. Set vapor-retarder-faced insulation with vapor-retarder facing building exterior **OR** building interior **OR** as indicated on Drawings, **as directed**. Do not obstruct ventilation spaces, except for firestopping.
 - b. Tape joints and ruptures in vapor retarder, and seal each continuous area of insulation to surrounding construction to ensure airtight installation.
 - c. Install insulation straight and true in one-piece lengths. Comply with the following installation method:
 - 1) Over-Framing Installation: Extend insulation over and perpendicular to top flange of framing members.
 - d. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with framing to hold insulation in place.

C. Metal Wall Panel Installation

1. General: Install metal wall panels according to manufacturer's written instructions in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to girts and subgirts unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - a. Commence metal wall panel installation and install minimum of 300 sq. ft. (27.8 sq. m.) in presence of factory-authorized representative.
 - b. Shim or otherwise plumb substrates receiving metal wall panels.
 - c. Flash and seal metal wall panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until weather barrier and flashings that will be concealed by metal wall panels are installed.
 - d. Install screw fasteners in predrilled holes.
 - e. Locate and space fastenings in uniform vertical and horizontal alignment.
 - f. Install flashing and trim as metal wall panel work proceeds.
 - g. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
 - h. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete and elsewhere as indicated or, if not indicated, as necessary for waterproofing.
 - i. Align bottom of metal wall panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
 - j. Provide weathertight escutcheons for pipe and conduit penetrating exterior walls.
2. Fasteners:
 - a. Steel Wall Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized steel fasteners for surfaces exposed to the interior.
 - b. Aluminum Wall Panels: Use aluminum or stainless-steel fasteners for surfaces exposed to the exterior; use aluminum or galvanized steel fasteners for surfaces exposed to the interior.
 - c. Copper Wall Panels: Use copper, stainless-steel or hardware-bronze fasteners.
 - d. Stainless-Steel Wall Panels: Use stainless-steel fasteners.
3. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action as recommended by metal wall panel manufacturer.
4. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weathertight performance of metal wall panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by metal wall panel manufacturer.



- a. Seal metal wall panel end laps with double beads of tape or sealant, full width of panel. Seal side joints where recommended by metal wall panel manufacturer.
 - b. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants".
 5. Lap-Seam Metal Wall Panels: Fasten metal wall panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.
 - a. Lap ribbed or fluted sheets one full rib corrugation. Apply panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.
 - b. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal wall panels.
 - c. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 - d. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
 - e. Provide sealant tape at lapped joints of metal wall panels and between panels and protruding equipment, vents, and accessories.
 - f. Apply a continuous ribbon of sealant tape to weather-side surface of fastenings on end laps; on side laps of nesting-type panels; on side laps of corrugated nesting-type, ribbed, or fluted panels; and elsewhere as needed to make panels weathertight.
 - g. At panel splices, nest panels with minimum 6-inch (152-mm) end lap, sealed with butyl-rubber sealant and fastened together by interlocking clamping plates.
 6. Zee Clips: Provide Zee clips of size indicated or, if not indicated, as required to act as standoff from subgirts for thickness of insulation indicated. Attach to subgirts with fasteners.
 7. Metal Liner Panels: Install panels on exterior side of girts with girts exposed to the interior **OR** interior side of girts with flush appearance on the inside **OR** girts as indicated on Drawings, **as directed**.
 8. Fire-Rated Metal Wall Panel Assemblies: Install metal liner panels on exterior side of girts, fastening through faces of panels, with girts exposed to the interior. Install subgirts horizontally, fastened to legs of metal liner panels. Install substrate board as indicated in Division 06 Section "Sheathing", in number of layers required for fire rating, over subgirts, attached with board fasteners. Install second set of subgirts horizontally, fastened through substrate board into first set of subgirts. Install exterior metal wall panels, fastened to second set of subgirts.
 - a. Comply with UL **OR** FMG, **as directed**, requirements for fire-rated construction.
- D. Metal Soffit Panel Installation
1. In addition to complying with requirements of "Metal Wall Panel Installation, General" Article, install metal soffit panels to comply with the requirements of this article.
 2. Metal Soffit Panels: Provide metal soffit panels full width of soffits. Install panels perpendicular to support framing.
 - a. Flash and seal panels with weather closures where metal soffit panels meet walls and at perimeter of all openings.
- E. Accessory Installation
1. General: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
 - a. Install components required for a complete metal wall panel assembly including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
 2. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - a. Install exposed flashing and trim that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form



hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.

- b. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (605 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).

F. Field Quality Control

1. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports, **as directed by the Owner**.
2. Water Penetration: Test areas of installed system indicated on Drawings for compliance with system performance requirements according to ASTM E 1105 at minimum differential pressure of 20 percent of inward-acting, wind-load design pressure as defined by SEI/ASCE 7, but not less than 6.24 lbf/sq. ft. (300 Pa).
3. Water-Spray Test: After completing the installation of 75-foot- (23-m-) by-2-story minimum area of metal wall panel assembly, test assembly for water penetration according to AAMA 501.2 in a 2-bay area directed by the Owner.
4. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect and test completed metal wall panel installation, including accessories.
5. Remove and replace metal wall panels where tests and inspections indicate that they do not comply with specified requirements.
6. Additional tests and inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

G. Cleaning And Protection

1. Remove temporary protective coverings and strippable films, if any, as metal wall panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal wall panel installation, clean finished surfaces as recommended by metal wall panel manufacturer. Maintain in a clean condition during construction.
2. After metal wall panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.
3. Replace metal wall panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 46 16 00

**SECTION 07 46 16 00a - METAL PLATE WALL PANELS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for metal plate wall panels. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes metal plate wall panels.

C. Definition

1. Metal Plate Wall Panel Assembly: Metal plate wall panels, attachment system components, miscellaneous metal framing, and accessories necessary for a complete weathertight wall system.

D. Performance Requirements

1. General Performance: Metal plate wall panel assemblies shall comply with performance requirements without failure due to defective manufacture, fabrication, installation, or other defects in construction.
2. Delegated Design: Design metal plate wall panel assembly, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Air Infiltration: Air leakage through assembly of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) of wall area when tested according to ASTM E 283 at the following test-pressure difference:
 - a. Test-Pressure Difference: 1.57 lbf/sq. ft. (75 Pa) which is equivalent to a 25-mph (40-km/h) wind.
4. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:
 - a. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa) which is equivalent to a 50-mph (80-km/h) wind.
5. Water Penetration under Dynamic Pressure: No evidence of water leakage when tested according to AAMA 501.1 under dynamic pressure equal to 20 percent of inward-acting, wind-load design pressure of not less than 6.24 lbf/sq. ft. (300 Pa) {which is equivalent to a 50-mph (80-km/h) wind} and not more than 12 lbf/sq. ft. (575 Pa).
 - a. Water Leakage: As defined according to AAMA 501.1.
OR
Water Leakage: Uncontrolled water infiltrating the system or appearing on system's normally exposed interior surfaces from sources other than condensation. Water controlled by flashing and gutters that is drained back to the exterior and cannot damage adjacent materials or finishes is not water leakage.
6. Structural Performance: Provide metal plate wall panel assemblies capable of withstanding the effects of the following loads and stresses within limits and under conditions indicated, based on testing according to ASTM E 330:
 - a. Wind Loads: Determine loads based on the following minimum design wind pressures:
 - 1) Uniform pressure of 20 lbf/sq. ft. (957 Pa) **OR** 30 lbf/sq. ft. (1436 Pa), **as directed**, acting inward or outward.
OR
Uniform pressure as indicated on Drawings.
 - b. Deflection Limits: Metal plate wall panel assemblies shall withstand wind loads with horizontal deflections no greater than 1/180 **OR** 1/240, **as directed**, of the span.



7. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show fabrication and installation layouts of metal plate wall panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details. Distinguish among factory-, shop-, and field-assembled work.
3. Samples: For each type of exposed finish required.
4. Delegated-Design Submittal: For metal plate wall panel assembly indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Coordination Drawings: Exterior elevations, drawn to scale and coordinating penetrations and wall-mounted items.
6. Product Test Reports.
7. Field quality-control reports.
8. Maintenance Data.
9. Warranties: Sample of special warranties.

F. Quality Assurance

1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
2. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
3. Fire-Resistance Ratings: Where indicated, provide metal plate wall panels identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
4. Preinstallation Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Deliver components, metal plate wall panels, and other manufactured items so as not to be damaged or deformed. Package panels for protection during transportation and handling.
2. Unload, store, and erect metal plate wall panels in a manner to prevent bending, warping, twisting, and surface damage.
3. Stack metal plate wall panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store panels to ensure dryness, with positive slope for drainage of water. Do not store panels in contact with other materials that might cause staining, denting, or other surface damage.
4. Retain strippable protective covering on metal plate wall panel for period of installation.
5. Protect foam-plastic insulation as follows:
 - a. Do not expose to sunlight, except to extent necessary for period of installation and concealment.
 - b. Protect against ignition at all times. Do not deliver foam-plastic insulation materials to Project site before installation time.
 - c. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal plate wall panel assemblies that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period: Two years from date of Final Completion.



2. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal plate wall panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - a. Finish Warranty Period:
 - 1) 20 years from date of Final Completion for fluoropolymer finish.
 - 2) 10 years from date of Final Completion for siliconized polyester.

1.2 PRODUCTS

A. Panel Materials

1. Aluminum Plate: ASTM B 209 (ASTM B 209M). Alloy and temper as recommended by manufacturer for application.
2. Copper Plate: ASTM B 152/B 152M, solid copper alloy.
3. Panel Sealant: ASTM C 920; elastomeric polyurethane, polysulfide, or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal plate wall panels and remain weathertight; and as recommended in writing by panel manufacturer.

B. Miscellaneous Metal Framing

1. Miscellaneous Metal Framing, General: ASTM C 645, cold-formed metallic-coated steel sheet, ASTM A 653/A 653M, G40 (Z120) hot-dip galvanized **OR** ASTM A 653/A 653M, G60 (Z180) hot-dip galvanized, **as directed**, or coating with equivalent corrosion resistance unless otherwise indicated.
2. Subgirts: Manufacturer's standard C- or Z-shaped sections, 0.064-inch (1.63-mm) nominal thickness.
3. Zee Clips: 0.079-inch (2.01-mm) nominal thickness.
4. Base or Sill Angles **OR** Channels, **as directed**: 0.079-inch (2.01-mm) nominal thickness.
5. Hat-Shaped, Rigid Furring Channels:
 - a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.025 inch (0.64 mm) **OR** 0.040 inch (1.02 mm), **as directed**.
 - b. Depth: As indicated **OR** 7/8 inch (22 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
6. Cold-Rolled Furring Channels: Minimum 1/2-inch- (13-mm-) wide flange.
 - a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.064 inch (1.63 mm), **as directed**.
 - b. Depth: As indicated **OR** 3/4 inch (19 mm), **as directed**.
 - c. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with nominal thickness of 0.040 inch (1.02 mm).
 - d. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.57-mm-) diameter wire, or double strand of 0.048-inch- (1.22-mm-) diameter wire.
7. Fasteners for Miscellaneous Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten miscellaneous metal framing members to substrates.

C. Miscellaneous Materials

1. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy and temper recommended by manufacturer for type of use and finish indicated.
2. Panel Fasteners: Self-tapping screws; bolts and nuts; self-locking rivets and bolts; end-welded studs; and other suitable fasteners designed to withstand design loads. Provide exposed fasteners with heads matching color of metal wall panels by means of plastic caps or factory-applied coating. Provide EPDM, PVC, or neoprene sealing washers.

D. Metal Plate Wall Panels

1. Metal Plate Wall Panels: Provide factory-formed, metal plate wall panels fabricated from single sheets of metal formed into profile for installation method indicated. Include attachment system components, panel stiffeners, and accessories required for weathertight system.



- a. Material: Tension-leveled, smooth aluminum sheet, ASTM B 209 (ASTM B 209M), 0.120 inch (3.05 mm) **OR** 0.125 inch (3.18 mm) **OR** 0.1875 inch (4.76 mm) **OR** 0.190 inch (4.82 mm), **as directed**, thick.
 - b. Panel Depth: 2 inches (51 mm) **OR** As indicated on Drawings, **as directed**.
 - c. Exterior Finish: Two-coat fluoropolymer **OR** Three-coat fluoropolymer **OR** Four-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Clear anodized **OR** Color anodized, **as directed**.
 - 1) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
2. Attachment System Components: Formed from extruded aluminum.
 - a. Provide internal drainage system that allows individual panels to be installed and removed without disturbing adjacent panels.
 - b. Include manufacturer's standard subgirts, perimeter extrusions, tracks, and drainage channels, panel stiffeners, panel clips and anchor channels, **as applicable**.
 - c. Alignment Pins: Stainless steel.
- E. Accessories
1. Metal Plate Wall Panel Accessories: Provide components required for a complete metal plate wall panel assembly including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of panels unless otherwise indicated.
 2. Flashing and Trim: Same material, finish, and color as adjacent metal plate wall panels, minimum 0.030 inch (0.76 mm) thick unless otherwise indicated.
- F. Fabrication
1. General: Fabricate and finish metal plate wall panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
 2. Fabricate metal plate wall panels in a manner that eliminates condensation on interior side of panel and with joints between panels designed to form weathertight seals.
 3. Metal Plate Wall Panels: Fabricate panels with panel stiffeners as required to comply with deflection limits. Weld and grind panel corners smooth. Fabricate panels to the following dimensional tolerances:
 - a. Length and Width: Plus or minus 0.032 inch (0.81 mm) up to 48 inches (1219 mm); 0.064 inch (1.63 mm) more than 48 inches (1219 mm).
 - b. Diagonal: Plus or minus 0.1875 inch (4.76 mm).
 - c. Panel Bow: Not more than 0.2 percent of panel width or length up to 0.1875 inch (4.76 mm) maximum.
 - d. Thickness: Plus or minus 0.008 inch (0.2 mm).
 - e. Squareness: 0.1875-inch (4.76-mm) difference between diagonal measurements.
 - f. Camber: 0.032 inch (0.81 mm).
 4. Sheet Metal Accessories: Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.
 - a. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
 - b. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
 - c. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 - d. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.



- e. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
- f. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended by metal plate wall panel manufacturer.
 - 1) Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal plate wall panel manufacturer for application, but not less than thickness of metal being secured.

G. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

H. Aluminum Finishes

1. Two-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
2. Three-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
3. Four-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
4. Mica Fluoropolymer: AAMA 2605. 2-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
5. Metallic Fluoropolymer: AAMA 2605. 3-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
6. FEVE Fluoropolymer: AAMA 2605. 2-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
7. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
8. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
9. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).

I. Copper-Alloy Finishes

1. Exposed Finish: Mill.
2. Exposed Finish: Finish designations prefixed by CDA comply with the system established by the Copper Development Association for designating copper-alloy finish systems.
 - a. Brushed Satin: CDA M32-06x (Mechanical Finish: directionally textured, medium satin; Coating: clear organic, air drying, as specified below):



- 1) Clear, Organic Coating: Clear, air-drying, acrylic lacquer specially developed for coating copper-alloy products, applied by air spray in 2 coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
- b. Mirror Polished: CDA M22-06x (Mechanical Finish: buffed, specular; Coating: clear organic, air drying, as specified below):
 - 1) Clear, Organic Coating: Clear, air-drying, acrylic lacquer specially developed for coating copper-alloy products, applied by air spray in 2 coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).

1.3 EXECUTION

A. Preparation

1. Miscellaneous Framing: Install subgirts, base angles, sills, furring, and other miscellaneous metal plate wall panel support members and anchorage according to ASTM C 754 and panel manufacturer's written instructions.

B. Metal Plate Wall Panel Installation

1. General: Install metal plate wall panels according to manufacturer's written instructions in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to girts and subgirts unless otherwise indicated. Anchor panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - a. Commence metal plate wall panel installation and install minimum of 300 sq. ft. (27.8 sq. m) in presence of factory-authorized representative.
 - b. Shim or otherwise plumb substrates receiving metal plate wall panels.
 - c. Flash and seal metal plate wall panels with weather closures at perimeter of all openings. Do not begin installation until weather barrier and flashings that will be concealed by panels are installed.
 - d. Install flashing and trim as metal plate wall panel work proceeds.
 - e. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated or, if not indicated, as necessary for waterproofing.
 - f. Provide weathertight escutcheons for pipe and conduit penetrating exterior walls.
2. Fasteners:
 - a. Aluminum Plate Wall Panels: Use aluminum or stainless-steel fasteners for surfaces exposed to the exterior and aluminum or galvanized-steel fasteners for surfaces exposed to the interior.
 - b. Copper Plate Wall Panels: Use copper, stainless-steel, or hardware-bronze fasteners.
3. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action as recommended by metal plate wall panel manufacturer.
4. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weathertight performance of metal wall plate panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by panel manufacturer.
 - a. Seal metal plate wall panel end laps with double beads of sealant, full width of panel. Seal side joints where recommended by panel manufacturer.
 - b. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants".
5. Attachment System, General: Install attachment system required to support metal plate wall panels and to provide a complete weathertight wall system, including subgirts, perimeter extrusions, tracks, drainage channels, panel clips, and anchor channels.
 - a. Include attachment to supports, panel-to-panel joinery, panel-to-dissimilar-material joinery, and panel-system joint seals.
6. Flange-Attachment Installation: Attach metal plate wall panels, formed with extended perimeter flanges, to supports at locations, spacings, and with fasteners recommended by manufacturer.



- a. Seal horizontal and vertical joints between adjacent panels with sealant backing and sealant. Install sealant backing and sealant according to requirements specified in Division 07 Section "Joint Sealants".
- b. Seal horizontal and vertical joints between adjacent panels with manufacturer's standard gaskets.
7. Clip Installation: Attach panel clips to supports at locations, spacings, and with fasteners recommended by manufacturer. Attach flanges of metal plate wall panels to panel clips with fasteners **OR** by welding, **as directed**, as recommended by manufacturer.
 - a. Seal horizontal and vertical joints between adjacent metal plate wall panels with sealant backing and sealant. Install sealant backing and sealant according to requirements specified in Division 07 Section "Joint Sealants".
 - b. Seal horizontal and vertical joints between adjacent metal plate wall panels with manufacturer's standard gaskets.
8. Subgirt-and-Spline Installation: Provide manufacturer's standard subgirts and splines that provide support and complete secondary drainage system, draining to the exterior at horizontal joints. Install support system at locations, spacings, and with fasteners recommended by manufacturer. Attach metal plate wall panels by interlocking perimeter extrusions attached to panels with subgirts and splines. Fully engage integral subgirt-and-spline gaskets and leave horizontal and vertical joints with open reveal. Terminate edge of panels flush with perimeter extrusions.
 - a. Install metal plate wall panels to allow individual panels to be installed and removed without disturbing adjacent panels.
 - b. Do not apply sealants to joints unless otherwise indicated on Drawings.
9. Track-Support Installation: Provide manufacturer's standard horizontal tracks and vertical tracks **OR** drain channels, **as directed**, that provide support and complete secondary drainage system, draining to the exterior at horizontal joints through drain tube. Install support system at locations, spacings, and with fasteners recommended by manufacturer. Attach metal plate wall panels to tracks by interlocking panel edges with manufacturer's standard "T" clips.
 - a. Install metal plate wall panels to allow individual panels to be installed and removed without disturbing adjacent panels.
 - b. Seal horizontal and vertical joints between adjacent metal plate wall panels with sealant backing and sealant. Install sealant backing and sealant according to requirements specified in Division 07 Section "Joint Sealants".
10. Rail-Support Installation: Provide manufacturer's standard interlocking rails that provide support and complete secondary drainage system, draining to the exterior at horizontal joints. Install rails at locations, spacings, and with fasteners recommended by manufacturer. Attach metal plate wall panels by overlapping and interlocking support rails with perimeter rails attached to panels. Apply sealant, foam sealant, and tape sealant at locations recommended by manufacturer. Leave horizontal and vertical joints with open reveal.
 - a. Install metal plate wall panels to allow individual panels to be installed and removed without disturbing adjacent panels.
 - b. Install backer plates before installing support rails.
 - c. Do not apply sealants to joints unless otherwise indicated on Drawings.
11. Rainscreen-Principle Installation: Provide manufacturer's standard pressure-equalized, rainscreen-principle system with vertical channel that provides support and complete secondary drainage system, draining at base of wall. Notch vertical channel to receive support pins. Install vertical channels supported by channel brackets or adjuster angles and at locations, spacings, and with fasteners recommended by manufacturer. Attach metal plate wall panels by engaging horizontal support pins into notches in vertical channels and into flanges of panels. Leave horizontal and vertical joints with open reveal.
 - a. Install metal plate wall panels to allow individual panels to be installed and removed without disturbing adjacent panels.
 - b. Do not apply sealants to joints unless otherwise indicated on Drawings.

C. Accessory Installation



1. General: Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.
 - a. Install components required for a complete metal plate wall panel assembly including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
2. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - a. Install exposed flashing and trim that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
 - b. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (610 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).

D. Erection Tolerances

1. Installation Tolerances: Shim and align metal plate wall panel units within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m), nonaccumulative, on level, plumb, and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

E. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Water Penetration: Test areas of installed system indicated on Drawings for compliance with system performance requirements according to ASTM E 1105 at minimum differential pressure of 20 percent of inward-acting, wind-load design pressure as defined by SEI/ASCE 7, but not less than 6.24 lbf/sq. ft. (300 Pa).
3. Water-Spray Test: After completing the installation of 75-foot- (23-m-) by-2-story minimum area of metal plate wall panel assembly, test assembly for water penetration according to AAMA 501.2 in a 2-bay area directed by the Owner.
4. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust completed metal plate wall panel installation, including accessories.
5. Metal plate wall panels will be considered defective if they do not pass tests and inspections.
6. Additional tests and inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
7. Prepare test and inspection reports.

F. Cleaning

1. Remove temporary protective coverings and strippable films, if any, as metal plate wall panels are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of metal plate wall panel installation, clean finished surfaces as recommended by panel manufacturer. Maintain in a clean condition during construction.
2. After metal plate wall panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.
3. Replace metal plate wall panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 46 16 00a

**SECTION 07 46 16 00b - SIDING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for siding. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Aluminum, Fiber-cement, and Vinyl siding.
 - b. Aluminum, Fiber-cement, and Vinyl soffit.

C. Submittals

1. Product Data: For each type of product indicated.
 - a. For vinyl siding, include VSI's official certification logo printed on product data.
2. Samples: For siding and soffit including related accessories.
3. Qualification Data: For qualified vinyl siding Installer.
4. Product certificates.
5. Product test reports.
6. Research/evaluation reports
7. Maintenance data.
8. Warranty: Sample of special warranty.

D. Quality Assurance

1. Labeling: Provide fiber-cement siding that is tested and labeled according to ASTM C 1186 by a qualified testing agency acceptable to authorities having jurisdiction.
2. Vinyl Siding Installer Qualifications: A qualified installer who employs a VSI-Certified Installer on Project.
3. Vinyl Siding Certification Program: Provide vinyl siding products that are listed in VSI's list of certified products.
4. Source Limitations: Obtain each type, color, texture, and pattern of siding and soffit, including related accessories, from single source from single manufacturer.
5. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling

1. Store materials in a dry, well-ventilated, weathertight place.

F. Warranty

1. Special Warranty: Standard form in which manufacturer agrees to repair or replace siding and/or soffit that fail(s) in materials or workmanship within 10 **OR** 25 **OR** 50, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Aluminum Siding

1. General: Formed and coated aluminum siding complying with AAMA 1402.
2. Horizontal Pattern: 8-inch (203-mm) exposure in plain, single-board **OR** beaded-edge, single-board **OR** plain, double-board, 4-inch (102-mm), **as directed**, style.
3. Horizontal Pattern: 10-inch (254-mm) exposure in plain, **OR** Dutch-lap, **as directed**, double, 5-inch (127-mm) board style.



4. Vertical Pattern: 12-inch (300-mm) exposure in board-and-batten, single-board style.
5. Vertical Pattern: 16-inch (400-mm) exposure in V-grooved, triple, 5-1/3-inch (135-mm) board style.
6. Texture: Smooth **OR** Wood grain, **as directed**.
7. Nominal Thickness: 0.019 inch (0.5 mm) **OR** 0.024 inch (0.6 mm), **as directed**.
8. Insulation: Manufacturer's standard integral insulation panels.
9. Finish: Manufacturer's standard three-coat PVDF **OR** primer and baked-on acrylic **OR** primer and baked-on polyester, **as directed**.
 - a. Colors: As selected by the Owner from manufacturer's full range of industry colors.

B. Fiber-Cement Siding

1. General: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84.
 - a. Horizontal Pattern: Boards 5-1/4 inches (133 mm) **OR** 6-1/4 to 6-1/2 inches (159 to 165 mm) **OR** 7-1/4 to 7-1/2 inches (184 to 190 mm) **OR** 8-1/4 to 8-1/2 inches (210 to 216 mm) **OR** 9-1/4 to 9-1/2 inches (235 to 241 mm), **as directed**, wide in plain **OR** beaded-edge, **as directed**, style.
 - 1) Texture: Smooth **OR** Rough sawn **OR** Wood grain, **as directed**.
 - b. Vertical Pattern: 48-inch- (1200-mm-) wide sheets with wood-grain texture and grooves 8 inches (203 mm) **OR** 12 inches (300 mm), **as directed**, o.c.
 - c. Shingle Pattern: 48-inch- (1200-mm-) wide, straight-edge notched **OR** staggered-edge notched, **as directed**, sheets with wood-grain texture.
 - d. Panel Texture: 48-inch- (1200-mm-) wide sheets with smooth **OR** stucco **OR** wood-grain, **as directed**, texture.
 - e. Factory Priming: Manufacturer's standard acrylic primer.

C. Vinyl Siding

1. General: Integrally colored vinyl siding complying with ASTM D 3679.
2. Horizontal Pattern: 6-1/2- or 7-inch (165- or 178-mm) exposure in beaded-edge, single-board style.
3. Horizontal Pattern: 8-inch (203-mm) exposure in plain, single-board **OR** double board, 4-inch (102-mm) **OR** triple board, 2-2/3-inch (68-mm), **as directed**, style.
4. Horizontal Pattern: 8-inch (203-mm) exposure in Dutch-lap, double, 4-inch (102-mm) board style.
5. Horizontal Pattern: 9-inch (229-mm) exposure in plain, double board, 4-1/2-inch (114-mm) **OR** triple board, 3-inch (76-mm), **as directed**, style.
6. Horizontal Pattern: 9-inch (229-mm) exposure in Dutch-lap, double, 4-1/2-inch (114-mm) board style.
7. Horizontal Pattern: 10-inch (254-mm) exposure in plain, **OR** Dutch-lap, **as directed**, double, 5-inch (127-mm) board style.
8. Vertical Pattern: 6-inch (152-mm) exposure in V-grooved, single-board style.
9. Vertical Pattern: 8-inch (203-mm) exposure in beaded-edge, double, 4-inch (102-mm) board style.
10. Vertical Pattern: 10-inch (254-mm) exposure in V-grooved, double, 5-inch (127-mm) board style.
11. Vertical Pattern: 12-inch (300-mm) exposure in V-grooved, double board, 6-inch (152-mm) **OR** triple board, 4-inch (102-mm), **as directed**, style.
12. Shingle Pattern: 48-inch- (1200-mm-) wide, straight-edge notched **OR** staggered-edge notched **OR** half-round edge **OR** octagon edge, **as directed**, sheets with wood-grain texture.
13. Texture: Smooth **OR** Wood grain, **as directed**.
14. Nominal Thickness: 0.040 inch (1.0 mm) **OR** 0.044 inch (1.1 mm), **as directed**.
15. Minimum Profile Depth (Butt Thickness): 1/2 inch (13 mm) **OR** 5/8 inch (16 mm) **OR** 3/4 inch (19 mm), **as directed**.
16. Nailing Hem: Double thickness.
17. Finish: Wood-grain print with clear protective coating containing not less than 70 percent PVDF.
 - a. Colors: As selected by the Owner from manufacturer's full range of industry colors.



- D. Aluminum Soffit
1. General: Formed and coated aluminum soffit complying with AAMA 1402.
 2. Pattern: 6-inch (152-mm) exposure in V-grooved, single-board style.
 3. Pattern: 10-inch (254-mm) exposure in V-grooved, double, 5-inch (127-mm) board style.
 4. Pattern: 12-inch (300-mm) exposure in V-grooved, double, 6-inch (152-mm) board style.
 5. Pattern: 16-inch (400-mm) exposure in V-grooved, triple board, 5-1/3-inch (135-mm) **OR** quadruple board, 4-inch (102-mm), **as directed**, style.
 6. Texture: Smooth **OR** Wood grain, **as directed**.
 7. Ventilation: Provide perforated **OR** unperforated, **as directed**, soffit unless otherwise indicated.
 8. Nominal Thickness: 0.019 inch (0.5 mm) **OR** 0.024 inch (0.6 mm), **as directed**.
 9. Finish: Manufacturer's standard three-coat PVDF **OR** primer and baked-on acrylic **OR** primer and baked-on polyester, **as directed**.
 - a. Colors: As selected by the Owner from manufacturer's full range of industry colors **OR** Match adjacent siding, **as directed**.
- E. Fiber-Cement Soffit
1. General: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84.
 2. Pattern: 12-inch- (300-mm-) **OR** 16-inch- (400-mm-) **OR** 24-inch- (600-mm-), **as directed**, wide sheets with smooth **OR** wood-grain, **as directed**, texture.
 3. Ventilation: Provide perforated **OR** unperforated, **as directed**, soffit unless otherwise indicated.
 4. Factory Priming: Manufacturer's standard acrylic primer.
- F. Vinyl Soffit
1. General: Integrally colored vinyl soffit complying with ASTM D 4477.
 2. Pattern: 6-inch (152-mm) exposure in V-grooved, single-board **OR** beaded-edge, triple board, 2-inch (51-mm), **as directed**, style.
 3. Pattern: 8-inch (203-mm) exposure in V-grooved, double, 4-inch (102-mm) board style.
 4. Pattern: 10-inch (254-mm) exposure in V-grooved, double, 5-inch (127-mm) board style.
 5. Pattern: 12-inch (300-mm) exposure in V-grooved, double board, 6-inch (152-mm) **OR** triple board, 4-inch (102-mm), **as directed**, style.
 6. Texture: Smooth **OR** Wood grain, **as directed**.
 7. Ventilation: Provide perforated **OR** unperforated, **as directed**, soffit unless otherwise indicated.
 8. Nominal Thickness: 0.035 inch (0.9 mm) **OR** 0.040 inch (1.0 mm) **OR** 0.044 inch (1.1 mm), **as directed**.
 9. Minimum Profile Depth: 1/2 inch (13 mm) **OR** 5/8 inch (16 mm) **OR** 3/4 inch (19 mm), **as directed**.
 10. Colors: As selected by the Owner from manufacturer's full range of industry colors **OR** Match adjacent siding, **as directed**.
- G. Accessories
1. Siding Accessories, General: Provide starter strips, edge trim, outside and inside corner caps, and other items as recommended by siding manufacturer for building configuration.
 - a. Provide accessories made from same material as **OR** matching color and texture of, **as directed**, adjacent siding unless otherwise indicated.
 2. Aluminum Accessories: Where aluminum accessories are indicated, provide accessories complying with AAMA 1402.
 - a. Texture: Smooth **OR** Wood grain, **as directed**.
 - b. Nominal Thickness: 0.019 inch (0.5 mm) **OR** 0.024 inch (0.6 mm), **as directed**.
 - c. Finish: Manufacturer's standard three-coat PVDF **OR** primer and baked-on acrylic **OR** primer and baked-on polyester, **as directed**.
 3. Vinyl Accessories: Integrally colored vinyl accessories complying with ASTM D 3679 except for wind-load resistance.
 - a. Texture: Smooth **OR** Wood grain, **as directed**.



4. Decorative Accessories: Provide the following aluminum **OR** fiber-cement **OR** vinyl, **as directed**, decorative accessories as indicated:
 - a. Corner posts with fluted faces, **as directed**.
 - b. Door and window casings with fluted faces, **as directed**, and corner rosettes, **as directed**.
 - c. Entrance and window head pediments.
 - d. Pilasters with fluted faces, **as directed**.
 - e. Shutters with paneled **OR** louvered, **as directed**, faces.
 - f. Louvers.
 - g. Lattice.
 - h. Fasciae.
 - i. Moldings and trim.
5. Colors for Decorative Accessories: As selected by the Owner from manufacturer's full range of industry colors **OR** Match adjacent siding, **as directed**.
6. Flashing: Provide aluminum **OR** stainless-steel, **as directed**, flashing complying with Division 07 Section "Sheet Metal Flashing And Trim" at window and door heads and where indicated.
 - a. Finish for Aluminum Flashing: Same as aluminum siding **OR** Siliconized polyester coating, same color as siding **OR** High-performance organic finish, same color as siding **OR** Factory-prime coating, **as directed**.
7. Fasteners:
 - a. For fastening to wood, use siding nails **OR** ribbed bugle-head screws, **as directed**, of sufficient length to penetrate a minimum of 1 inch (25 mm) into substrate.
 - b. For fastening to metal, use ribbed bugle-head screws of sufficient length to penetrate a minimum of 1/4 inch (6 mm), or three screw-threads, into substrate.
 - c. For fastening aluminum, use aluminum fasteners. Where fasteners will be exposed to view, use prefinished aluminum fasteners in color to match item being fastened.
 - d. For fastening fiber cement, use hot-dip galvanized **OR** stainless-steel, **as directed**, fasteners.
 - e. For fastening vinyl, use aluminum **OR** hot-dip galvanized **OR** stainless-steel, **as directed**, fasteners. Where fasteners will be exposed to view, use prefinished aluminum fasteners in color to match item being fastened.
8. Insect Screening for Soffit Vents: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh **OR** PVC-coated, glass-fiber fabric, 18-by-14 or 18-by-16 (1.4-by-1.8- or 1.4-by-1.6-mm) mesh **OR** Stainless steel, 18-by-18 (1.4-by-1.4-mm) mesh, **as directed**.
9. Continuous Soffit Vents: Aluminum, hat-channel shape, with stamped louvers **OR** perforations, **as directed**; 2 inches (51 mm) wide and not less than 96 inches (2438 mm) long.
 - a. Net-Free Area: 4 sq. in./linear ft. (280 sq. cm/m) **OR** 6 sq. in./linear ft. (420 sq. cm/m) **OR** 8 sq. in./linear ft. (560 sq. cm/m), **as directed**.
 - b. Finish: Mill finish **OR** White paint **OR** Brown paint, **as directed**.
10. Round Soffit Vents: Stamped aluminum louvered vents, 2 inches (51 mm) **OR** 2-1/2 inches (64 mm) **OR** 3 inches (76 mm) **OR** 4 inches (102 mm), **as directed**, in diameter, made to be inserted into round holes cut into soffit.
 - a. Finish: Mill finish **OR** White paint **OR** Brown paint, **as directed**.

1.3 EXECUTION

A. Preparation

1. Clean substrates of projections and substances detrimental to application.

B. Installation

1. General: Comply with siding and soffit manufacturer's written installation instructions applicable to products and applications indicated unless more stringent requirements apply.
 - a. Do not install damaged components.
 - b. Center nails in elongated nailing slots without binding siding to allow for thermal movement.



2. Install aluminum siding and soffit and related accessories according to AAMA 1402.
 - a. Install fasteners no more than 24 inches (600 mm) o.c.
 3. Install fiber-cement siding and soffit and related accessories.
 - a. Install fasteners no more than 24 inches (600 mm) o.c.
 4. Install vinyl siding and soffit and related accessories according to ASTM D 4756.
 - a. Install fasteners for horizontal vinyl siding no more than 16 inches (400 mm) o.c.
 - b. Install fasteners for vertical vinyl siding no more than 12 inches (300 mm) o.c.
 5. Install joint sealants as specified in Division 07 Section "Joint Sealants" and to produce a weathertight installation.
 6. Where aluminum siding will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape or installing nonconductive spacers as recommended by manufacturer for this purpose.
- C. Adjusting And Cleaning
1. Remove damaged, improperly installed, or otherwise defective materials and replace with new materials complying with specified requirements.
 2. Clean finished surfaces according to manufacturer's written instructions and maintain in a clean condition during construction.

END OF SECTION 07 46 16 00b



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Task	Specification	Specification Description
07 46 19 00	07 46 16 00	Metal Wall Panels
07 46 19 00	07 46 16 00a	Metal Plate Wall Panels
07 46 19 00	07 46 16 00b	Siding



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**SECTION 07 46 23 00 - MISCELLANEOUS CARPENTRY**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for miscellaneous carpentry. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Framing with dimension lumber.
 - b. Rooftop equipment bases and support curbs.
 - c. Wood blocking, cants, and nailers.
 - d. Wood furring and grounds.
 - e. Wood sleepers.
 - f. Interior wood trim.
 - g. Wood shelving and clothes rods.
 - h. Plywood backing panels.

C. Definitions

1. Dimension Lumber: Lumber of 2 inches nominal (38 mm actual) or greater but less than 5 inches nominal (114 mm actual) in least dimension.
2. Lumber grading agencies, and the abbreviations used to reference them, include the following:
 - a. NeLMA: Northeastern Lumber Manufacturers' Association.
 - b. NHLA: National Hardwood Lumber Association.
 - c. NLGA: National Lumber Grades Authority.
 - d. SPIB: The Southern Pine Inspection Bureau.
 - e. WCLIB: West Coast Lumber Inspection Bureau.
 - f. WWPA: Western Wood Products Association.

D. Submittals

1. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - a. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
 - b. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
 - c. For fire-retardant treatments specified to be High-Temperature (HT) type include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.
 - d. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
 - e. Include copies of warranties from chemical treatment manufacturers for each type of treatment.
2. LEED Submittals:
 - a. Product Data for Credit EQ 4.1: For adhesives, including printed statement of VOC content.
 - b. Product Data for Credit EQ 4.4: For composite-wood products, documentation indicating that product contains no urea formaldehyde.



- c. Certificates for Credit MR 7: Chain-of-custody certificates certifying that products specified to be made from certified wood comply with forest certification requirements. Include evidence that mill is certified for chain of custody by an FSC-accredited certification body.
 - 1) Include statement indicating costs for each certified wood product.
- 3. Research/Evaluation Reports: For the following, showing compliance with building code in effect for Project:
 - a. Preservative-treated wood.
 - b. Fire-retardant-treated wood.
 - c. Power-driven fasteners.
 - d. Powder-actuated fasteners.
 - e. Expansion anchors.
 - f. Metal framing anchors.

E. Quality Assurance

- 1. Forest Certification: For the following wood products, provide materials produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship":
 - a. Dimension lumber framing.
 - b. Miscellaneous lumber.
 - c. Interior wood trim.
 - d. Shelving and clothes rods.

F. Delivery, Storage, And Handling

- 1. Stack lumber flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.
- 2. Deliver interior wood materials that are to be exposed to view only after building is enclosed and weatherproof, wet work other than painting is dry, and HVAC system is operating and maintaining temperature and humidity at occupancy levels.

1.2 PRODUCTS

A. Wood Products, General

- 1. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
 - a. Factory mark each piece of lumber with grade stamp of grading agency.
 - b. For exposed lumber indicated to receive a stained or natural finish, mark grade stamp on end or back of each piece or omit grade stamp and provide certificates of grade compliance issued by grading agency.
 - c. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.
 - d. Provide dressed lumber, S4S, unless otherwise indicated.

B. Wood-Preservative-Treated Materials

- 1. Preservative Treatment by Pressure Process: AWPA C2, except that lumber that is not in contact with the ground and is continuously protected from liquid water may be treated according to AWPA C31 with inorganic boron (SBX).
 - a. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.
 - b. For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not require incising, contain colorants, bleed through, or otherwise adversely affect finishes.



2. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or does not comply with requirements for untreated material.
 3. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
 - a. For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece or omit marking and provide certificates of treatment compliance issued by inspection agency.
 4. Application: Treat all miscellaneous carpentry, unless otherwise indicated **OR** items indicated on Drawings, and the following, **as directed**:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
 - b. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.
 - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
 - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawl spaces or unexcavated areas.
 - e. Wood floor plates that are installed over concrete slabs-on-grade.
- C. Fire-Retardant-Treated Materials
1. General: Comply with performance requirements in AWWA C20 (lumber) and AWWA C27 (plywood).
 - a. Use treatment that does not promote corrosion of metal fasteners.
 - b. Use Exterior type for exterior locations and where indicated.
 - c. Use Interior Type A, High Temperature (HT) for enclosed roof framing, framing in attic spaces, and where indicated.
 - d. Use Interior Type A, unless otherwise indicated.
 2. Identify fire-retardant-treated wood with appropriate classification marking of testing and inspecting agency acceptable to authorities having jurisdiction.
 - a. For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece or omit marking and provide certificates of treatment compliance issued by inspection agency.
 3. For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not bleed through, contain colorants, or otherwise adversely affect finishes.
 4. Application: Treat all miscellaneous carpentry, unless otherwise indicated **OR** items indicated on Drawings, and the following, **as directed**:
 - a. Framing for raised platforms.
 - b. Concealed blocking.
 - c. Roof construction.
 - d. Plywood backing panels.
- D. Dimension Lumber Framing
1. Maximum Moisture Content: 15 percent **OR** 19 percent **OR** 15 percent for 2-inch nominal (38-mm actual) thickness or less, 19 percent for more than 2-inch nominal (38-mm actual) thickness, **as directed**.
 2. Non-Load-Bearing Interior Partitions: Construction or No. 2 **OR** Construction, Stud, or No. 3 **OR** Standard, Stud, or No. 3, **as directed**, grade of any species.
 3. Other Framing: No. 2 **OR** Construction or No. 2 **OR** Construction, Stud, or No., **as directed**, grade and any of the following species:
 - a. Hem-fir (north); NLGA.
 - b. Southern pine; SPIB.
 - c. Douglas fir-larch; WCLIB or WWPA.
 - d. Mixed southern pine; SPIB.
 - e. Spruce-pine-fir; NLGA.
 - f. Douglas fir-south; WWPA.
 - g. Hem-fir; WCLIB or WWPA.



- h. Douglas fir-larch (north); NLGA.
- i. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.

E. Miscellaneous Lumber

1. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - a. Blocking.
 - b. Nailers.
 - c. Rooftop equipment bases and support curbs.
 - d. Cants.
 - e. Furring.
 - f. Grounds.
 - g. Utility shelving.
2. For items of dimension lumber size, provide Construction or No. 2 **OR** Standard, Stud, or No. 3, **as directed**, grade lumber with 15 **OR** 19, **as directed**, percent maximum moisture content of any species.
3. For exposed boards, provide lumber with 15 **OR** 19, **as directed**, percent maximum moisture content and any of the following species and grades:
 - a. Eastern white pine, Idaho white, lodgepole, ponderosa, or sugar pine; Premium or 2 Common (Sterling) **OR** Standard or No. 3 Common, **as directed**, grade; NeLMA, NLGA, WCLIB, or WWPA.
 - b. Mixed southern pine, No. 1 **OR** 2, **as directed**, grade; SPIB.
 - c. Hem-fir or hem-fir (north), Select Merchantable or No. 1 Common **OR** Construction or No. 2 Common, **as directed**, grade; NLGA, WCLIB, or WWPA.
 - d. Spruce-pine-fir (south) or spruce-pine-fir, Select Merchantable or No. 1 Common **OR** Construction or No. 2 Common, **as directed**, grade; NeLMA, NLGA, WCLIB, or WWPA.
4. For concealed boards, provide lumber with 15 **OR** 19, **as directed**, percent maximum moisture content and any of the following species and grades:
 - a. Mixed southern pine, No. 2 **OR** 3, **as directed**, grade; SPIB.
 - b. Hem-fir or hem-fir (north), Construction or 2 Common **OR** Standard or 3 Common, **as directed**, grade; NLGA, WCLIB, or WWPA.
 - c. Spruce-pine-fir (south) or spruce-pine-fir, Construction or 2 Common **OR** Standard or 3 Common, **as directed**, grade; NeLMA, NLGA, WCLIB, or WWPA.
 - d. Eastern softwoods, No. 2 **OR** 3, **as directed**, Common grade; NELMA.
 - e. Northern species, No. 2 **OR** 3, **as directed**, Common grade; NLGA.
 - f. Western woods, Construction or No. 2 Common **OR** Standard or No. 3 Common, **as directed**, grade; WCLIB or WWPA.
5. For blocking not used for attachment of other construction Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.
6. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.
7. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.

F. Interior Wood Trim

1. General: Provide kiln-dried finished (surfaced) material without finger-jointing, unless otherwise indicated.
2. Softwood Lumber Trim for Transparent (Stain or Clear) Finish: Provide one of the following species and grade:
 - a. Grade C Select **OR** D Select **OR** Finish **OR** Premium, **as directed**, eastern white pine; NeLMA or NLGA.
 - b. Grade C Select (Choice) **OR** D Select (Quality) **OR** 1 Common (Colonial) **OR** 2 Common (Sterling), **as directed**, Idaho white, lodgepole, ponderosa, or sugar pine; NLGA or WWPA.



- c. Grade Superior or C & Btr **OR** Prime or D, **as directed**, Finish Douglas fir-larch or Douglas fir-south; NLGA, WCLIB, or WWPA.
 - d. Clear Heart **OR** Grade A **OR** Grade B, **as directed**, western red cedar; NLGA, WCLIB, or WWPA.
 3. Hardwood Lumber Trim for Transparent (Stain or Clear) Finish: Clear red oak **OR** white maple, **as directed**, selected for compatible grain and color, **as directed**.
 4. Lumber Trim for Opaque (Painted) Finish: Either finger-jointed or solid lumber, of one of the following species and grades:
 - a. Grade D Select **OR** Finish **OR** Premium, **as directed**, eastern white pine; NeLMA or NLGA.
 - b. Grade D Select (Quality) **OR** 1 Common (Colonial) **OR** 2 Common (Sterling), **as directed**, Idaho white, lodgepole, ponderosa, or sugar pine; NLGA or WWPA.
 - c. Grade A **OR** B, **as directed**, Finish aspen, basswood, cottonwood, gum, magnolia, red alder, soft maple, sycamore, tupelo, or yellow poplar; NHLA.
 5. Moldings: Made to patterns included in WMMPA WM 7 and graded according to WMMPA WM 4.
 - a. Moldings for Transparent (Stain or Clear) Finish: N-grade eastern white, Idaho white, lodgepole, ponderosa, or sugar pine **OR** western red cedar **OR** Douglas fir **OR** red oak **OR** white maple, **as directed**, selected for compatible grain and color.
 - b. Moldings for Opaque (Painted) Finish: P-grade eastern white, Idaho white, lodgepole, ponderosa, or sugar pine **OR** aspen, basswood, cottonwood, gum, magnolia, soft maple, tupelo, or yellow poplar **OR** primed medium-density fiberboard, **as directed**.
- G. Shelving And Clothes Rods
 1. Shelving: Made from one of the following materials, 3/4-inch (19-mm) thick. Do not use particleboard or medium-density fiberboard that contains urea formaldehyde.
 - a. Melamine-faced particleboard with radiused and filled front edge.
 - b. Particleboard with radiused and filled **OR** solid-wood, **as directed**, front edge.
 - c. Medium-density fiberboard with radiused **OR** solid-wood, **as directed**, front edge.
 - d. Wood boards of same species and grade indicated above for interior lumber trim for opaque **OR** transparent, **as directed**, finish.
 2. Shelf Cleats: 3/4-by-3-1/2-inch (19-by-89-mm) boards **OR** 3/4-by-5-1/2-inch (19-by-140-mm) boards with hole and notch to receive clothes rods, **as directed**, of same species and grade indicated above for interior lumber trim for opaque finish.
 3. Shelf Brackets: Prime-painted formed steel with provision to support clothes rod where rod is indicated.
 4. Clothes Rods:
 - a. 1-1/2-inch- (38-mm-) diameter, clear, kiln-dried hardwood rods **OR** clear, kiln-dried softwood rods; either Douglas fir or southern pine **OR** aluminum tubes, **as directed**.
OR
1-1/4-inch- (32-mm-) diameter, chrome-plated steel **OR** stainless-steel, **as directed**, tubes.
 5. Rod Flanges: Clear, kiln-dried hardwood turnings **OR** Clear, kiln-dried softwood turnings **OR** Aluminum **OR** Chrome-plated steel **OR** Stainless steel, **as directed**.
- H. Plywood Backing Panels
 1. Telephone and Electrical Equipment Backing Panels: DOC PS 1, Exposure 1, C-D Plugged, fire-retardant treated, **as directed**, in thickness indicated or, if not indicated, not less than 1/2-inch (13-mm) nominal thickness.
- I. Fasteners
 1. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.
 - a. Where carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M **OR** of Type 304 stainless steel, **as directed**.
 2. Nails, Brads, and Staples: ASTM F 1667.
 3. Power-Driven Fasteners: NES NER-272.



4. Wood Screws: ASME B18.6.1.
5. Screws for Fastening to Cold-Formed Metal Framing: ASTM C 954, except with wafer heads and reamer wings, length as recommended by screw manufacturer for material being fastened.
6. Lag Bolts: ASME B18.2.1 (ASME B18.2.3.8M).
7. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where indicated, flat washers.
8. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.
 - a. Material:
 - 1) Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.

OR

 Stainless steel with bolts and nuts complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2 (ASTM F 738M and ASTM F 836M, Grade A1 or A4).

J. Metal Framing Anchors

1. Galvanized Steel Sheet: Hot-dip, zinc-coated steel sheet complying with ASTM A 653/A 653M, G60 (Z180) coating designation.
 - a. Use for interior locations where stainless steel is not indicated.
2. Stainless-Steel Sheet: ASTM A 666, Type 304 **OR** 316, **as directed**.
 - a. Use for exterior locations and where indicated.

K. Miscellaneous Materials

1. Adhesives for Gluing Furring and Sleepers to Concrete or Masonry: Formulation complying with ASTM D 3498 that is approved for use indicated by adhesive manufacturer.
 - a. Use adhesives that have a VOC content of 70 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1.3 EXECUTION

A. Installation, General

1. Set carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.
2. Framing Standard: Comply with AF&PA's "Details for Conventional Wood Frame Construction," unless otherwise indicated.
3. Metal Framing Anchors: Install metal framing to comply with manufacturer's written instructions.
4. Do not splice structural members between supports, unless otherwise indicated.
5. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.
 - a. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches (406 mm) o.c.
6. Provide fire blocking in furred spaces, stud spaces, and other concealed cavities as indicated and as follows:
 - a. Fire block furred spaces of walls, at each floor level, at ceiling, and at not more than 96 inches (2438 mm) o.c. with solid wood blocking or noncombustible materials accurately fitted to close furred spaces.
 - b. Fire block concealed spaces of wood-framed walls and partitions at each floor level, at ceiling line of top story, and at not more than 96 inches (2438 mm) o.c. Where fire blocking is not inherent in framing system used, provide closely fitted solid wood blocks of same width as framing members and 2-inch nominal- (38-mm actual-) thickness.



- c. Fire block concealed spaces between floor sleepers with same material as sleepers to limit concealed spaces to not more than 100 sq. ft. (9.3 sq. m) and to solidly fill space below partitions.
 - d. Fire block concealed spaces behind combustible cornices and exterior trim at not more than 20 feet (6 m) o.c.
 7. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
 8. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.
 - a. Use inorganic boron for items that are continuously protected from liquid water.
 - b. Use copper naphthenate for items not continuously protected from liquid water.
 9. Securely attach carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
 - a. NES NER-272 for power-driven fasteners.
 - b. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code.
 - c. "Nailing Schedule," and Tables in Section 2304 of the ICC's International Building Code.
 - d. Table 2306.1, "Fastening Schedule," in SBCCI's Standard Building Code.
 - e. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.
 - f. Table 602.3(1), "Fastener Schedule for Structural Members," and Table 602.3(2), "Alternate Attachments," in ICC's International One- and Two-Family Dwelling Code.
 10. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood; do not countersink nail heads, unless otherwise indicated.
- B. Wood Ground, Sleeper, Blocking, And Nailers Installation
1. Install where indicated and where required for screeding or attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.
 2. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated.
 3. Provide permanent grounds of dressed, pressure-preservative-treated, key-beveled lumber not less than 1-1/2 inches (38 mm) wide and of thickness required to bring face of ground to exact thickness of finish material. Remove temporary grounds when no longer required.
- C. Wood Furring Installation
1. Install level and plumb with closure strips at edges and openings. Shim with wood as required for tolerance of finish work.
 2. Furring to Receive Plywood or Hardboard Paneling: Install 1-by-3-inch nominal- (19-by-63-mm actual-) size furring horizontally **OR** vertically **OR** horizontally and vertically, **as directed**, at 24 inches (610 mm) **OR** 600 mm, **as directed**, o.c.
 3. Furring to Receive Gypsum Board **OR** Plaster Lath, **as directed**: Install 1-by-2-inch nominal- (19-by-38-mm actual-) size furring vertically at 16 inches (406 mm) **OR** 400 mm, **as directed**, o.c.
- D. Wood Trim Installation
1. Install with minimum number of joints practical, using full-length pieces from maximum lengths of lumber available. Do not use pieces less than 24 inches (610 mm) long except where necessary. Stagger joints in adjacent and related standing and running trim. Cope at returns and miter at corners to produce tight-fitting joints with full-surface contact throughout length of joint. Use scarf joints for end-to-end joints.
 - a. Match color and grain pattern across joints.
 - b. Install trim after gypsum board joint-finishing operations are completed.



- c. Drill pilot holes in hardwood before fastening to prevent splitting. Fasten to prevent movement or warping. Countersink fastener heads and fill holes.
- d. Install to tolerance of 1/8 inch in 96 inches (3 mm in 2438 mm) for level and plumb. Install adjoining finish carpentry with 1/32-inch (0.8-mm) maximum offset for flush installation and 1/16-inch (1.6-mm) maximum offset for reveal installation.

E. Protection

- 1. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.
- 2. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION 07 46 23 00

**SECTION 07 46 23 00a - SHEATHING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for sheathing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Wall sheathing.
 - b. Roof sheathing.
 - c. Composite nail base insulated roof sheathing.
 - d. Subflooring.
 - e. Underlayment.
 - f. Building paper.
 - g. Building wrap.
 - h. Sheathing joint-and-penetration treatment.
 - i. Flexible flashing at openings in sheathing.

C. Submittals

1. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - a. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated plywood complies with requirements. Indicate type of preservative used and net amount of preservative retained.
 - b. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated plywood complies with requirements. Include physical properties of treated materials.
 - c. For fire-retardant treatments specified to be High-Temperature (HT) type, include physical properties of treated plywood both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5516.
 - d. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
 - e. Include copies of warranties from chemical treatment manufacturers for each type of treatment.
 - f. For building wrap, include data on air-/moisture-infiltration protection based on testing according to referenced standards.
2. LEED Submittals:
 - a. Product Data for Credit EQ 4.1: For adhesives, including printed statement of VOC content.
 - b. Product Data for Credit EQ 4.4: For composite-wood products, documentation indicating that product contains no urea formaldehyde.
 - c. Certificates for Credit MR 7: Chain-of-custody certificates certifying that products specified to be made from certified wood comply with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.
 - 1) Include statement indicating costs for each certified wood product.
3. Research/Evaluation Reports: For the following, showing compliance with building code in effect for Project:
 - a. Preservative-treated plywood.
 - b. Fire-retardant-treated plywood.



- c. Foam-plastic sheathing.
- d. Building wrap.

D. Quality Assurance

1. Fire-Test-Response Characteristics: For assemblies with fire-resistance ratings, provide materials and construction identical to those of assemblies tested for fire resistance per ASTM E 119 by a testing and inspecting agency acceptable to authorities having jurisdiction.
2. Forest Certification: For the following wood products, provide materials produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship":
 - a. Plywood.
 - b. Oriented strand board.
 - c. Fiberboard wall sheathing.
 - d. Particleboard underlayment.
 - e. Hardboard underlayment.

E. Delivery, Storage, And Handling

1. Stack plywood and other panels flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.

1.2 PRODUCTS

A. Wood Panel Products, General

1. Plywood: DOC PS 1 **OR** Either DOC PS 1 or DOC PS 2, unless otherwise indicated, **as directed**.
2. Oriented Strand Board: DOC PS 2.
3. Thickness: As needed to comply with requirements specified, but not less than thickness indicated.
4. Factory mark panels to indicate compliance with applicable standard.

B. Preservative-Treated Plywood

1. Preservative Treatment by Pressure Process: AWPA C9.
 - a. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.
2. Mark plywood with appropriate classification marking of an inspection agency acceptable to authorities having jurisdiction.
3. Application: Treat all plywood, unless otherwise indicated **OR** Treat items indicated on Drawings, **as directed**, and plywood in contact with masonry or concrete or used with roofing, flashing, vapor barriers, and waterproofing.

C. Fire-Retardant-Treated Plywood

1. General: Comply with performance requirements in AWPA C27.
 - a. Use treatment that does not promote corrosion of metal fasteners.
 - b. Use Exterior type for exterior locations and where indicated.
 - c. Use Interior Type A, High Temperature (HT) for roof sheathing and where indicated.
 - d. Use Interior Type A, unless otherwise indicated.
2. Kiln-dry material after treatment to a maximum moisture content of 15 percent. Do not use material that is warped or does not comply with requirements for untreated material.
3. Identify fire-retardant-treated plywood with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection, or another testing and inspecting agency acceptable to authorities having jurisdiction.
4. Application: Treat all plywood, unless otherwise indicated **OR** Treat plywood indicated on Drawings, and the following, **as directed**:
 - a. Roof and wall sheathing within 48 inches (1220 mm) of fire **OR** party, **as directed**, walls.



- b. Roof sheathing.
- c. Subflooring and underlayment for raised platforms.

D. Wall Sheathing

- 1. Plywood Wall Sheathing: Exterior, Structural I **OR** Exterior **OR** Exposure 1, Structural I **OR** Exposure 1, **as directed**, sheathing.
- 2. Oriented-Strand-Board Wall Sheathing: Exposure 1, Structural I **OR** Exposure 1, **as directed**, sheathing.
- 3. Paper-Surfaced Gypsum Wall Sheathing: ASTM C 79/C 79M or ASTM C 1396/C 1396M, gypsum sheathing; with water-resistant-treated core and with water-repellent paper bonded to core's face, back, and long edges.
 - a. Type and Thickness: Regular, 1/2 inch (13 mm) **OR** Type X, 5/8 inch (15.9 mm), **as directed**, thick.
- 4. Glass-Mat Gypsum Wall Sheathing: ASTM C 1177/1177M.
 - a. Type and Thickness: Regular, 1/2 inch (13 mm) **OR** Type X, 5/8 inch (15.9 mm), **as directed**, thick.
- 5. Cellulose Fiber-Reinforced Gypsum Sheathing: ASTM C 1278/C 1278M, gypsum sheathing.
 - a. Type and Thickness: Regular, 1/2 inch (13 mm) **OR** Type X, 5/8 inch (15.9 mm), **as directed**, thick.
- 6. Fiberboard Wall Sheathing: ASTM C 208, Type IV, Grade 1 (Regular) **OR** 2 (Structural), **as directed**, cellulosic fiberboard sheathing with square edges, 1/2 inch (13 mm) **OR** 25/32 inch (20 mm), **as directed**, thick.
- 7. Extruded-Polystyrene-Foam Wall Sheathing: ASTM C 578, Type IV, in manufacturer's standard lengths and widths with tongue-and-groove or shiplap long edges as standard with manufacturer.
 - a. Thickness: 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** As indicated, **as directed**.
- 8. Foil-Faced, Polyisocyanurate-Foam Wall Sheathing: ASTM C 1289, Type I, Class 2, aluminum-foil-faced, glass-fiber-reinforced, rigid, cellular, polyisocyanurate thermal insulation. Foam-plastic core and facings shall have a flame-spread index of 25 or less when tested individually.
 - a. Thickness: 7/16 inch (11.1 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (15.9 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** As indicated, **as directed**.

E. Roof Sheathing

- 1. Plywood Roof Sheathing: Exterior, Structural I **OR** Exterior **OR** Exposure 1, Structural I **OR** Exposure 1, **as directed**, sheathing.
- 2. Oriented-Strand-Board Roof Sheathing: Exposure 1, Structural I **OR** Exposure 1, **as directed**, sheathing.

F. Composite Nail Base Insulated Roof Sheathing

- 1. Oriented-Strand-Board-Surfaced, Polyisocyanurate-Foam Sheathing: Rigid, cellular, polyisocyanurate thermal insulation with oriented strand board laminated to one face complying with ASTM C 1289, Type V.
- 2. Vented, Oriented-Strand-Board-Surfaced, Polyisocyanurate-Foam Sheathing:
 - a. Rigid, cellular, polyisocyanurate thermal insulation complying with ASTM C 1289, Type II, Class 1, with oriented strand board adhered to spacers on one face.
OR
Rigid, cellular, polyisocyanurate thermal insulation with oriented strand board laminated to one face complying with ASTM C 1289, Type V. Oriented-strand-board face has a second layer of oriented strand board adhered to it with spacers between.
 - 1) Polyisocyanurate-Foam Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 2-1/2 inches (64 mm) **OR** 3 inches (76 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (102 mm), **as directed**.
 - 2) Oriented-Strand-Board Nominal Thickness: 7/16 inch (11.1 mm) **OR** 5/8 inch (15.9 mm), **as directed**.
 - 3) Spacers: Wood furring strips or blocks not less than 3/4 inch (19 mm) thick and spaced not more than 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 24 inches (600 mm), **as directed**, o.c.



G. Subflooring And Underlayment

1. Plywood Combination Subfloor-Underlayment: DOC PS 1, Exterior, Structural I, C-C Plugged **OR** Exterior, C-C Plugged **OR** Exposure 1, Structural I, Underlayment **OR** Exposure 1, Underlayment, **as directed**, single-floor panels.
2. Oriented-Strand-Board Combination Subfloor-Underlayment: Exposure 1 single-floor panels.
3. Plywood Subflooring: Exterior, Structural I **OR** Exterior **OR** Exposure 1, Structural I **OR** Exposure 1, **as directed**, single-floor panels or sheathing.
4. Oriented-Strand-Board Subflooring: Exposure 1, Structural I sheathing **OR** single-floor panels or sheathing, **as directed**.
5. Underlayment, General: Provide underlayment in nominal thicknesses indicated or, if not indicated, not less than 1/4 inch (6.4 mm) over smooth subfloors and not less than 3/8 inch (9.5 mm) over board or uneven subfloors.
6. Plywood Underlayment for Resilient Flooring: DOC PS 1, Exterior A-C **OR** Exterior B-C **OR** Exterior, C-C Plugged **OR** Exposure 1 Underlayment, **as directed**, with fully sanded face.
7. Plywood Underlayment for Ceramic Tile: DOC PS 1, Exterior, C-C Plugged, not less than 5/8-inch (15.9-mm) nominal thickness, for ceramic tile set in organic **OR** epoxy, **as directed**, adhesive.
8. Plywood Underlayment for Carpet: DOC PS 1, Exterior, C-C Plugged **OR** Exposure 1, Underlayment **OR** Interior, Underlayment, **as directed**.
9. Particleboard Underlayment: ANSI A208.1, Grade PBU **OR** M-2, Exterior Glue, complying with dimensional tolerances and thickness swell requirements of Grade PBU, **as directed**.
10. Hardboard Underlayment: AHA A135.4, Class 4 (Service), Surface S1S; with back side sanded.

H. Fasteners

1. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.
 - a. For roof and wall, **as directed**, sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M **OR** of Type 304 stainless steel, **as directed**.
2. Nails, Brads, and Staples: ASTM F 1667.
3. Power-Driven Fasteners: NES NER-272.
4. Wood Screws: ASME B18.6.1.
5. Screws for Fastening Wood Structural Panels to Cold-Formed Metal Framing: ASTM C 954, except with wafer heads and reamer wings, length as recommended by screw manufacturer for material being fastened.
 - a. For wall and roof sheathing panels, provide screws with organic-polymer or other corrosion-protective coating having a salt-spray resistance of more than 800 hours according to ASTM B 117.
6. Screws for Fastening Gypsum Sheathing to Cold-Formed Metal Framing: Steel drill screws, in length recommended by sheathing manufacturer for thickness of sheathing board to be attached, with organic-polymer or other corrosion-protective coating having a salt-spray resistance of more than 800 hours according to ASTM B 117.
 - a. For steel framing less than 0.0329 inch (0.835 mm) thick, attach sheathing to comply with ASTM C 1002.
 - b. For steel framing from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick, attach sheathing to comply with ASTM C 954.
7. Screws for Fastening Oriented-Strand-Board-Surfaced, Polyisocyanurate-Foam Sheathing to Metal Roof Deck: Steel drill screws, in type and length recommended by sheathing manufacturer for thickness of sheathing board to be attached, with organic-polymer or other corrosion-protective coating having a salt-spray resistance of more than 800 hours according to ASTM B 117. Provide washers or plates if recommended by sheathing manufacturer.

I. Weather-Resistant Sheathing Paper

1. Building Paper:
 - a. ASTM D 226, Type 1 (No. 15 asphalt-saturated organic felt), unperforated.

OR



- IBC Standard 1404.2, Grade D (water-vapor-permeable, kraft building paper), except that water resistance shall be not less than 1 hour and water-vapor transmission shall be not less than 75 g/sq. m x 24 h.
2. Building Wrap: ASTM E 1677, Type I air retarder; with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, when tested according to ASTM E 84; UV stabilized; and acceptable to authorities having jurisdiction.
 - a. Water-Vapor Permeance: Not less than 535 **OR** 152 **OR** 125 **OR** 63, **as directed**, g through 1 sq. m of surface in 24 hours per ASTM E 96, Desiccant Method (Procedure A).
 - b. Allowable UV Exposure Time: Not less than three months.
 3. Building-Wrap Tape: Pressure-sensitive plastic tape recommended by building-wrap manufacturer for sealing joints and penetrations in building wrap.
- J. Sheathing Joint-And-Penetration Treatment Materials
1. Sealant for Paper-Surfaced **OR** Glass-Mat, **as directed**, Gypsum Sheathing Board:
 - a. Elastomeric, medium-modulus, neutral-curing silicone joint sealant compatible with joint substrates formed by gypsum sheathing and other materials, recommended by sheathing manufacturer for application indicated, and complying with requirements for elastomeric sealants specified in Division 07 Section "Joint Sealants".
OR
Silicone emulsion sealant complying with ASTM C 834, compatible with sheathing tape and sheathing, and recommended by tape and sheathing manufacturers for use with glass-fiber sheathing tape and for covering exposed fasteners.
 2. Sheathing Tape for Glass-Mat Gypsum Sheathing Board: Self-adhering glass-fiber tape, minimum 2 inches (50 mm) wide, 10 by 10 or 10 by 20 threads/inch (390 by 390 or 390 by 780 threads/m), of type recommended by sheathing and tape manufacturers for use with silicone emulsion sealant in sealing joints in glass-mat gypsum sheathing board and with a history of successful in-service use.
 3. Sheathing Tape for Foam-Plastic Sheathing: Pressure-sensitive plastic tape recommended by sheathing manufacturer for sealing joints and penetrations in sheathing.
- K. Miscellaneous Materials
1. Adhesives for Field Gluing Panels to Framing: Formulation complying with APA AFG-01 **OR** ASTM D 3498, **as directed**, that is approved for use with type of construction panel indicated by manufacturers of both adhesives and panels.
 - a. Use adhesives that have a VOC content of 50 **OR** 70, **as directed**, g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, rubberized-asphalt compound, bonded to a high-density, cross-laminated polyethylene film to produce an overall thickness of not less than 0.025 inch (0.6 mm) **OR** 0.030 inch (0.8 mm) **OR** 0.040 inch (1.0 mm), **as directed**.
 3. Primer for Flexible Flashing: Product recommended by manufacturer of flexible flashing for substrate.

1.3 EXECUTION

- A. Installation, General
1. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
 2. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction, unless otherwise indicated.
 3. Securely attach to substrate by fastening as indicated, complying with the following:
 - a. NES NER-272 for power-driven fasteners.
 - b. Table 2304.9.1, "Fastening Schedule," in ICC's "International Building Code."
 - c. "Nailing Schedule," and Tables in Section 2304 of the ICC's International Building Code.
 - d. Table 2306.1, "Fastening Schedule," in SBCCI's "Standard Building Code."



- e. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's "International Residential Code for One- and Two-Family Dwellings."
- f. Table 602.3(1), "Fastener Schedule for Structural Members," and Table 602.3(2), "Alternate Attachments," in ICC's "International One- and Two-Family Dwelling Code."
- 4. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections. Install fasteners without splitting wood.
- 5. Coordinate wall and roof sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.
- 6. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.
- 7. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

B. Wood Structural Panel Installation

- 1. General: Comply with applicable recommendations in APA Form No. E30S, "Engineered Wood Construction Guide," for types of structural-use panels and applications indicated.
- 2. Fastening Methods: Fasten panels as indicated below:
 - a. Combination Subfloor-Underlayment:
 - 1) Glue and nail **OR** Nail, **as directed**, to wood framing.
 - 2) Screw to cold-formed metal framing.
 - 3) Space panels 1/8 inch (3 mm) apart at edges and ends.
 - b. Subflooring:
 - 1) Glue and nail **OR** Nail **OR** Nail or staple, **as directed**, to wood framing.
 - 2) Screw to cold-formed metal framing.
 - 3) Space panels 1/8 inch (3 mm) apart at edges and ends.
 - c. Wall and Roof Sheathing:
 - 1) Nail **OR** Nail or staple, **as directed**, to wood framing. Apply a continuous bead of glue to framing members at edges of wall sheathing panels.
 - 2) Screw to cold-formed metal framing.
 - 3) Space panels 1/8 inch (3 mm) apart at edges and ends.
 - d. Underlayment:
 - 1) Nail **OR** Nail or staple, **as directed**, to subflooring.
 - 2) Space panels 1/32 inch (0.8 mm) apart at edges and ends.
 - 3) Fill and sand edge joints of underlayment receiving resilient flooring right before installing flooring.

C. Gypsum Sheathing Installation

- 1. Comply with GA-253 and with manufacturer's written instructions.
 - a. Fasten gypsum sheathing to wood framing with nails **OR** screws, **as directed**.
 - b. Fasten gypsum sheathing to cold-formed metal framing with screws.
 - c. Install boards with a 3/8-inch (9.5-mm) gap where non-load-bearing construction abuts structural elements.
 - d. Install boards with a 1/4-inch (6.4-mm) gap where they abut masonry or similar materials that might retain moisture, to prevent wicking.
- 2. Apply fasteners so heads bear tightly against face of sheathing boards but do not cut into facing.
- 3. Horizontal Installation: Install sheathing with V-grooved edge down and tongue edge up. Interlock tongue with groove to bring long edges in contact with edges of adjacent boards without forcing. Abut ends of boards over centers of studs, and stagger end joints of adjacent boards not less than one stud spacing. Attach boards at perimeter and within field of board to each steel stud.



- a. Space fasteners approximately 8 inches (200 mm) o.c. and set back a minimum of 3/8 inch (9.5 mm) from edges and ends of boards.
 - b. For sheathing under stucco cladding, boards may be initially tacked in place with screws if overlying self-furring metal lath is screw-attached through sheathing to studs immediately after sheathing is installed.
4. Vertical Installation: Install board vertical edges centered over studs. Abut ends and edges of each board with those of adjacent boards. Attach boards at perimeter and within field of board to each stud.
 - a. Space fasteners approximately 8 inches (200 mm) o.c. and set back a minimum of 3/8 inch (9.5 mm) from edges and ends of boards.
 - b. For sheathing under stucco cladding, boards may be initially tacked in place with screws if overlying self-furring metal lath is screw-attached through sheathing to studs immediately after sheathing is installed.
- D. Fiberboard Sheathing Installation
1. Comply with ASTM C 846 and with manufacturer's written instructions.
 2. Fasten fiberboard sheathing panels to intermediate supports and then at edges and ends. Use galvanized roofing nails or galvanized staples, **as directed**; comply with manufacturer's recommended spacing and referenced fastening schedule. Drive fasteners flush with surface of sheathing and locate perimeter fasteners at least 3/8 inch (9.5 mm) from edges and ends.
 3. Install sheathing vertically with long edges parallel to, and centered over, studs. Install solid wood blocking where end joints do not occur over framing. Allow 1/8-inch (3-mm) open space between edges and ends of adjacent units. Stagger horizontal joints if any.
 4. Cover sheathing as soon as practical after installation to prevent deterioration from wetting.
- E. Foam-Plastic Sheathing Installation
1. Comply with manufacturer's written instructions.
 2. Foam-Plastic Wall Sheathing: Install vapor-relief strips or equivalent for permitting escape of moisture vapor that otherwise would be trapped in stud cavity behind sheathing.
- F. Particleboard Underlayment Installation
1. Comply with the National Particleboard Association's recommendations for type of subfloor indicated. Fill and sand gouges, gaps, and chipped edges. Sand uneven joints flush.
 - a. Fastening Method: Glue and nail **OR** Nail **OR** Nail or staple, **as directed**, underlayment to subflooring.
- G. Hardboard Underlayment Installation
1. Comply with AHA's "Application Instructions for Basic Hardboard Products" and with hardboard manufacturer's written instructions for preparing and applying hardboard underlayment.
 - a. Fastening Method: Nail **OR** Nail or staple, **as directed**, underlayment to subflooring.
- H. Weather-Resistant Sheathing-Paper Installation
1. General: Cover sheathing with weather-resistant sheathing paper as follows:
 - a. Cut back barrier 1/2 inch (13 mm) on each side of the break in supporting members at expansion- or control-joint locations.
 - b. Apply barrier to cover vertical flashing with a minimum 4-inch (100-mm) overlap, unless otherwise indicated.
 2. Building Paper: Apply horizontally with a 2-inch (50-mm) overlap and a 6-inch (150-mm) end lap; fasten to sheathing with galvanized staples or roofing nails.
 3. Building Wrap: Comply with manufacturer's written instructions.
 - a. Seal seams, edges, fasteners, and penetrations with tape.
 - b. Extend into jambs of openings and seal corners with tape.
- I. Sheathing Joint-And-Penetration Treatment
1. Seal sheathing joints according to sheathing manufacturer's written instructions.



- a. Apply elastomeric sealant to joints and fasteners and trowel flat. Apply sufficient quantity of sealant to completely cover joints and fasteners after troweling. Seal other penetrations and openings.
- b. Apply glass-fiber sheathing tape to glass-mat gypsum sheathing board joints, and apply and trowel silicone emulsion sealant to embed entire face of tape in sealant. Apply sealant to exposed fasteners with a trowel so fasteners are completely covered. Seal other penetrations and openings.
- c. Apply sheathing tape to joints between foam-plastic sheathing panels and at items penetrating sheathing. Apply at upstanding flashing to overlap both flashing and sheathing.

J. Flexible Flashing Installation

1. Apply flexible flashing where indicated to comply with manufacturers written instructions.
 - a. Prime substrates as recommended by flashing manufacturer.
 - b. Lap seams and junctures with other materials at least 4 inches (100 mm), except that at flashing flanges of other construction, laps need not exceed flange width.
 - c. Lap flashing over weather-resistant building paper at bottom and sides of openings.
 - d. Lap weather-resistant building paper over flashing at heads of openings.
 - e. After flashing has been applied, roll surfaces with a hard rubber or metal roller to ensure that flashing is completely adhered to substrates.

K. Protection

1. Paper-Surfaced Gypsum Sheathing: Protect sheathing by covering exposed exterior surface of sheathing with weather-resistant sheathing paper securely fastened to framing. Apply covering immediately after sheathing is installed.

END OF SECTION 07 46 23 00a



Task	Specification	Specification Description
07 46 23 00	07 26 13 00	Rough Carpentry
07 46 29 00	07 26 13 00	Rough Carpentry
07 46 29 00	07 46 23 00	Miscellaneous Carpentry
07 46 29 00	07 46 23 00a	Sheathing
07 46 33 00	07 46 16 00b	Siding



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**SECTION 07 46 46 00 - EXTERIOR ARCHITECTURAL WOODWORK**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for exterior architectural woodwork. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Exterior standing and running trim.
 - b. Exterior frames and jambs.
 - c. Exterior shutters.
 - d. Exterior ornamental work.
 - e. Shop priming exterior woodwork.
 - f. Shop finishing exterior woodwork.

C. Submittals

1. Product Data: For each type of product and process indicated and incorporated into items of exterior architectural woodwork during fabrication, finishing, and installation.
 - a. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements.
 - b. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements.
2. Shop Drawings: Show location of each item, dimensioned plans and elevations, large-scale details, attachment devices, and other components.
3. Samples: For lumber for exterior wood stain finish and lumber and panel products for shop-applied opaque finish, for each finish system and color, with one-half of exposed surface finished.
4. LEED Submittal:
 - a. Certificates for Credit MR 7: Chain-of-custody certificates certifying that products specified to be made from certified wood comply with forest certification requirements. Include evidence that mill is certified for chain of custody by an FSC-accredited certification body.
 - 1) Include statement indicating costs for each certified wood product.
5. Woodwork Quality Standard Compliance Certificates: AWI Quality Certification Program certificates **OR** WI-certified compliance certificates, **as directed**.

D. Quality Assurance

1. Quality Standard: Unless otherwise indicated, comply with AWI's "Architectural Woodwork Quality Standards" **OR** WI's "Manual of Millwork", **as directed**.
 - a. Provide AWI Quality Certification Program labels and certificates indicating that woodwork, including installation.
 - b. Provide WI-certified compliance labels and certificates indicating that woodwork, including installation.
2. Fire-Test-Response Characteristics: Where fire-retardant materials or products are indicated, provide materials and products with specified fire-test-response characteristics as determined by testing identical products per test method indicated by UL, ITS, or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify with appropriate markings of applicable testing and inspecting agency in the form of separable paper label or, where required by authorities having jurisdiction, imprint on surfaces of materials that will be concealed from view after installation.



3. Forest Certification: Provide exterior architectural woodwork produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."

1.2 PRODUCTS

A. Materials

1. General: Provide materials that comply with requirements of AWI's **OR** WI's, **as directed**, quality standard for each type of woodwork and quality grade specified, unless otherwise indicated.
2. Wood Products: Comply with the following:
 - a. Hardboard: AHA A135.4.
 - b. Softwood Plywood: DOC PS 1, Exterior **OR** Medium Density Overlay, **as directed**.

B. Wood-Preservative-Treated Materials

1. Preservative Treatment by Nonpressure Process: Comply with AWPA N1 using the following preservative for woodwork items indicated to receive water-repellent preservative treatment:
 - a. Water-Repellent Preservative: Formulation made specifically for dip treatment of woodwork items and containing 3-iodo-2-propynyl butyl carbamate (IPBC) complying with AWPA P8 as its active ingredient.
 - b. Water-Repellent Preservative/Insecticide: Formulation made specifically for dip treatment of woodwork items and containing 3-iodo-2-propynyl butyl carbamate (IPBC) as its active ingredient, combined with an insecticide containing chlorpyrifos as its active ingredient, both complying with AWPA P8.
2. Preservative Treatment by Pressure Process: AWPA C2 (lumber) and AWPA C9 (plywood) and the following:
 - a. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
 - b. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.
 - c. Mark each treated item with treatment quality mark of an inspection agency approved by the American Lumber Standards Committee Board of Review.
3. Extent of Treatment: Treat blocking and nailers by pressure process and treat other exterior architectural woodwork either by pressure or nonpressure process.
 - a. Items fabricated from the following wood species need not be treated:
 - 1) Redwood **OR** All-heart redwood, **as directed**.
 - 2) Western red cedar **OR** All-heart western red cedar, **as directed**.
 - 3) Teak.
 - 4) African mahogany.

C. Fire-Retardant-Treated Materials

1. General: Where fire-retardant-treated materials are indicated, provide materials that comply with performance requirements of AWPA C20 (lumber) and AWPA C27 (plywood), exterior type.
 - a. Fire-Retardant Chemicals: Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
 - b. Mill lumber before treatment and implement special procedures during treatment and drying processes that prevent lumber from warping and developing discolorations from drying sticks or other causes, marring, and other defects affecting appearance of treated woodwork.
 - c. Kiln-dry materials before and after treatment to levels required for untreated materials.



- d. Do not use treated materials that do not comply with requirements of referenced woodworking standard or that are warped, discolored, or otherwise defective.
 - e. Identify fire-retardant-treated materials with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection, or another testing and inspecting agency acceptable to authorities having jurisdiction.
- D. Installation Materials
1. Blocking, Shims, and Nailers: Softwood or hardwood lumber, pressure-preservative treated **OR** fire-retardant treated, **as directed**, kiln dried to less than 15 percent moisture content.
 2. Nails: Aluminum **OR** Hot-dip galvanized **OR** Stainless steel, **as directed**.
 3. Screws: Aluminum **OR** Bronze **OR** Hot-dip galvanized **OR** Stainless steel, **as directed**.
 - a. Provide self-drilling screws for metal framing supports, as recommended by metal-framing manufacturer.
 4. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide nonferrous-metal or hot-dip galvanized anchors and inserts, unless otherwise indicated. Provide toothed-steel or lead expansion sleeves for drilled-in-place anchors.
- E. Fabrication
1. Wood Moisture Content: 9 to 15 **OR** 10 to 15 **OR** 7 to 12, **as directed**, percent.
 2. Fabricate woodwork to dimensions, profiles, and details indicated. Ease edges to radius indicated for the following:
 - a. Edges of Solid-Wood (Lumber) Members 3/4 Inch (19 mm) Thick or Less: 1/16 inch (1.6 mm).
 - b. Edges of Rails and Similar Members More Than 3/4 Inch (19 mm) Thick: 1/8 inch (3 mm).
 3. Complete fabrication, including assembly, finishing, and hardware application, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
 4. Shop cut openings, to maximum extent possible, to receive hardware, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Smooth edges of cutouts and seal with a water-resistant coating suitable for exterior applications.
 5. Woodwork for Transparent Finish:
 - a. Grade: Premium **OR** Custom **OR** Economy, **as directed**.
 - b. Wood Species: Teak **OR** African mahogany **OR** White oak **OR** All-heart redwood **OR** Western red cedar **OR** Eastern white pine, **as directed**.
 6. Woodwork for Opaque Finish:
 - a. Grade: Premium **OR** Custom **OR** Economy, **as directed**.
 - b. Wood Species: All-heart redwood **OR** Western red cedar **OR** Ponderosa pine **OR** Eastern white pine, sugar pine, or western white pine **OR** Any closed-grain hardwood, **as directed**.
 7. Backout or groove backs of flat trim members and kerf backs of other wide, flat members, except for members with ends exposed in finished work.
 8. Shop Priming: Shop prime woodwork for paint finish with one coat of wood primer specified in Division 07.
 - a. Backpriming: Apply one coat of sealer or primer, compatible with finish coats, to concealed surfaces of woodwork. Apply two coats to surfaces installed in contact with concrete or masonry and to end-grain surfaces.
 9. Shop Finishing: Entire finish of exterior architectural woodwork is specified in this Section. To greatest extent possible, finish architectural woodwork at fabrication shop. Defer only final touchup and cleaning until after installation.
 - a. Grade: Same grade as item to be finished **OR** Premium **OR** Custom **OR** Economy, **as directed**.
 - b. Backpriming: Apply one coat of sealer or primer, compatible with finish coats, to concealed surfaces of woodwork. Apply two coats to surfaces installed in contact with concrete or masonry and to end-grain surfaces.
 - c. AWI Finish System: Conversion varnish **OR** Catalyzed polyurethane, **as directed**.



- d. WI Finish System: 4, conversion varnish **OR** 5, catalyzed polyurethane **OR** 7a., synthetic enamel, **OR as directed**.
- e. Sheen: Satin 31-45 **OR** Semigloss 46-60 **OR** Gloss 61-100, **as directed**, gloss units measured on 60-degree gloss meter per ASTM D 523.

1.3 EXECUTION

A. Preparation

1. Before installation, condition woodwork to average prevailing humidity conditions in installation areas.
2. Deliver concrete inserts and similar anchoring devices to be built into substrates well in advance of time substrates are to be built.
3. Before installing architectural woodwork, examine shop-fabricated work for completion and complete work as required, including removal of packing and backpriming.

B. Installation

1. Quality Standard: Install woodwork to comply with same grade specified in Part 1.2 for type of woodwork involved.
2. Install woodwork true and straight with no distortions. Shim as required with concealed shims. Install level and plumb to a tolerance of 1/8 inch in 96 inches (3 mm in 2400 mm).
3. Scribe and cut woodwork to fit adjoining work, and refinish cut surfaces or repair damaged finish at cuts.
4. Fire-Retardant-Treated Wood: Handle, store, and install fire-retardant-treated wood to comply with chemical treatment manufacturer's written instructions, including those for adhesives used to install woodwork.
5. Preservative-Treated Wood: Where cut or drilled in field, treat cut ends and drilled holes according to AWPA M4.
6. Anchor woodwork to anchors or blocking built in or directly attached to substrates. Secure to grounds, stripping and blocking with countersunk concealed fasteners and blind nailing. Use fine finishing nails for exposed nailing, countersunk and filled flush with woodwork.
7. Standing and Running Trim: Install with minimum number of joints possible, using full-length pieces (from maximum length of lumber available) to greatest extent possible. Do not use pieces less than 36 inches (900 mm) long, except where shorter single-length pieces are necessary. Scarf running joints and stagger in adjacent and related members.
 - a. Install standing and running trim with no more variation from a straight line than 1/8 inch in 96 inches (3 mm in 2400 mm).
8. Complete finishing work specified in this Section to extent not completed at shop or before installation of woodwork. Fill nail and screw holes with matching filler where exposed.
9. Refer to Division 07 for final finishing of installed architectural woodwork.

C. Adjusting And Cleaning

1. Repair damaged and defective woodwork, where possible, to eliminate functional and visual defects; replace woodwork where not possible to repair. Adjust joinery for uniform appearance.
2. Clean woodwork on exposed and semiexposed surfaces. Touch up shop-applied finishes to restore damaged or soiled areas.

END OF SECTION 07 46 46 00

**SECTION 07 46 46 00a - INTERIOR ARCHITECTURAL WOODWORK**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for interior architectural woodwork. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Interior standing and running trim.
 - b. Interior frames and jambs.
 - c. Stairwork and rails.
 - d. Flush wood paneling and wainscots.
 - e. Interior ornamental work.
 - f. Wood cabinets.
 - g. Plastic-laminate cabinets.
 - h. Wood countertops.
 - i. Plastic-laminate countertops.
 - j. Solid-surfacing-material countertops.
 - k. Laminated-plastic laboratory tops.
 - l. Closet and utility shelving.
 - m. Shop finishing of interior woodwork.

C. Definitions

1. Interior architectural woodwork includes wood furring, blocking, shims, and hanging strips for installing woodwork items unless concealed within other construction before woodwork installation.
2. Rough carriages for stairs are a part of interior architectural woodwork. Platform framing, headers, partition framing, and other rough framing associated with stairwork are specified in Division 06 Section "Rough Carpentry".

D. Submittals

1. Product Data: For panel products, high-pressure decorative laminate, adhesive for bonding plastic laminate, solid-surfacing material, fire-retardant-treated materials, cabinet hardware and accessories, handrail brackets, and finishing materials and processes.
 - a. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements.
2. Shop Drawings: Show location of each item, dimensioned plans and elevations, large-scale details, attachment devices, and other components.
3. Samples:
 - a. Lumber with or for transparent finish, for each species and cut, finished on 1 side and 1 edge.
 - b. Veneer leaves representative of and selected from flitches to be used for transparent-finished woodwork.
 - c. Veneer-faced panel products with or for transparent finish for each species and cut. Include at least one face-veneer seam and finish as specified.
 - d. Lumber and panel products with shop-applied opaque finish, for each finish system and color, with exposed surface finished.
 - e. Plastic-laminates, for each type, color, pattern, and surface finish.
 - f. Thermoset decorative panels, for each type, color, pattern, and surface finish.
 - g. Solid-surfacing materials.



- h. Corner pieces as follows:
 - 1) Cabinet-front frame joints between stiles and rails, as well as exposed end pieces, 18 inches (450 mm) high by 18 inches (450 mm) wide by 6 inches (150 mm) deep.
 - 2) Miter joints for standing trim.
- i. Exposed cabinet hardware and accessories, one unit for each type and finish.
- 4. LEED Submittals:
 - a. Product Data for Credit EQ 4.1: For installation adhesives, including printed statement of VOC content.
 - b. Product Data for Credit EQ 4.4:
 - 1) For each composite-wood product used, documentation indicating that the bonding agent contains no urea formaldehyde.
 - 2) For each adhesive used, documentation indicating that the adhesive contains no urea formaldehyde.
 - c. Product Data for Credit(s) MR 4.1 and MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content
 - 1) Include statement indicating costs for each product having recycled content.
 - d. Certificates for Credit MR 7: Chain-of-custody certificates certifying that products specified to be made from certified wood comply with forest certification requirements. Include evidence that mill is certified for chain of custody by an FSC-accredited certification body.
 - 1) Include statement indicating costs for each certified wood product.
- 5. Product Certificates: For each type of product, signed by product manufacturer.
- 6. Woodwork Quality Standard Compliance Certificates: AWI Quality Certification Program certificates **OR** WI-certified compliance certificates, **as directed**.

E. Quality Assurance

- 1. Installer Qualifications: Fabricator of woodwork.
- 2. Quality Standard: Unless otherwise indicated, comply with AWI's "Architectural Woodwork Quality Standards" **OR** WI's "Manual of Millwork", **as directed**.
 - a. Provide AWI Quality Certification Program labels and certificates for woodwork, including installation.
 - b. Provide WI-certified compliance labels and certificates for woodwork, including installation.
- 3. Fire-Test-Response Characteristics: Where fire-retardant materials or products are indicated, provide materials and products with specified fire-test-response characteristics as determined by testing identical products per test method indicated by UL, ITS, or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify with appropriate markings of applicable testing and inspecting agency in the form of separable paper label or, where required by authorities having jurisdiction, imprint on surfaces of materials that will be concealed from view after installation.
- 4. Forest Certification: Provide interior architectural woodwork produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
- 5. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

- 1. Do not deliver woodwork until painting and similar operations that could damage woodwork have been completed in installation areas. If woodwork must be stored in other than installation areas, store only in areas where environmental conditions comply with requirements specified in "Project Conditions" Article.

1.2 PRODUCTS

A. Materials



1. General: Provide materials that comply with requirements of AWI's **OR** WI's, **as directed**, quality standard for each type of woodwork and quality grade specified, unless otherwise indicated.
 2. Wood Species and Cut for Transparent Finish: Red oak, plain sawn or sliced **OR** White oak, rift sawn or cut **OR** White ash, plain sawn or sliced **OR** Hickory, plain sawn or sliced, **as directed**.
 3. Wood Species for Opaque Finish: Any closed-grain hardwood **OR** Eastern white pine, sugar pine, or western white pine, **as directed**.
 4. Wood Products: Comply with the following:
 - a. Hardboard: AHA A135.4.
 - b. Medium-Density Fiberboard: ANSI A208.2, Grade MD, made with binder containing no urea formaldehyde.
 - c. Particleboard: ANSI A208.1, Grade M-2 **OR** M-2-Exterior Glue, **as directed**.
 - d. Particleboard: Straw-based particleboard complying with requirements in ANSI A208.1, Grade M-2, except for density.
 - e. Softwood Plywood: DOC PS 1, Medium Density Overlay.
 - f. Veneer-Faced Panel Products (Hardwood Plywood): HPVA HP-1, made with adhesive containing no urea formaldehyde.
 5. Thermoset Decorative Panels: Particleboard or medium-density fiberboard finished with thermally fused, melamine-impregnated decorative paper complying with LMA SAT-1.
 - a. Provide PVC or polyester edge banding complying with LMA EDG-1 on components with exposed or semiexposed edges.
 6. High-Pressure Decorative Laminate: NEMA LD 3, grades as indicated or, if not indicated, as required by woodwork quality standard.
 7. Chemical-Resistant, High-Pressure Decorative Laminate: NEMA LD 3, Grade HGP.
 8. Solid-Surfacing Material: Homogeneous solid sheets of filled plastic resin complying with ISSFA-2.
 - a. Type: Standard type or Veneer type made from material complying with requirements for Standard type, as indicated, unless Special Purpose type is indicated.
 - b. Colors and Patterns: As selected by the Owner from manufacturer's full range.
 9. Float Glass for Cabinet Doors: ASTM C 1036, Type I, Class 1 (clear) **OR** 2 or 3 (tinted), **as directed**, Quality-Q3, 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**, thick.
 - a. Tint Color: Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 10. Tempered Float Glass for Cabinet Doors: ASTM C 1048, Kind FT, Condition A, Type I, Class 1 (clear) **OR** 2 or 3 (tinted), **as directed**, Quality-Q3, with exposed edges seamed before tempering, 6 mm thick, unless otherwise indicated.
 - a. Tint Color: Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
 11. Mirror Glass for Cabinet Doors: ASTM C 1503, Mirror Select **OR** Glazing, **as directed**, Quality-Q3, 3.0 mm **OR** 4.0 mm **OR** 5.0 mm **OR** 6.0 mm, **as directed**, thick.
 12. Decorative Glass for Cabinet Doors: Provide decorative glass complying with Division 08 Section "Decorative Glass Glazing".
 13. Tempered Float Glass for Cabinet Shelves: ASTM C 1048, Kind FT, Condition A, Type I, Class 1 (clear) **OR** 2 or 3 (tinted), **as directed**, Quality-Q3; with exposed edges seamed before tempering, 6 mm thick.
 - a. Tint Color: Blue-green **OR** Bronze **OR** Green **OR** Gray, **as directed**.
- B. Fire-Retardant-Treated Materials
1. General: Where fire-retardant-treated materials are indicated, use materials complying with requirements in this Article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified.
 - a. Do not use treated materials that do not comply with requirements of referenced woodworking standard or that are warped, discolored, or otherwise defective.
 - b. Use fire-retardant-treatment formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
 - c. Identify fire-retardant-treated materials with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection, or another testing and inspecting agency acceptable to authorities having jurisdiction.



2. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Comply with performance requirements of AWWPA C20 (lumber) and AWWPA C27 (plywood). Use the following treatment type:
 - a. Exterior Type: Organic-resin-based formulation thermally set in wood by kiln drying.
 - b. Interior Type A: Low-hygroscopic formulation.
 - c. Mill lumber after treatment within limits set for wood removal that do not affect listed fire-test-response characteristics, using a woodworking plant certified by testing and inspecting agency.
 - d. Mill lumber before treatment and implement special procedures during treatment and drying processes that prevent lumber from warping and developing discolorations from drying sticks or other causes, marring, and other defects affecting appearance of treated woodwork.
 - e. Kiln-dry materials before and after treatment to levels required for untreated materials.
3. Fire-Retardant Particleboard: Panels made from softwood particles and fire-retardant chemicals mixed together at time of panel manufacture to achieve flame-spread index of 25 or less and smoke-developed index of 25 or less per ASTM E 84.
4. Fire-Retardant Fiberboard: Medium-density fiberboard panels complying with ANSI A208.2, made from softwood fibers, synthetic resins, and fire-retardant chemicals mixed together at time of panel manufacture to achieve flame-spread index of 25 or less and smoke-developed index of 200 or less per ASTM E 84.

C. Cabinet Hardware And Accessories

1. General: Provide cabinet hardware and accessory materials associated with architectural cabinets, except for items specified in Division 08 Section "Door Hardware".
2. Butt Hinges: 2-3/4-inch (70-mm), 5-knuckle steel hinges made from 0.095-inch- (2.4-mm-) thick metal, and as follows:
 - a. Semiconcealed Hinges for Flush Doors: BHMA A156.9, B01361.
 - b. Semiconcealed Hinges for Overlay Doors: BHMA A156.9, B01521.
3. Frameless Concealed Hinges (European Type): BHMA A156.9, B01602, 100 **OR** 135 **OR** 170, **as directed**, degrees of opening, self-closing.
4. Back-Mounted Pulls: BHMA A156.9, B02011.
5. Wire Pulls: Back mounted, solid metal **OR** plastic, **as directed**, 4 inches (100 mm) long, 5/16 inch (8 mm) in diameter **OR** 5 inches (127 mm) long, 2-1/2 inches (63.5 mm) deep, and 5/16 inch (8 mm) in diameter, **as directed**.
6. Catches: Magnetic catches, BHMA A156.9, B03141 **OR** Push-in magnetic catches, BHMA A156.9, B03131 **OR** Roller catches, BHMA A156.9, B03071 **OR** Ball friction catches, BHMA A156.9, B03013, **as directed**.
7. Adjustable Shelf Standards and Supports: BHMA A156.9, B04071; with shelf rests, B04081 **OR** BHMA A156.9, B04102; with shelf brackets, B04112, **as directed**.
8. Shelf Rests: BHMA A156.9, B04013; metal **OR** plastic **OR** metal, two-pin type with shelf hold-down clip, **as directed**.
9. Drawer Slides: BHMA A156.9, B05091.
 - a. Standard Duty (Grade 1, Grade 2, and Grade 3): Side mounted and extending under bottom edge of drawer; full-extension **OR** partial-extension, **as directed**, type; zinc-plated steel **OR** epoxy-coated steel, **as directed**, with polymer rollers.
 - b. Heavy Duty (Grade 1HD-100 and Grade 1HD-200): Side mounted; full-extension **OR** full-overtravel-extension, **as directed**, type; zinc-plated steel ball-bearing slides.
 - c. Box Drawer Slides: Grade 1 **OR** Grade 1HD-100, **as directed**; for drawers not more than 6 inches (150 mm) high and 24 inches (600 mm) wide.
 - d. File Drawer Slides: Grade 1HD-100 **OR** Grade 1HD-200, **as directed**; for drawers more than 6 inches (150 mm) high or 24 inches (600 mm) wide.
 - e. Pencil Drawer Slides: Grade 2 **OR** Grade 1, **as directed**; for drawers not more than 3 inches (75 mm) high and 24 inches (600 mm) wide.
 - f. Keyboard Slides: Grade 1 **OR** Grade 1HD-100, **as directed**; for computer keyboard shelves.



- g. Trash Bin Slides: Grade 1HD-100 **OR** Grade 1HD-200, **as directed**; for trash bins not more than 20 inches (500 mm) high and 16 inches (400 mm) wide.
- 10. Plastic **OR** Aluminum, **as directed**, Slides for Sliding Glass Doors: BHMA A156.9, B07063.
- 11. Door Locks: BHMA A156.11, E07121.
- 12. Drawer Locks: BHMA A156.11, E07041.
- 13. Grommets for Cable Passage through Countertops: 1-1/4-inch (32-mm) **OR** 2-inch (51-mm), **as directed**, OD, brown **OR** black, **as directed**, molded-plastic grommets and matching plastic caps with slot for wire passage.
- 14. Paper Slots: 12 inches (305 mm) **OR** 17 inches (432 mm), **as directed**, long by 1-3/4 inches (45 mm) wide by 1 inch (25 mm) deep; brown **OR** black, **as directed**, molded-plastic, paper-slot liner with 1/4-inch (6.4-mm) lip.
- 15. Exposed Hardware Finishes: For exposed hardware, provide finish that complies with BHMA A156.18 for BHMA finish number indicated.
 - a. Dark, Oxidized, Satin Bronze, Oil Rubbed: BHMA 613 for bronze base; BHMA 640 for steel base; match the Owner's sample.
 - b. Bright Brass, Clear Coated: BHMA 605 for brass base; BHMA 632 for steel base.
 - c. Satin Brass, Blackened, Bright Relieved, Clear Coated: BHMA 610 for brass base; BHMA 636 for steel base.
 - d. Satin Chromium Plated: BHMA 626 for brass or bronze base; BHMA 652 for steel base.
 - e. Bright Chromium Plated: BHMA 625 for brass or bronze base; BHMA 651 for steel base.
 - f. Satin Stainless Steel: BHMA 630.
- 16. For concealed hardware, provide manufacturer's standard finish that complies with product class requirements in BHMA A156.9.

D. Miscellaneous Materials

- 1. Furring, Blocking, Shims, and Hanging Strips:
 - a. Softwood or hardwood lumber, kiln dried to less than 15 percent moisture content.
OR
Fire-retardant-treated softwood lumber, kiln dried to less than 15 percent moisture content.
- 2. Rough Carriages for Stairs:
 - a. Select Structural **OR** No. 1 **OR** No. 2, **as directed**, grade and any of the following species, kiln dried to 15 percent maximum moisture content:
 - 1) Douglas fir-larch.
 - 2) Douglas fir-south.
 - 3) Douglas fir-larch (north).
 - 4) Hem-fir.
 - 5) Hem-fir (north).
 - 6) Southern pine.
 - 7) Spruce-pine-fir (south).
 - 8) Spruce-pine-fir.**OR**
Laminated veneer lumber, made with an exterior-type adhesive complying with ASTM D 2559, and with the following allowable design values as determined according to ASTM D 5456:
 - 1) Extreme Fiber Stress in Bending, Edgewise: 2850 psi (19.7 MPa) **OR** 2600 psi (17.9 MPa) **OR** 2500 psi (17.2 MPa), **as directed**, for 12-inch nominal- (286-mm actual-) depth members.
 - 2) Modulus of Elasticity, Edgewise: 2,000,000 psi (13 800 MPa) **OR** 1,800,000 psi (12 400 MPa), **as directed**.
- 3. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide nonferrous-metal or hot-dip galvanized anchors and inserts on inside face of exterior walls and elsewhere as required for corrosion resistance. Provide toothed-steel or lead expansion sleeves for drilled-in-place anchors.
- 4. Handrail Brackets: Cast **OR** Extruded **OR** Stamped, **as directed**, from malleable iron **OR** aluminum **OR** bronze **OR** stainless steel, **as directed**, with wall flange drilled for exposed anchor



- OR** and tapped for concealed hanger bolt, **as directed**, and with support arm for screwing to underside of rail. Sized to provide 1-1/2-inch (38-mm) clearance between handrail and wall.
5. Handrail/Bumper Rail Brackets: Pairs of extruded-aluminum channels; one for fastening to back of rail and one for fastening to face of wall. They are then assembled in overlapping fashion and fastened together top and bottom with self-tapping screws. Sized to provide 1-1/2-inch (38-mm) clearance between handrail and wall.
 6. Adhesives, General: Do not use adhesives that contain urea formaldehyde.
 7. VOC Limits for Installation Adhesives and Glues: Use installation adhesives that comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - a. Wood Glues: 30 g/L.
 - b. Contact Adhesive: 250 g/L.
 8. Adhesive for Bonding Plastic Laminate: Unpigmented contact cement **OR** Contact cement **OR** PVA **OR** Urea formaldehyde **OR** Resorcinol, **as directed**.
 - a. Adhesive for Bonding Edges: Hot-melt adhesive or adhesive specified above for faces.
- E. Fabrication, General
1. Interior Woodwork Grade: Unless otherwise indicated, provide Premium **OR** Custom **OR** Economy, **as directed**, -grade interior woodwork complying with referenced quality standard.
 2. Wood Moisture Content: Comply with requirements of referenced quality standard for wood moisture content in relation to ambient relative humidity during fabrication and in installation areas.
 3. Sand fire-retardant-treated wood lightly to remove raised grain on exposed surfaces before fabrication.
 4. Fabricate woodwork to dimensions, profiles, and details indicated. Ease edges to radius indicated for the following:
 - a. Corners of Cabinets and Edges of Solid-Wood (Lumber) Members 3/4 Inch (19 mm) Thick or Less: 1/16 inch (1.5 mm).
 - b. Edges of Rails and Similar Members More Than 3/4 Inch (19 mm) Thick: 1/8 inch (3 mm).
 - c. Corners of Cabinets and Edges of Solid-Wood (Lumber) Members and Rails: 1/16 inch (1.5 mm).
 5. Complete fabrication, including assembly, finishing, **as directed**, and hardware application, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
 6. Shop-cut openings to maximum extent possible to receive hardware, appliances, plumbing fixtures, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.
 - a. Seal edges of openings in countertops with a coat of varnish.
 7. Install glass to comply with applicable requirements in Division 08 Section "Glazing" and in GANA's "Glazing Manual." For glass in wood frames, secure glass with removable stops.
- F. Interior Standing and Running Trim:
1. For transparent-finished trim items wider than available lumber, use veneered construction. Do not glue for width.
 2. Backout or groove backs of flat trim members and kerf backs of other wide, flat members, except for members with ends exposed in finished work.
 3. Assemble casings in plant except where limitations of access to place of installation require field assembly.
- G. Interior Frames and Jambs
1. Products fabricated from particleboard or medium-density fiberboard with veneered, exposed surfaces.



- H. Fire-Rated Interior Frames and Jambs
1. Products fabricated from fire-retardant particleboard or fire-retardant medium-density fiberboard with veneered, exposed surfaces and listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to NFPA 252.
 - a. Fire Rating: 20 minutes.
- I. Stairwork and Rails:
1. Treads: Transparent **OR** Opaque, **as directed**, finish.
 2. Risers: Transparent **OR** Opaque, **as directed**, finish.
 3. Stringers: Transparent **OR** Opaque, **as directed**, finish.
 4. Balusters: Transparent **OR** Opaque, **as directed**, finish.
 5. Handrails: Transparent **OR** Opaque, **as directed**, finish.
 6. Scotia, Cove, and Other Moldings: Transparent **OR** Opaque, **as directed**, finish.
- J. Flush Wood Paneling and Wainscots:
1. Lumber Trim and Edges: At fabricator's option, trim and edges indicated as solid wood (except moldings) may be either lumber or veneered construction compatible with grain and color of veneered panels.
 2. Matching of Adjacent Veneer Leaves: Book **OR** Slip **OR** Random, **as directed**, match.
 3. Veneer Matching within Panel Face: Running **OR** Balance **OR** Center-balance, **as directed**, match.
 4. Panel-Matching Method (Economy Grade): No matching between panels is required. Select and arrange panels for similarity of grain pattern and color between adjacent panels.
 5. Panel-Matching Method (Custom or Premium Grade): In each separate area, use premanufactured sets used full width **OR** premanufactured sets selectively reduced in width **OR** sequence-matched, uniform-size sets, **as directed**.
 6. Fire-Retardant-Treated Paneling: Provide panels consisting of wood veneer and fire-retardant particleboard or fire-retardant medium-density fiberboard. Panels shall have flame-spread index of 75 **OR** 25, **as directed**, or less and smoke-developed index of 450 or less per ASTM E 84.
- K. Interior Ornamental Work
1. Interior ornamental work includes the following:
 - a. Balustrades.
 - b. Columns.
 - c. Grilles.
 - d. Mantels.
 - e. Pediment heads.
 - f. Pilasters.
- L. Wood Cabinets for Transparent Finish:
1. AWI Type of Cabinet Construction: Flush overlay **OR** Reveal overlay **OR** Reveal overlay on face frame **OR** Flush inset **OR** Flush inset with face frame **OR** As indicated, **as directed**.
 2. WI Construction Style: Style A, Frameless **OR** B, Face Frame, **as directed**.
 3. WI Construction Type: Type I, multiple self-supporting units rigidly joined together **OR** II, single-length sections to fit access openings, **as directed**.
 4. WI Door and Drawer Front Style: Flush overlay **OR** Reveal overlay **OR** Lipped **OR** Flush, **as directed**.
 5. Reveal Dimension: 1/2 inch (13 mm) **OR** As indicated, **as directed**.
 6. Grain Direction: Vertically for drawer fronts, doors, and fixed panels **OR** Horizontally for drawer fronts, doors, and fixed panels **OR** As indicated, **as directed**.
 7. Matching of Veneer Leaves: Book **OR** Slip **OR** Random, **as directed**, match.
 8. Veneer Matching within Panel Face: Running **OR** Balance **OR** Center-balance, **as directed**, match.



9. Semiexposed Surfaces Other Than Drawer Bodies: Same species and cut indicated for exposed surfaces **OR** Thermoset decorative panels **OR** Compatible species to that indicated for exposed surfaces, stained to match, **as directed**.
10. Drawer Sides and Backs: Solid-hardwood lumber, same species indicated for exposed surfaces **OR** Solid-hardwood lumber, stained to match species indicated for exposed surfaces **OR** Solid hardwood lumber **OR** Thermoset decorative panels, **as directed**.
11. Drawer Bottoms: Hardwood plywood **OR** Thermoset decorative panels, **as directed**.
12. Provide dust panels of 1/4-inch (6.4-mm) plywood or tempered hardboard above compartments and drawers, unless located directly under tops.

M. Wood Cabinets for Opaque Finish:

1. AWI Type of Cabinet Construction: Flush overlay **OR** Reveal overlay **OR** Reveal overlay on face frame **OR** Flush inset **OR** Flush inset with face frame **OR** As indicated, **as directed**.
2. WI Construction Style: Style A, Frameless **OR** B, Face Frame, **as directed**.
3. WI Construction Type: Type I, multiple self-supporting units rigidly joined together **OR** II, single-length sections to fit access openings, **as directed**.
4. WI Door and Drawer Front Style: Flush overlay **OR** Reveal overlay **OR** Lipped **OR** Flush, **as directed**.
5. Reveal Dimension: 1/2 inch (13 mm) **OR** As indicated, **as directed**.
6. Species for Exposed Lumber Surfaces: Any closed-grain hardwood.
7. Panel Product for Exposed Surfaces: Medium-density fiberboard **OR** overlay, **as directed**.
8. Semiexposed Surfaces Other Than Drawer Bodies: Match materials indicated for exposed surfaces **OR** Thermoset decorative panels, **as directed**.
9. Drawer Sides and Backs: Solid-hardwood lumber **OR** Thermoset decorative panels, **as directed**.
10. Drawer Bottoms: Hardwood plywood **OR** Thermoset decorative panels, **as directed**.
11. Provide dust panels of 1/4-inch (6.4-mm) plywood or tempered hardboard above compartments and drawers, unless located directly under tops.

N. Plastic-Laminate Cabinets:

1. AWI Type of Cabinet Construction: Flush overlay **OR** Reveal overlay **OR** Reveal overlay on face frame **OR** Flush inset **OR** Flush inset with face frame **OR** As indicated, **as directed**.
2. WI Construction Style: Style A, Frameless **OR** B, Face Frame, **as directed**.
3. WI Construction Type: Type I, multiple self-supporting units rigidly joined together **OR** II, single-length sections to fit access openings, **as directed**.
4. WI Door and Drawer Front Style: Flush overlay **OR** Reveal overlay **OR** Lipped **OR** Flush, **as directed**.
5. Reveal Dimension: 1/2 inch (13 mm) **OR** As indicated, **as directed**.
6. Laminate Cladding for Exposed Surfaces: High-pressure decorative laminate as follows:
 - a. Horizontal Surfaces Other Than Tops: Grade HGS **OR** HGL, **as directed**.
 - b. Postformed Surfaces: Grade HGP, **as directed**.
 - c. Vertical Surfaces: Grade HGS **OR** VGS, **as directed**.
 - d. Edges: Grade HGS **OR** Grade VGS **OR** PVC tape, 0.018-inch (0.460-mm) minimum thickness, matching laminate in color, pattern, and finish **OR** PVC T-mold matching laminate in color, pattern, and finish **OR** PVC edge banding, 0.12 inch (3 mm) thick, matching laminate in color, pattern, and finish, **as directed**.
7. Materials for Semiexposed Surfaces Other Than Drawer Bodies: High-pressure decorative laminate, Grade VGS **OR** High-pressure decorative laminate, Grade CLS **OR** Thermoset decorative panels, **as directed**.
8. Drawer Sides and Backs: Solid-hardwood lumber **OR** Thermoset decorative panels, **as directed**.
9. Drawer Bottoms: Hardwood plywood **OR** Thermoset decorative panels, **as directed**.
10. Colors, Patterns, and Finishes: As indicated by manufacturer's designations **OR** Match sample, **as directed**.
11. Colors, Patterns, and Finishes: As selected by the Owner from laminate manufacturer's full range of solid colors **OR** wood grains **OR** patterns, **as directed**, gloss **OR** matte, **as directed**, finish.



12. Provide dust panels of 1/4-inch (6.4-mm) plywood or tempered hardboard above compartments and drawers, unless located directly under tops.
- O. Wood Countertops
1. Type of Top:
 - a. Solid wood for transparent finish, edge glued, with crown direction reversed in adjacent boards, to produce widths indicated. Select boards for similarity of color and grain and arrange boards for optimum match between adjacent boards.
OR
Solid laminated for transparent finish. Narrow strips of lumber glued together with crown direction reversed in adjacent strips. Arrange strips for random mix of color and grain.
OR
Panel product for transparent finish (wood veneer laminated over core).
 - 1) Core Material: Particleboard or medium-density fiberboard **OR** Particleboard **OR** Medium-density fiberboard **OR** Particleboard made with exterior glue **OR** Medium-density fiberboard made with exterior glue **OR** Exterior-grade plywood **OR** Fire-retardant particleboard, **as directed**.
- P. Plastic-Laminate Countertops:
1. High-Pressure Decorative Laminate Grade: HGS **OR** HGP, **as directed**.
 2. Colors, Patterns, and Finishes: As selected by the Owner from laminate manufacturer's full range of solid colors **OR** wood grains **OR** patterns, **as directed**, gloss **OR** matte, **as directed**, finish.
 3. Edge Treatment: Same as laminate cladding on horizontal surfaces **OR** Lumber edge for transparent finish matching wood species and cut on cabinet surfaces **OR** As indicated, **as directed**.
 4. Core Material at Sinks: Particleboard made with exterior glue **OR** Medium-density fiberboard made with exterior glue or exterior-grade plywood, **as directed**.
- Q. Solid-Surfacing-Material Countertops:
1. Solid-Surfacing-Material Thickness: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**.
 2. Colors, Patterns, and Finishes: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 3. Fabricate tops in one piece with shop-applied backsplashes **OR** loose backsplashes for field application, **as directed**. Comply with solid-surfacing-material manufacturer's written recommendations for adhesives, sealers, fabrication, and finishing.
 4. Install integral sink bowls in countertops in shop.
- R. Laminated-Plastic Laboratory Tops
1. High-Pressure Decorative Laminate: Grade HGS **OR** Grade HGP **OR** Chemical-resistant, Grade HGP, **as directed**.
 2. Colors and Patterns: Provide materials and products that result in colors and patterns of exposed laminate surfaces complying with the following requirements:
 3. Core Material: Particleboard **OR** Particleboard made with exterior glue **OR** Fire-retardant particleboard **OR** Rotary-cut lauan or closed-grain hardwood plywood **OR** Exterior-grade rotary-cut lauan or closed-grain hardwood plywood, **as directed**.
- S. Closet And Utility Shelving
1. Shelf Material: 3/4-inch (19-mm) solid lumber **OR** veneer-faced panel product with solid-lumber edge **OR** veneer-faced panel product with veneer edge banding **OR** thermoset decorative panel with solid-lumber edge **OR** thermoset decorative panel with PVC or polyester edge banding **OR** medium-density fiberboard with solid-lumber edge **OR** particleboard with solid-lumber edge **OR** medium-density fiberboard with radiused edge **OR** particleboard with radiused and filled edge, **as directed**.
 2. Cleats: 3/4-inch (19-mm) solid lumber **OR** thermoset decorative panel **OR** panel product, **as directed**.



3. Wood Species: Match species indicated for other types of transparent-finished architectural woodwork located in same area of building, unless otherwise indicated **OR** Match species indicated for door to closet where shelving is located **OR** Any closed-grain hardwood **OR** Eastern white pine, sugar pine, or western white pine, **as directed**.

T. Shop Finishing

1. Grade: Provide finishes of same grades as items to be finished.
2. General: Finish architectural woodwork at fabrication shop as specified in this Section. Defer only final touchup, cleaning, and polishing until after installation.
3. General: Shop finish transparent-finished interior architectural woodwork at fabrication shop as specified in this Section. Refer to Division 07 for finishing opaque-finished architectural woodwork.
4. General: Drawings indicate items that are required to be shop finished. Finish such items at fabrication shop as specified in this Section. Refer to Division 07 for finishing architectural woodwork not indicated to be shop finished.
5. Shop Priming: Shop apply the prime coat including backpriming, if any, for transparent-finished items specified to be field finished. Refer to Division 07 for material and application requirements.
6. Preparation for Finishing: Comply with referenced quality standard for sanding, filling countersunk fasteners, sealing concealed surfaces, and similar preparations for finishing architectural woodwork, as applicable to each unit of work.
 - a. Backpriming: Apply one coat of sealer or primer, compatible with finish coats, to concealed surfaces of woodwork. Apply two coats to back of paneling and to end-grain surfaces. Concealed surfaces of plastic-laminate-clad woodwork do not require backpriming when surfaced with plastic laminate, backing paper, or thermoset decorative panels.

U. Transparent Finish:

1. Grade: Premium **OR** Custom **OR** Economy, **as directed**.
2. AWI Finish System: Acrylic lacquer **OR** Conversion varnish **OR** Catalyzed vinyl, **as directed**.
3. WI Finish System: 2, water-reducible acrylic lacquer **OR** 3b., catalyzed vinyl lacquer **OR** 4, conversion varnish, **as directed**.
4. Staining: None required **OR** Match approved sample, **as directed**.
5. Wash Coat for Stained Finish: Apply wash-coat sealer to woodwork made from closed-grain wood before staining and finishing.
6. Open Finish for Open-Grain Woods: Do not apply filler to open-grain woods.
7. Filled Finish for Open-Grain Woods: After staining (if any), apply paste wood filler to open-grain woods and wipe off excess. Tint filler to match stained wood.
 - a. Apply wash-coat sealer after staining and before filling.
8. Sheen: Flat, 15-30 **OR** Satin, 31-45 **OR** Semigloss, 46-60 **OR** Gloss, 61-100, **as directed** gloss units measured on 60-degree gloss meter per ASTM D 523.

V. Opaque Finish:

1. Grade: Premium **OR** Custom **OR** Economy, **as directed**.
2. AWI Finish System: Conversion varnish **OR** Catalyzed vinyl, **as directed**.
3. WI Finish System: 3b., catalyzed vinyl lacquer **OR** 4, conversion varnish **OR** 7a., synthetic enamel, **as directed**.
4. Color: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
5. Sheen: Flat, 15-30 **OR** Satin, 31-45 **OR** Semigloss, 46-60 **OR** Gloss, 61-100, **as directed**, gloss units measured on 60-degree gloss meter per ASTM D 523.

1.3 EXECUTION

A. Preparation



1. Before installation, condition woodwork to average prevailing humidity conditions in installation areas.
2. Before installing architectural woodwork, examine shop-fabricated work for completion and complete work as required, including removal of packing and backpriming.

B. Installation

1. Grade: Install woodwork to comply with requirements for the same grade specified in Part 1.2 for fabrication of type of woodwork involved.
2. Assemble woodwork and complete fabrication at Project site to comply with requirements for fabrication in Part 1.2, to extent that it was not completed in the shop.
3. Install woodwork level, plumb, true, and straight. Shim as required with concealed shims. Install level and plumb (including tops) to a tolerance of 1/8 inch in 96 inches (3 mm in 2400 mm).
4. Scribe and cut woodwork to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.
5. Fire-Retardant-Treated Wood: Handle, store, and install fire-retardant-treated wood to comply with chemical treatment manufacturer's written instructions, including those for adhesives used to install woodwork.
6. Anchor woodwork to anchors or blocking built in or directly attached to substrates. Secure with countersunk, concealed fasteners and blind nailing as required for complete installation. Use fine finishing nails or finishing screws for exposed fastening, countersunk and filled flush with woodwork and matching final finish if transparent finish is indicated.
7. Standing and Running Trim: Install with minimum number of joints possible, using full-length pieces (from maximum length of lumber available) to greatest extent possible. Do not use pieces less than 36 inches (900 mm) **OR** 60 inches (1500 mm) **OR** 96 inches (2400 mm), **as directed**, long, except where shorter single-length pieces are necessary. Scarf running joints and stagger in adjacent and related members.
 - a. Fill gaps, if any, between top of base and wall with plastic wood filler, sand smooth, and finish same as wood base if finished.
 - b. Install wall railings on indicated metal brackets securely fastened to wall framing.
 - c. Install standing and running trim with no more variation from a straight line than 1/8 inch in 96 inches (3 mm in 2400 mm).
8. Paneling: Anchor paneling to supporting substrate with concealed panel-hanger clips **OR** splined connection strips, **as directed**. Do not use face fastening, unless covered by trim **OR** otherwise indicated.
 - a. Install flush paneling with no more than 1/16 inch in 96-inch (1.5 mm in 2400-mm) vertical cup or bow and 1/8 inch in 96-inch (3 mm in 2400-mm) horizontal variation from a true plane.
9. Stairs: Securely anchor carriages to supporting substrates. Install stairs with treads and risers no more than 1/8 inch (3 mm) from indicated position.
10. Railings:
 - a. General: Install rails with no more than 1/8 inch in 96-inch (3 mm in 2400-mm) variation from a straight line.
 - b. Stair Rails: Glue and dowel or pin balusters to treads and railings, and railings to newel posts.
 - c. Wall Rails: Support rails on indicated metal brackets securely fastened to wall framing.
11. Cabinets: Install without distortion so doors and drawers fit openings properly and are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete installation of hardware and accessory items as indicated.
 - a. Install cabinets with no more than 1/8 inch in 96-inch (3 mm in 2400-mm) sag, bow, or other variation from a straight line.
 - b. Maintain veneer sequence matching of cabinets with transparent finish.
 - c. Fasten wall cabinets through back, near top and bottom, at ends and not more than 16 inches (400 mm) o.c. with No. 10 wafer-head screws sized for 1-inch (25-mm) penetration into wood framing, blocking, or hanging strips **OR** No. 10 wafer-head sheet metal screws through metal backing or metal framing behind wall finish **OR** toggle bolts through metal backing or metal framing behind wall finish, **as directed**.



12. Countertops: Anchor securely by screwing through corner blocks of base cabinets or other supports into underside of countertop.
 - a. Align adjacent solid-surfacing-material countertops and form seams to comply with manufacturer's written recommendations using adhesive in color to match countertop. Carefully dress joints smooth, remove surface scratches, and clean entire surface.
 - b. Install countertops with no more than 1/8 inch in 96-inch (3 mm in 2400-mm) sag, bow, or other variation from a straight line.
 - c. Secure backsplashes to tops with concealed metal brackets at 16 inches (400 mm) o.c. and to walls with adhesive.
 - d. Calk space between backsplash and wall with sealant specified in Division 07 Section "Joint Sealants".
13. Touch up finishing work specified in this Section after installation of woodwork. Fill nail holes with matching filler where exposed.
14. Refer to Division 07 for final finishing of installed architectural woodwork not indicated to be shop finished.

C. Adjusting And Cleaning

1. Repair damaged and defective woodwork, where possible, to eliminate functional and visual defects; where not possible to repair, replace woodwork. Adjust joinery for uniform appearance.
2. Clean, lubricate, and adjust hardware.
3. Clean woodwork on exposed and semiexposed surfaces. Touch up shop-applied finishes to restore damaged or soiled areas.

END OF SECTION 07 46 46 00a



Task	Specification	Specification Description
07 46 46 00	01 22 16 00	No Specification Required
07 46 46 00	07 46 16 00b	Siding



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**SECTION 07 46 63 00 - INSULATED-CORE METAL WALL PANELS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for insulated-core metal wall panels. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Foamed-insulation-core metal wall panels.
 - b. Laminated-insulation-core metal wall panels.
 - c. Honeycomb-core metal wall panels.

C. Definitions

1. Metal Wall Panel Assembly: Insulated-core metal wall panels, attachment system components, miscellaneous metal framing, and accessories necessary for a complete weathertight wall system.

D. Performance Requirements

1. General Performance: Metal wall panel assemblies shall comply with performance requirements without failure due to defective manufacture, fabrication, installation, or other defects in construction.
2. Delegated Design: Design metal wall panel assembly, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Air Infiltration: Air leakage through assembly of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) of wall area when tested according to ASTM E 283 at the following test-pressure difference:
 - a. Test-Pressure Difference: 1.57 lbf/sq. ft. (75 Pa) which is equivalent to a 25-mph (40-km/h) wind.
4. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:
 - a. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa) which is equivalent to a 50-mph (80-km/h) wind.
5. Water Penetration under Dynamic Pressure: No evidence of water leakage when tested according to AAMA 501.1 under dynamic pressure equal to 20 percent of inward-acting, wind-load design pressure of not less than 6.24 lbf/sq. ft. (299 Pa) and not more than 12 lbf/sq. ft. (575 Pa).
 - a. Water Leakage: As defined according to AAMA 501.1.
OR
Water Leakage: Uncontrolled water infiltrating the system or appearing on system's normally exposed interior surfaces from sources other than condensation. Water controlled by flashing and gutters that is drained back to the exterior and cannot damage adjacent materials or finishes is not water leakage.
6. Structural Performance: Metal wall panel assemblies shall withstand the effects the following loads and stresses within limits and under conditions indicated, based on testing according to ASTM E 330:
 - a. Wind Loads: Determine loads based on the following minimum design wind pressures:
 - 1) Uniform pressure of 20 lbf/sq. ft. (958 Pa) **OR** 30 lbf/sq. ft. (1436 Pa), **as directed**, acting inward or outward.
OR
Uniform pressure as indicated on Drawings.



- b. Deflection Limits: Metal wall panel assemblies shall withstand wind loads with horizontal deflections no greater than 1/180 **OR** 1/240, **as directed**, of the span.
- 7. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- 8. Thermal Performance: Provide insulated metal wall panel assemblies with thermal-resistance value (R-value) indicated when tested according to ASTM C 518.

E. Submittals

- 1. Product Data: For each type of product indicated.
- 2. Shop Drawings: Show fabrication and installation layouts of metal wall panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details. Distinguish between factory-, shop-, and field-assembled work.
- 3. Samples: For each type of exposed finish required.
- 4. Delegated-Design Submittal: For metal wall panel assembly indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- 5. Coordination Drawings: Exterior elevations, drawn to scale, and coordinating penetrations and wall-mounted items.
- 6. Product Test Reports.
- 7. Field quality-control reports.
- 8. Maintenance Data.
- 9. Warranties: Sample of special warranties.

F. Quality Assurance

- 1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- 2. Fire-Test-Response Characteristics: Provide metal wall panels and system components with the following fire-test-response characteristics as determined by testing identical panels and system components per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify products with appropriate markings of applicable testing agency.
 - a. Fire-Resistance Characteristics: Provide materials and construction tested for fire resistance per ASTM E 119.
 - b. Intermediate-Scale Multistory Fire Test: Tested mockup, representative of completed multistory wall assembly of which wall panel is a part, complies with NFPA 285 for test method and required fire-test-response characteristics of exterior non-load-bearing wall panel assemblies.
 - c. Radiant Heat Exposure: No ignition when tested according to NFPA 268.
 - d. Potential Heat: Acceptable level when tested according to NFPA 259.
 - e. Surface-Burning Characteristics: Provide wall panels with flame-spread index of 25 or less and smoke-developed index of 450 or less, per ASTM E 84.
- 3. Preinstallation Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

- 1. Deliver components, sheets, metal wall panels, and other manufactured items so as not to be damaged or deformed. Package metal wall panels for protection during transportation and handling.
- 2. Unload, store, and erect metal wall panels in a manner to prevent bending, warping, twisting, and surface damage.
- 3. Stack metal wall panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal wall panels to ensure dryness, with positive slope for



- drainage of water. Do not store metal wall panels in contact with other materials that might cause staining, denting, or other surface damage.
4. Retain strippable protective covering on metal wall panels for period of metal wall panel installation.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal wall panel assemblies that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period: Two years from date of Final Completion.
2. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal wall panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - a. Finish Warranty Period:
 - 1) 20 years from date of Final Completion for fluoropolymer finish.
 - 2) 10 years from date of Final Completion for siliconized polyester.

1.2 PRODUCTS

A. Panel Materials

1. Metallic-Coated Steel Sheet: Restricted flatness steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - b. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - c. Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 - d. Exposed Coil-Coated Finish:
 - 1) Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) Four-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 4) Mica Fluoropolymer: AAMA 621. Two-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 5) Metallic Fluoropolymer: AAMA 621. Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 6) FEVE Fluoropolymer: AAMA 621. Two-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.



- 7) Siliconized-Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
- 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mil (0.097 mm) for topcoat.
- e. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
2. Aluminum Sheet: Coil-coated sheet, ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.
 - a. Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 - b. Exposed Coil-Coated Finishes:
 - 1) Two-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) Three-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) Four-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 4) Mica Fluoropolymer: AAMA 620. Two-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 5) Metallic Fluoropolymer: AAMA 620. Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 6) FEVE Fluoropolymer: AAMA 620. Two-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 7) Siliconized-Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mil (0.097 mm) for topcoat.
 - c. Exposed Anodized Finish:
 - 1) Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
 - 2) Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - d. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
3. Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 temper.
 - a. Exposed Finish: Apply the following finish, as specified or indicated on Drawings.
 - 1) Natural finish.



- 2) Brushed Satin: CDA M32-06x (Mechanical Finish: directionally textured, medium satin; Coating: clear organic, air drying, as specified below):
 - a) Clear, Organic Coating: Clear, air-drying, acrylic lacquer specially developed for coating copper-alloy products, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
 - 3) Mirror Polished: CDA M22-06x (Mechanical Finish: buffed, specular; Coating: clear organic, air drying, as specified below):
 - a) Clear, Organic Coating: Clear, air-drying, acrylic lacquer specially developed for coating copper-alloy products, applied by air spray in two coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
 - 4) Pre-patinated: ASTM B 882. Copper sheets artificially aged by chemical reaction to convert surface to inorganic crystalline structure with color range and durability of naturally-formed patina.
 4. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304 **OR** 316, **as directed**, fully annealed.
 - a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 - b. Polished Finish: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1) Run grain of directional finishes with long dimension of each piece.
 - 2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - 3) Directional Satin Finish: No. 4.
 - c. Bright, Cold-Rolled, Unpolished Finish: No. 2B.
 5. Panel Sealants:
 - a. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
 - b. Joint Sealant: ASTM C 920; elastomeric polyurethane, polysulfide, or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal wall panels and remain weathertight; and as recommended in writing by metal wall panel manufacturer.
 - c. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.
- B. Insulation For Panel Cores
1. Polyisocyanurate Insulation: Closed cell, modified polyisocyanurate foam using a non-CFC blowing agent, foamed-in-place **OR** board, **as directed**, type, with maximum flame-spread index of 25 and smoke-developed index of 450.
 - a. Closed-Cell Content: 90 percent when tested according to ASTM D 2856.
 2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.60-lb/cu. ft. (26-kg/cu. m) minimum density, unless otherwise indicated; with maximum flame-spread index of 25 and smoke-developed index of 450.
 3. Molded-Polystyrene Board Insulation: ASTM C 578, Type I, 0.9 lb/cu. ft. (14 kg/cu. m) **OR** Type II, 1.35 lb/cu. ft. (22 kg/cu. m), Class 2 or 3, Grade 3, **as directed**, with maximum flame-spread index of 25 and smoke-developed index of 450.
- C. Miscellaneous Metal Framing
1. Miscellaneous Metal Framing, General: ASTM C 645, cold-formed metallic-coated steel sheet, ASTM A 653/A 653M, G40 (Z120) hot-dip galvanized **OR** ASTM A 653/A 653M, G60 (Z180) hot-dip galvanized, **as directed**, or coating with equivalent corrosion resistance unless otherwise indicated.
 2. Subgirts: Manufacturer's standard C- or Z-shaped sections, 0.064-inch (1.63-mm) nominal thickness.
 3. Zee Clips: 0.079-inch (2.01-mm) nominal thickness.
 4. Base or Sill Angles **OR** Channels, **as directed**: 0.079-inch (2.01-mm) nominal thickness.
 5. Hat-Shaped, Rigid Furring Channels:



- a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.025 inch (0.64 mm) **OR** 0.040 inch (1.02 mm), **as directed**.
 - b. Depth: As indicated **OR** 7/8 inch (21 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
6. Cold-Rolled Furring Channels: Minimum 1/2-inch- (13-mm-) wide flange.
- a. Nominal Thickness: As indicated **OR** As required to meet performance requirements **OR** 0.064 inch (1.63 mm), **as directed**.
 - b. Depth: As indicated **OR** 3/4 inch (19 mm), **as directed**.
 - c. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with 0.040-inch (1.02-mm) nominal thickness.
7. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.52-mm-) diameter wire, or double strand of 0.048-inch- (1.22-mm-) diameter wire.
8. Fasteners for Miscellaneous Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten miscellaneous metal framing members to substrates.
- D. Miscellaneous Materials
1. Panel Fasteners: Self-tapping screws; bolts and nuts; self-locking rivets and bolts; end-welded studs; and other suitable fasteners designed to withstand design loads. Provide exposed fasteners with heads matching color of metal wall panels by means of plastic caps or factory-applied coating. Provide EPDM, PVC, or neoprene sealing washers.
 2. Backer Board: Hardboard complying with AHA A135.4, Class 1 tempered, 1/8 inch (3 mm) **OR** 1/4 inch (6 mm), **as directed**, thick unless otherwise indicated.
- E. Foamed-Insulation-Core Metal Wall Panels
1. General: Provide factory-formed and -assembled metal wall panels fabricated from two metal facing sheets and insulation core foamed in place during fabrication, and with joints between panels designed to form weathertight seals. Include accessories required for weathertight installation.
 - a. Panel Performance:
 - 1) Flatwise Tensile Strength: 30 psi (207 kPa) when tested according to ASTM C 297.
 - 2) Humid Aging: Volume increase not greater than 6.0 percent and no delamination or metal corrosion when tested for 7 days at 140 deg F (60 deg C) and 100 percent relative humidity according to ASTM D 2126.
 - 3) Heat Aging: Volume increase not greater than 2.0 percent and no delamination, surface blistering, or permanent bowing when tested for 7 days at 200 deg F (93 deg C) according to ASTM D 2126.
 - 4) Cold Aging: Volume decrease not more than 1.0 percent and no delamination, surface blistering, or permanent bowing when tested for 7 days at minus 20 deg F (29 deg C) according to ASTM D 2126.
 - 5) Fatigue: No evidence of delamination, core cracking, or permanent bowing when tested to a 20-lbf/sq. ft. (958-kPa) positive and negative wind load and with deflection of L/180 for 2 million cycles.
 - 6) Autoclave: No delamination when exposed to 2-psi (13.8-kPa) pressure at a temperature of 212 deg F (100 deg C) for 2-1/2 hours.
 - b. Polyisocyanurate Insulation-Core Performance:
 - 1) Density: 2.0 to 2.6 lb/cu. ft. (32 to 42 kg/cu. m) when tested according to ASTM D 1622.
 - 2) Compressive Strength: Minimum 20 psi (138 kPa) when tested according to ASTM D 1621.
 - 3) Shear Strength: 26 psi (179 kPa) when tested according to ASTM C 273.
 2. Exposed-Fastener, Foamed-Insulation-Core Metal Wall Panels: Formed with raised, trapezoidal major rib at panel edge and two intermediate stiffening ribs symmetrically spaced between major rib and panel edge; designed for lapping side edges of adjacent panels and mechanically attaching to supports using exposed fasteners in side laps.
 - a. Facings: Fabricate panel with exterior and interior facings of same material and thickness.



- 1) Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 3) Backer Board: On back side of exterior facing.
 - 4) Exterior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - a) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - 5) Interior Facing Finish: Manufacturer's standard white polyester.
 - b. Snap-On Batten: Same material, finish, and color as exterior facings of wall panels.
 - c. Panel Coverage: 36 inches (914 mm) **OR** 40 inches (1016 mm), **as directed**, nominal.
 - d. Panel Thickness: 1.0 inch (25 mm) **OR** 1.5 inches (38 mm) **OR** 2.0 inches (51 mm) **OR** 2.5 inches (64 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm) **OR** 5.0 inches (127 mm), **as directed**.
 - e. Thermal-Resistance Value (R-Value): as directed by the Owner.
3. Concealed-Fastener, Foamed-Insulation-Core Metal Wall Panels: Formed with tongue-and-groove panel edges; designed for sequential installation by interlocking panel edges and mechanically attaching panels to supports using concealed clips or fasteners.
- a. Facings: Fabricate panel with exterior and interior facings of same material and thickness.
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 3) Material: Stainless-steel sheet, 0.031 inch (0.79 mm) **OR** 0.038 inch (0.97 mm), **as directed**, thick with No. 4 **OR** 2B, **as directed**, finish.
 - 4) Backer Board: On back side of exterior facing.
 - 5) Exterior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol, **as directed**.
 - a) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - 6) Interior Facing Finish: Manufacturer's standard siliconized polyester.
 - 7) Exterior Surface: Smooth, flat **OR** Striated **OR** Shallow ribs **OR** Shallow V grooves, **as directed**.
 - b. Panel Coverage: 24 inches (610 mm) **OR** 30 inches (762 mm) **OR** 36 inches (914 mm) **OR** 39.37 inches (1000 mm) **OR** 42 inches (1067 mm), **as directed**, nominal.
 - c. Panel Thickness: 2.0 inches (51 mm) **OR** 2.5 inches (64 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm) **OR** 5.0 inches (127 mm) **OR** 6.0 inches (152 mm), **as directed**.
 - d. Thermal-Resistance Value (R-Value): as directed by the Owner.
- F. Laminated-Insulation-Core Metal Wall Panels
1. General: Provide factory-formed and -assembled metal wall panels fabricated from two metal facing sheets and core material laminated or otherwise securely bonded to facing sheets during fabrication without use of contact adhesives, and with joints between panels designed to form weathertight seals. Include accessories required for weathertight installation.
 - a. Panel Performance:
 - 1) Flatwise Tensile Strength: 27 psi (186 kPa) when tested according to ASTM C 297.
 - 2) Humid Aging: Volume increase not greater than 6.0 percent and no delamination or metal corrosion when tested for 7 days at 140 deg F (60 deg C) and 100 percent relative humidity according to ASTM D 2126.
 - 3) Heat Aging: Volume increase not greater than 2.0 percent and no delamination, surface blistering, or permanent bowing when tested for 7 days at 200 deg F (93 deg C) according to ASTM D 2126.



- 4) Cold Aging: Volume decrease not more than 1.0 percent and no delamination, surface blistering, or permanent bowing when tested for 7 days at minus 20 deg F (29 deg C) according to ASTM D 2126.
 - 5) Fatigue: No evidence of delamination, core cracking, or permanent bowing when tested to a 20-lbf/sq. ft. (958-kPa) positive and negative wind load and with deflection of L/180 for 2 million cycles.
 - 6) Autoclave: No delamination when exposed to 2-psi (13.8-kPa) pressure at a temperature of 212 deg F (100 deg C) for 2-1/2 hours.
- b. Polyisocyanurate Insulation-Core Performance:
- 1) Density: 1.8 to 2.3 lb/cu. ft. (29 to 37 kg/cu. m) when tested according to ASTM D 1622.
 - 2) Compressive Strength: Minimum 20 psi (138 kPa) when tested according to ASTM D 1621.
 - 3) Shear Strength: 24 psi (164 kPa) when tested according to ASTM C 273.
2. Wrapped-Edge, Laminated-Insulation-Core Metal Wall Panels: Formed with flush exterior panel facing wrapped over panel edges; designed for independent installation by mechanically attaching panels to supports using staggered, concealed side clips engaging panel edges **OR** through extended panel edges to supports using concealed fasteners, **as directed**; with sealant **OR** gasketed, **as directed**, joints.
- a. Exterior Facing:
- 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 3) Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm) **OR** 0.063 inch (1.60 mm) **OR** 0.080 inch (2.03 mm), **as directed**, thick.
 - 4) Surface: Smooth, flat **OR** Embossed, **as directed**.
 - 5) Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - a) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
- b. Interior Facing:
- 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 3) Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - 4) Finish: Manufacturer's standard primer or white polyester.
- c. Core Material: Polyisocyanurate **OR** Extruded-polystyrene **OR** Expanded-polystyrene, **as directed**, board insulation.
- 1) Backer Board: 0.125-inch- (3-mm-) **OR** 0.250-inch- (6-mm-), **as directed**, thick hardboard behind exterior facing for increased impact resistance.
- d. Clips: Manufacturer's standard one piece, formed from zinc-coated (galvanized) steel **OR** aluminum-zinc alloy-coated steel **OR** stainless steel, **as directed**.
- e. Gaskets: Extruded, dry seal silicone.
- f. Sealant: Manufacturer's standard silicone.
- g. Panel Thickness: 1.0 inch (25 mm) **OR** 2.0 inches (51 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm) **OR** 5.0 inches (127 mm) **OR** 6.0 inches (152 mm), **as directed**.
- h. Thermal-Resistance Value (R-Value): as directed by the Owner.



3. Shiplap-Edge, Laminated-Insulation-Core Metal Wall Panels: Formed with flush exterior panel facing and with shiplap edges; designed for sequential installation by mechanically attaching panels to supports using concealed clips and fasteners; with factory-applied sealant **OR** gaskets, **as directed**, in side laps.
- a. Exterior Facing:
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 3) Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm) **OR** 0.063 inch (1.60 mm), **as directed**, thick.
 - 4) Surface: Smooth, flat **OR** Embossed, **as directed**.
 - 5) Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - a) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - b. Interior Facing:
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 3) Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 4) Finish: Manufacturer's standard primer or white polyester.
 - c. Core Material: Polyisocyanurate **OR** Extruded-polystyrene **OR** Expanded-polystyrene, **as directed**, board insulation.
 - 1) Backer Board: 0.125-inch- (3-mm-) **OR** 0.250-inch- (6-mm-), **as directed**, thick hardboard behind exterior facing for increased impact resistance.
 - d. Clips: Manufacturer's standard one piece, formed from zinc-coated (galvanized) steel **OR** aluminum-zinc alloy-coated steel **OR** stainless steel, **as directed**.
 - e. Gaskets: Extruded, dry seal silicone.
 - f. Sealant: Manufacturer's standard silicone.
 - g. Panel Thickness: 1.0 inch (25 mm) **OR** 2.0 inches (51 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm) **OR** 5.0 inches (127 mm) **OR** 6.0 inches (152 mm), **as directed**.
 - h. Thermal-Resistance Value (R-Value): as directed by the Owner.
4. Framed-Edge, Laminated-Insulation-Core Metal Wall Panels: Formed with flush exterior panel facing and integral, extruded edge members; designed for independent installation by mechanically attaching panels to supports through edge framing using concealed fasteners; with gasketed joints.
- a. Exterior Facing:
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71 mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 3) Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm) **OR** 0.063 inch (1.60 mm) **OR** 0.080 inch (2.03 mm), **as directed**, thick.
 - 4) Surface: Smooth, flat **OR** Embossed, **as directed**.
 - 5) Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - a) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.



- b. Interior Facing:
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 3) Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 4) Finish: Manufacturer's standard primer or white polyester.
 - c. Core Material: Polyisocyanurate **OR** Extruded-polystyrene **OR** Expanded-polystyrene, **as directed**, board insulation.
 - 1) Backer Board: 0.125-inch- (3.18-mm-) **OR** 0.250-inch- (6-mm-), **as directed**, thick hardboard behind exterior facing for increased impact resistance.
 - d. Edge Members: Extruded aluminum, not less than 0.063-inch (1.60-mm) wall thickness.
 - e. Gaskets: Extruded, dry seal silicone.
 - f. Panel Thickness: 1.0 inch (25 mm) **OR** 2.0 inches (51 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm) **OR** 5.0 inches (127 mm) **OR** 6.0 inches (152 mm), **as directed**.
 - g. Thermal-Resistance Value (R-Value): as directed by the Owner.
- G. Honeycomb-Core Metal Wall Panels
1. General: Provide factory-formed and -assembled metal wall panels fabricated from two metal facing sheets and honeycomb-core material laminated or otherwise securely bonded to facing sheets during fabrication without use of contact adhesives or pinch rollers, and with joints between panels designed to form weathertight seals. Include accessories required for weathertight installation.
 - a. Panel Performance:
 - 1) Fatigue: No evidence of delamination, core cracking, or permanent bowing when tested to a 20-lbf/sq. ft. (958-kPa) positive and negative wind load and with deflection of L/180 for 2 million cycles.
 - 2) Autoclave: No delamination when exposed to 2-psi (13.8-kPa) pressure at a temperature of 212 deg F (100 deg C) for 2-1/2 hours.
 2. Wrapped-Edge, Honeycomb-Core Metal Wall Panels: Formed with flush exterior panel facing wrapped over panel edges; designed for independent installation by mechanically attaching panels to supports using staggered, concealed side clips engaging panel edges **OR** through extended panel edges to supports using concealed fasteners, **as directed**; with sealant **OR** gasketed, **as directed**, joints.
 - a. Facings: Fabricate panel with exterior and interior facings of same material and thickness.
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 3) Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm) **OR** 0.063 inch (1.60 mm), **as directed**, thick.
 - 4) Exterior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - a) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - 5) Interior Facing Finish: Manufacturer's standard primer or polyester.
 - b. Kraft-Paper Honeycomb Core: Manufacturer's standard phenolic-resin impregnated paper, with not less than 15 percent resin content by weight and chemically treated for fire resistance; with maximum 1/2-inch (13-mm) cell size.
 - c. Aluminum Honeycomb Core: Manufacturer's standard 0.003-inch- (0.08-mm-) thick, commercial grade aluminum with maximum 3/4-inch (19-mm) cell size.



- d. Clips: Manufacturer's standard one piece, formed from zinc-coated (galvanized) steel **OR** aluminum-zinc alloy-coated steel **OR** stainless steel, **as directed**.
 - e. Gaskets: Extruded, dry seal silicone.
 - f. Sealant: Manufacturer's standard silicone.
 - g. Panel Thickness: 0.25 inch (6 mm) **OR** 1.0 inch (25 mm) **OR** 2.0 inches (51 mm) **OR** 3.0 inches (76 mm) **OR** 4.0 inches (102 mm), **as directed**.
3. Shiplap-Edge, Honeycomb-Core Metal Wall Panels: Formed with flush exterior panel facing and with shiplap edges; designed for sequential installation by mechanically attaching panels to supports using concealed clips and fasteners; with factory-applied sealant **OR** gaskets, **as directed**, in side laps.
- a. Facings: Fabricate panel with exterior and interior facings of same material and thickness.
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 2) Material: Aluminum-zinc alloy-coated steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm), **as directed**, nominal thickness.
 - 3) Material: Aluminum sheet, 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm) **OR** 0.063 inch (1.60 mm), **as directed**, thick.
 - 4) Exterior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - a) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - 5) Interior Facing Finish: Manufacturer's standard primer or polyester.
 - b. Kraft-Paper Honeycomb Core: Manufacturer's standard phenolic-resin-impregnated paper, with not less than 15 percent resin content by weight and chemically treated for fire resistance; with maximum 1/2-inch (13-mm) cell size.
 - c. Aluminum Honeycomb Core: Manufacturer's standard 0.003-inch- (0.08-mm-) thick, commercial grade aluminum with maximum 3/4-inch (19-mm) cell size.
 - d. Clips: Manufacturer's standard one piece, formed from zinc-coated (galvanized) steel **OR** aluminum-zinc alloy-coated steel **OR** stainless steel, **as directed**.
 - e. Gaskets: Extruded, dry seal silicone.
 - f. Sealant: Manufacturer's standard silicone.
 - g. Panel Thickness: 1.0 inch (25 mm) **OR** 1.25 inches (32 mm) **OR** 2.0 inches (51 mm), **as directed**.
4. Framed-Edge, Honeycomb-Core Metal Wall Panels: Formed with flush exterior panel facing and integral, extruded edge members; designed for independent installation by mechanically attaching panels to supports through edge framing using concealed fasteners; with gasketed joints.
- a. Facings: Fabricate panel with exterior and interior facings of same material and thickness.
 - 1) Material: Zinc-coated (galvanized) steel sheet, 0.028-inch (0.71-mm) nominal thickness.
 - 2) Material: Aluminum sheet, 0.040 inch (1.02 mm) **OR** 0.063 inch (1.60 mm), **as directed**, thick.
 - 3) Exterior Facing Finish: 2-coat fluoropolymer **OR** 3-coat fluoropolymer **OR** 4-coat fluoropolymer **OR** Mica fluoropolymer **OR** Metallic fluoropolymer **OR** FEVE fluoropolymer **OR** Siliconized polyester **OR** Plastisol **OR** Clear anodized **OR** Color anodized, **as directed**.
 - a) Color: As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.
 - 4) Interior Facing Finish: Manufacturer's standard primer or polyester.
 - b. Kraft-Paper Honeycomb Core: Manufacturer's standard phenolic-resin-impregnated paper, with not less than 15 percent resin content by weight and chemically treated for fire resistance; with maximum 1/2-inch (13-mm) cell size.
 - c. Aluminum Honeycomb Core: Manufacturer's standard 0.003-inch- (0.08-mm-) thick, commercial grade aluminum with maximum 3/4-inch (19-mm) cell size.



- d. Edge Members: Extruded aluminum, not less than 0.063-inch (1.6-mm) wall thickness.
- e. Gaskets: Extruded, dry seal silicone.
- f. Panel Thickness: 1.0 inch (25 mm) **OR** 2.0 inches (51 mm) **OR** 3.0 inches (76 mm), **as directed**.

H. Accessories

1. Wall Panel Accessories: Provide components required for a complete metal wall panel assembly including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal wall panels unless otherwise indicated.
 - a. Closures: Provide closures at eaves and rakes, fabricated of same metal as metal wall panels.
 - b. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 - c. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal wall panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
2. Flashing and Trim: Formed from 0.018-inch- (0.46-mm-) minimum thickness, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal wall panels.

I. Fabrication

1. General: Fabricate and finish metal wall panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
2. Fabricate metal wall panels in a manner that eliminates condensation on interior side of panel and with joints between panels designed to form weathertight seals.
3. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
4. Fabricate metal wall panel joints with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, in a manner that will minimize noise from movements within panel assembly.
5. Honeycomb-Core Metal Wall Panels: Fabricate panels using manufacturer's standard thermosetting structural adhesive in a lamination process that bonds panel under minimum 10-psi (69-kPa) pressure. Use of contact adhesives with pinch-roll process is not acceptable.
 - a. Panel Bow Tolerance: Not more than 0.5 percent of panel width or length.
6. Sheet Metal Accessories: Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of item indicated.
 - a. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
 - b. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
 - c. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 - d. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.
 - e. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.



- f. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended by metal wall panel manufacturer.
 - 1) Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal wall panel manufacturer for application but not less than thickness of metal being secured.

J. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

1.3 EXECUTION

A. Preparation

1. Miscellaneous Framing: Install subgirts, base angles, sills, furring, and other miscellaneous wall panel support members and anchorages according to ASTM C 754 and metal wall panel manufacturer's written recommendations.

B. Metal Wall Panel Installation, General

1. General: Install metal wall panels according to manufacturer's written instructions in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to girts and subgirts unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - a. Commence metal wall panel installation and install minimum of 300 sq. ft. (27.9 sq. m.) in presence of factory-authorized representative.
 - b. Shim or otherwise plumb substrates receiving metal wall panels.
 - c. Flash and seal metal wall panels with weather closures at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until weather barrier and flashings that will be concealed by metal wall panels are installed.
 - d. Install screw fasteners in predrilled holes.
 - e. Locate and space fastenings in uniform vertical and horizontal alignment.
 - f. Install flashing and trim as metal wall panel work proceeds.
 - g. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
 - h. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated or, if not indicated, as necessary for waterproofing.
 - i. Align bottom of metal wall panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
 - j. Provide weathertight escutcheons for pipe and conduit penetrating exterior walls.
2. Fasteners:
 - a. Steel Wall Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized steel fasteners for surfaces exposed to the interior.
 - b. Aluminum Wall Panels: Use aluminum or stainless-steel fasteners for surfaces exposed to the exterior; use aluminum or galvanized steel fasteners for surfaces exposed to the interior.
 - c. Copper Wall Panels: Use copper, stainless-steel, or hardware-bronze fasteners.
 - d. Stainless-Steel Wall Panels: Use stainless-steel fasteners.
3. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action as recommended by metal wall panel manufacturer.



4. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weathertight performance of metal wall panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by metal wall panel manufacturer.
 - a. Seal metal wall panel end laps with double beads of tape or sealant, full width of panel. Seal side joints where recommended by metal wall panel manufacturer.
 - b. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants".
- C. Insulated-Core Metal Wall Panel Installation
1. General: Apply continuous ribbon of sealant to panel joint on concealed side of insulated-core metal wall panels as vapor seal; apply sealant to panel joint on exposed side of panels for weather seal.
 - a. Fasten insulated-core metal wall panels to supports with fasteners at each lapped joint at location and spacing and with fasteners recommended by manufacturer.
 - b. Lap ribbed or fluted sheets one full rib corrugation. Apply panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.
 - c. Provide metal-backed washers under heads of exposed fasteners on weather side of insulated metal wall panels.
 - d. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 - e. Provide sealant tape at lapped joints of insulated metal wall panels and between panels and protruding equipment, vents, and accessories.
 - f. Apply a continuous ribbon of sealant tape to panel side laps and elsewhere as needed to make panels weathertight.
 - g. Apply snap-on battens to exposed-fastener, insulated-core metal wall panel seams to conceal fasteners.
 2. Foamed-Insulation-Core Metal Wall Panels: Fasten metal wall panels to supports with concealed clips at each joint at location and spacing and with fasteners recommended by manufacturer. Fully engage tongue and groove of adjacent panels.
 - a. Install clips to supports with self-tapping fasteners.
 3. Laminated-Insulation-Core Metal Wall Panels:
 - a. Wrapped-Edge Panels: Mechanically attach wall panels to supports using staggered, concealed side clips engaging wrapped panel edges. Install clips to supports with self-tapping fasteners. Seal joints with backer rod and sealant **OR** manufacturer's standard gaskets, **as directed**.
 - b. Wrapped-Edge Panels: Mechanically attach wall panels through extended edge of panels to supports using self-tapping fasteners. Seal joints with backer rod and sealant **OR** manufacturer's standard gaskets, **as directed**.
 - c. Shiplap-Edge Panels: Mechanically attach wall panels to supports using staggered, concealed side clips engaging tongue-and-groove panel edges. Install clips to supports with self-tapping fasteners.
 - 1) Horizontal Joints: Maintain reveal joint of consistent width **OR** Seal joints with backer rod and sealant **OR** Seal joints with manufacturer's standard gaskets, **as directed**.
 - 2) Vertical Joints: Maintain reveal joint of consistent width **OR** Seal joints with backer rod and sealant **OR** Seal joints with manufacturer's standard gaskets, **as directed**.
 - d. Framed-Edge Panels: Mechanically attach wall panels through integral, extruded edge members to supports using self-tapping fasteners. Seal joints with manufacturer's standard gaskets.
 4. Honeycomb-Core Metal Wall Panels:
 - a. Wrapped-Edge Panels: Mechanically attach wall panels to supports using staggered, concealed side clips engaging wrapped panel edges. Install clips to supports with self-tapping fasteners. Seal joints with backer rod and sealant **OR** manufacturer's standard gaskets, **as directed**.



- b. Wrapped-Edge Panels: Mechanically attach wall panels through extended edge of panels to supports using self-tapping fasteners. Seal joints with backer rod and sealant **OR** manufacturer's standard gaskets, **as directed**.
 - c. Shiplap-Edge Panels: Mechanically attach wall panels to supports using staggered, concealed side clips engaging tongue-and-groove panel edges. Install clips to supports with self-tapping fasteners.
 - 1) Horizontal Joints: Maintain reveal joint of consistent width **OR** Seal joints with backer rod and sealant **OR** Seal joints with manufacturer's standard gaskets, **as directed**.
 - 2) Vertical Joints: Maintain reveal joint of consistent width **OR** Seal joints with backer rod and sealant **OR** Seal joints with manufacturer's standard gaskets, **as directed**.
 - d. Framed-Edge Panels: Mechanically attach wall panels through integral, extruded edge members to supports using self-tapping fasteners. Seal joints with manufacturer's standard gaskets.
- D. Accessory Installation
- 1. General: Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.
 - a. Install components required for a complete metal wall panel assembly including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
 - 2. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - a. Install exposed flashing and trim that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
 - b. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (605 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).
- E. Field Quality Control
- 1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 - 2. Water Penetration: Test areas of installed system indicated on Drawings for compliance with system performance requirements according to ASTM E 1105 at minimum differential pressure of 20 percent of inward-acting, wind-load design pressure as defined by SEI/ASCE 7, but not less than 6.24 lbf/sq. ft. (299 Pa).
 - 3. Water-Spray Test: After completing the installation of 75-foot- (23-m-) by-2-story minimum area of metal wall panel assembly, test assembly for water penetration according to AAMA 501.2 in a 2-bay area directed by the Owner.
 - 4. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect and test completed metal wall panel installation, including accessories.
 - 5. Remove and replace metal wall panels where tests and inspections indicate that they do not comply with specified requirements.
 - 6. Additional tests and inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- F. Cleaning And Protection
- 1. Remove temporary protective coverings and strippable films, if any, as metal wall panels are installed unless otherwise indicated in manufacturer's written installation instructions. On



-
- completion of metal wall panel installation, clean finished surfaces as recommended by metal wall panel manufacturer. Maintain in a clean condition during construction.
2. After metal wall panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.
 3. Replace metal wall panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 46 63 00



Task	Specification	Specification Description
07 46 63 00	07 46 16 00	Metal Wall Panels



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**SECTION 07 51 13 00 - BUILT-UP ASPHALT ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for built-up asphalt roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Built-up asphalt roofing.
 - b. Vapor retarder.
 - c. Roof insulation.
2. Section includes the installation of insulation strips in ribs of acoustical roof deck. Insulation strips are furnished under Division 5 Section "Steel Deck."

C. Definitions

1. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to built-up roofing.
2. Hot Roofing Asphalt: Roofing asphalt heated to its equiviscous temperature, the temperature at which its viscosity is 125 centipoise for mop-applied roofing asphalt and 75 centipoise for mechanical spreader-applied roofing asphalt, within a range of plus or minus 25 deg F (14 deg C), measured at the mop cart or mechanical spreader immediately before application.

D. Performance Requirements

1. General Performance: Installed built-up roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Built-up roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by built-up roofing manufacturer based on testing and field experience.
3. Roofing System Design: Provide built-up roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
4. FM Approvals Listing: Provide built-up roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a built-up roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120, **as directed.**
 - b. Hail Resistance Rating: MH **OR** SH, **as directed.**
5. Energy Performance (for LEED-NC Credit SS 7.2): Provide roofing system with initial Solar Reflectance Index not less than 78 when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.
6. Energy Performance: Provide roofing system that is listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low-slope roof products.
7. Energy Performance (for roofs that must comply with California Energy Commission's CEC-Title 24): Provide roofing system with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC-1.

E. Submittals



1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Test Reports for Credit SS 7.2: For roof materials, indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For built-up roofing. Include plans, elevations, sections, details, and attachments to other work.
 - a. Base flashings and built-up terminations.
 - b. Tapered insulation, including slopes.
 - c. Crickets, saddles, and tapered edge strips, including slopes.
 - d. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.
4. Samples: For the following products:
 - a. Built-up roofing materials, including base sheet, ply sheet, cap sheet, and flashing sheet, of color specified.
 - b. Roof insulation.
 - c. 3 lb (1.5 kg) of aggregate surfacing material in gradation and color indicated.
 - d. Roof paver, full sized, in each color and texture required.
 - e. Walkway pads.
 - f. Six insulation fasteners of each type, length, and finish.
5. Qualification Data: For qualified Installer and manufacturer.
6. Manufacturer Certificates: Signed by roofing manufacturer certifying that built-up roofing complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of compliance with performance requirements.
7. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for components of built-up roofing.
8. Research/Evaluation Reports: For components of built-up roofing, from the ICC-ES.
9. Maintenance Data: For built-up roofing to include in maintenance manuals.
10. Warranties: Sample of special warranties.

F. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer that is UL listed **OR** FM Approvals approved, **as directed**, for built-up roofing identical to that used for this Project.
2. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by built-up roofing manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
3. Source Limitations: Obtain components including roof insulation and fasteners for built-up roofing from same manufacturer as built-up roofing or approved by built-up roofing manufacturer.
4. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical built-up roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
5. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
6. Preinstallation Roofing Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing manufacturer. Protect stored liquid material from direct sunlight.



- a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
 3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
 4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.
- H. Project Conditions
1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing to be installed according to manufacturer's written instructions and warranty requirements.
- I. Warranty
1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of built-up roofing that fail in materials or workmanship within specified warranty period.
 - a. Special warranty includes built-up roofing membrane, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, roof pavers, and other components of built-up roofing.
 - b. Warranty Period: 10 **OR** 15 **OR** 20 **OR** 25 **OR** 30, **as directed**, years from date of Final Completion.
 2. Special Project Warranty: Submit roofing Installer's warranty, signed by Installer, covering the Work of this Section, including all components of built-up roofing such as built-up roofing membrane, base flashing, roof insulation, fasteners, cover boards, substrate boards, vapor retarders, roof pavers, and walkway products, for the following warranty period:
 - a. Warranty Period: Two years from date of Final Completion.

1.2 PRODUCTS

A. Built-Up Roofing Manufacturers

B. Base-Sheet Materials

1. Sheathing Paper: Red-rosin type, minimum 3 lb/100 sq. ft. (0.16 kg/sq. m).
2. Base Sheet: ASTM D 4601, Type II, SBS-modified, asphalt-impregnated and -coated sheet, with glass-fiber-reinforcing mat, dusted with fine mineral surfacing on both sides.
 - a. Weight: 25 lb/100 sq. ft. (1.2 kg/sq. m) **OR** 40 lb/100 sq. ft. (1.95 kg/sq. m) **OR** 50 lb/100 sq. ft. (2.4 kg/sq. m) **OR** 60 lb/100 sq. ft. (3.0 kg/sq. m) **OR** 75 lb/100 sq. ft. (3.7 kg/sq. m), **as directed**, minimum.

OR

Base Sheet: ASTM D 4601, Type I **OR** II, **as directed**, nonperforated, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.

OR

Base Sheet: ASTM D 4897, Type II, venting, nonperforated, heavyweight, asphalt-impregnated and -coated, glass-fiber base sheet with coarse granular surfacing or embossed venting channels on bottom surface.

OR

Base Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.

C. Roofing Membrane Plies

1. Ply Sheet: ASTM D 2178, Type IV **OR** VI, **as directed**, asphalt-impregnated, glass-fiber felt.
2. Cap Sheet: ASTM D 3909, asphalt-impregnated and -coated, glass-fiber cap sheet, with white coarse mineral-granule top surfacing and fine mineral surfacing on bottom surface.



D. Base Flashing Sheet Materials

1. Backer Sheet: ASTM D 2178, Type IV **OR** VI, **as directed**, asphalt-impregnated, glass-fiber felt.
OR
Backer Sheet: ASTM D 4601, Type I **OR** II, **as directed**, asphalt-impregnated and -coated, glass-fiber sheet, dusted with fine mineral surfacing on both sides.
OR
Backer Sheet: ASTM D 2626, asphalt-saturated and -coated organic felt, dusted with fine mineral surfacing on both sides.
2. Granule-Surfaced Flashing Sheet: ASTM D 6164, Grade G, Type I or II, polyester-reinforced **OR** ASTM D 6163, Grade G, Type I or II, glass-fiber-reinforced **OR** ASTM D 6162, Grade G, Type I or II, composite polyester-reinforced and glass-fiber-reinforced, **as directed**, SBS-modified asphalt sheet; granular surfaced; suitable for application method specified, and as follows:
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.
3. Metal-Foil-Surfaced Flashing Sheet: ASTM D 6298, glass-fiber-reinforced, SBS-modified asphalt sheet; metal-foil surfaced; suitable for application method specified, and as follows:
 - a. Foil Surfacing: Aluminum **OR** Copper **OR** Stainless steel **OR** Aluminum, fluoropolymer coated finish, of color and gloss selected from manufacturer's full range, **as directed**.
4. Smooth-Surfaced Flashing Sheet: ASTM D 6222, Grade S, Type I or II, polyester-reinforced **OR** ASTM D 6223, Grade S, Type I or II, composite polyester-reinforced and glass-fiber-reinforced, **as directed**, APP-modified asphalt sheet; smooth surfaced; suitable for application method specified.
OR
Granule-Surfaced Flashing Sheet: ASTM D 6222, Grade G, Type I or II, polyester-reinforced **OR** ASTM D 6223, Grade G, Type I or II, composite polyester-reinforced and glass-fiber-reinforced, **as directed**, APP-modified asphalt sheet; granular surfaced; suitable for application method specified, and as follows:
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.
5. Glass-Fiber Fabric: Woven glass-fiber cloth, treated with asphalt, complying with ASTM D 1668, Type I.

E. Asphalt Materials

1. Asphalt Primer: ASTM D 41.
2. Roofing Asphalt: ASTM D 312, Type III **OR** IV **OR** III or IV as recommended by built-up roofing manufacturer for application, **as directed**.
3. Roofing Asphalt: ASTM D 6152, SEBS modified.

F. Auxiliary Built-Up Roofing Materials

1. General: Auxiliary materials recommended by roofing manufacturer for intended use and compatible with built-up roofing.
 - a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
 - b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Gypsum Board and Panel Adhesives: 50 g/L.
 - 3) Multipurpose Construction Adhesives: 70 g/L.
 - 4) Fiberglass Adhesives: 80 g/L.
 - 5) Contact Adhesives: 80 g/L.
 - 6) Other Adhesives: 250 g/L.
 - 7) Nonmembrane Roof Sealants: 300 g/L.
 - 8) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 9) Sealant Primers for Porous Substrates: 775 g/L.



2. Cold-Applied Adhesive: Roofing manufacturer's standard asphalt-based, one- or two-part, asbestos-free, cold-applied adhesive specially formulated for compatibility and use with built-up base flashings.
3. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required by roofing manufacturer for application.
4. Mastic Sealant: Polyisobutylene, plain or modified bitumen, nonhardening, nonmigrating, nonskinning, and nondrying.
5. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening built-up roofing components to substrate, tested by manufacturer for required pullout strength, and acceptable to roofing manufacturer.
6. Metal Flashing Sheet: Metal flashing sheet is specified in Division 7 Section "Sheet Metal Flashing and Trim."
7. Aggregate Surfacing: ASTM D 1863, No. 6 or No. 67, clean, dry, opaque, water-worn gravel or crushed stone, free of sharp edges **OR** crushed slag, free of sharp edges, **as directed**.
8. Miscellaneous Accessories: Provide miscellaneous accessories recommended by built-up roofing manufacturer.

G. Substrate Boards

1. Substrate Board: ASTM C 1396/C 1396M, Type X gypsum board, 5/8 inch (16 mm) thick.
OR
Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Substrate Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 728, perlite board, 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick, seal coated.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate board to roof deck.

H. Vapor Retarder

1. Polyethylene Film: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
 - a. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
OR
Adhesive: Manufacturer's standard lap adhesive, FM Approvals approved for vapor-retarder application.
2. Laminated Sheet: Kraft paper/polyethylene laminate, two layers, reinforced with woven fiberglass yarn, laminated and edge reinforced, with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and with manufacturer's standard adhesive, **as directed**.
3. Self-Adhering Sheet Vapor Retarder: ASTM D 1970, minimum of 40-mil- (1.0-mm-) thick, polyethylene film laminated to layer of rubberized asphalt adhesive; maximum permeance rating of 0.1 perm (6 ng/Pa x s x sq. m); cold-applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.
OR
Self-Adhering Sheet Vapor Retarder: 30- to 40-mil- (0.76- to 1.0-mm-) thick, polyethylene film laminated to layer of butyl rubber adhesive; maximum permeance rating of 0.1 perm (6 ng/Pa x s x sq. m); cold-applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.
4. Glass-Fiber Felts: ASTM D 2178, Type IV, asphalt impregnated.



I. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) **OR** X, 1.3-lb/cu. ft. (21-kg/cu. m), **as directed**, minimum density, square edged.
3. Molded-Polystyrene Board Insulation: ASTM C 578 Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density.
4. Composite Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density, with factory-applied facings, as follows:
 - a. Facer: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, asphalt coated, 1/2 inch (13 mm) thick.

OR

 - Facer: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
5. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 **OR** Type II, Class I, Grade 3, **as directed**, felt or glass-fiber mat facer on both major surfaces.
6. Composite Polyisocyanurate Board Insulation: ASTM C 1289, with factory-applied facing board on one major surface as indicated below by type, and felt or glass-fiber mat facer on the other surface.
 - a. Type IV, cellulosic-fiber-insulating-board facer, Grade 2, 1/2 inch (13 mm) thick.
 - b. Type V, OSB facer, 7/16 inch (11 mm) thick.
 - c. Type VII, glass mat faced gypsum board facer, 1/4 inch (6 mm) thick.
7. Perlite Board Insulation: ASTM C 728, rigid, mineral-aggregate thermal insulation board composed of expanded perlite, cellulosic fibers, binders, and waterproofing agents with top surface seal coated.
8. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 2, fibrous-felted, rigid insulation boards of wood fiber or other cellulosic-fiber and water-resistant binders, asphalt impregnated, chemically treated for deterioration.
9. Cellular-Glass Board Insulation: ASTM C 552, Type IV, rigid, cellular-glass thermal board insulation faced with manufacturer's standard kraft-paper sheets.
10. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches (1:48) unless otherwise indicated.
11. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

J. Insulation Accessories

1. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatible with built-up roofing.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation to substrate and acceptable to roofing manufacturer.
3. Modified Asphaltic Insulation Adhesive: Insulation manufacturer's recommended modified asphaltic, asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.

OR

Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one- or multicomponent urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.

OR

Full-Spread Applied Insulation Adhesive: Insulation manufacturer's recommended spray-applied, low-rise, two-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
4. Insulation Cant Strips: ASTM C 728, perlite insulation board.
5. Insulation Cant Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.



6. Wood Nailer Strips: Comply with requirements in Division 6 Section "Rough Carpentry" **OR** "Miscellaneous Carpentry", **as directed**.
 7. Tapered Edge Strips: ASTM C 728, perlite insulation board.
OR
Tapered Edge Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.
 8. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, 1/2 inch (13 mm) thick.
OR
Cover Board: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
OR
Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Cover Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
 9. Substrate Joint Tape: 6- or 8-inch- (150- or 200-mm-) wide, coated, glass fiber.
- K. Coating Materials
1. Roof Coating: ASTM D 1227, Type II Class 1, mineral-colloid-emulsified, fibered **OR** 2, chemically emulsified, filled or fibered, **as directed**, asphalt emulsion, asbestos free.
OR
Roof Coating: ASTM D 1227, Type III, Class 1, mineral-colloid-emulsified **OR** 2, chemically emulsified, **as directed**, asphalt emulsion, nonfibered.
OR
Roof Coating: ASTM D 2824, Type I, nonfibered **OR** III, fibered, asbestos-free, **as directed**, aluminum-pigmented asphaltic coating.
OR
Roof Coating: Acrylic elastomer emulsion coating, formulated for use on bituminous roof surfaces and complying with ASTM D 6083 **OR** the following, **as directed**:
 - a. Initial Percent Elongation (Break): Not less than 60 percent at 0 deg F (-18 deg C) and 200 percent at 73 deg F (23 deg C) when tested according to ASTM D 2370.
 - b. Initial Tensile Strength (Maximum Stress): Not less than 100 psi (1.38 MPa) at 73 deg F (23 deg C) and 200 psi (2.76 MPa) at 0 deg F (-18 deg C) when tested according to ASTM D 2370.
 - c. Final Percent Elongation (Break) after Accelerated Weathering 1000 hrs.: Not less than 40 percent at 0 deg F (-18 deg C) and 100 percent at 73 deg F (23 deg C) when tested according to ASTM D 2370.
 - d. Permeance: Not more than 50 perms when measured according to ASTM D 1653.
 - e. Accelerated Weathering 1000 hrs.: No cracking or checking when tested according to ASTM D 4798.
 - f. Color: White **OR** Gray **OR** Buff, **as directed**.
- L. Walkways
1. Walkway Pads: Mineral-granule-surfaced, reinforced asphaltic composition **OR** Polymer-modified, reconstituted solid-rubber, surface-textured, **as directed**, slip-resisting pads, manufactured as a traffic pad for foot traffic and acceptable to roofing manufacturer, 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, thick, minimum.
 2. Walkway Cap Sheet Strips: ASTM D 6164, Grade G, Type I or II, polyester-reinforced **OR** ASTM D 6163, Grade G, Type I or II, glass-fiber-reinforced **OR** ASTM D 6162, Grade G, Type I or II, composite polyester-reinforced and glass-fiber-reinforced, **as directed**, SBS-modified asphalt sheet; granular surfaced; suitable for application method specified, and as follows:
 - a. Granule Color: White **OR** Gray **OR** Tan, **as directed**.
 3. Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not



greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:

- a. Size: 24 by 24 inches (600 by 600 mm). Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
- b. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum; ASTM C 140.
- c. Colors and Textures: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with the following requirements and other conditions affecting performance of roofing system:
 - a. Verify that roof openings and penetrations are in place and curbs are set and braced and that roof drain bodies are securely clamped in place.
 - b. Verify that wood cants, blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
 - c. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Division 05 Section "Steel Decking".
 - d. Verify that deck is securely fastened with no projecting fasteners and with no adjacent units in excess of 1/16 inch (1.6 mm) out of plane relative to adjoining deck.
 - e. Verify that minimum concrete drying period recommended by roofing manufacturer has passed.
 - f. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
 - 1) Test for moisture by pouring 1 pint (0.5 L) of hot roofing asphalt on deck at start of each day's work and at start of each roof area or plane. Do not proceed with roofing work if test sample foams or can be easily and cleanly stripped after cooling.
 - g. Verify that concrete curing compounds that will impair adhesion of roofing components to roof deck have been removed.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Prime surface of concrete deck with asphalt primer at a rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
4. Install insulation strips in ribs of acoustical roof decks according to acoustical roof deck manufacturer's written instructions.

C. Substrate Board Installation

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - a. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.
OR
Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to built-up roofing manufacturer's written instructions.

**D. Vapor-Retarder Installation**

1. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 - a. Continuously seal side and end laps with tape **OR** adhesive, **as directed**.

OR

Laminate Sheet: Install laminate-sheet vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively. Bond vapor retarder to substrate as follows:

 - a. Apply adhesive at rate recommended by vapor-retarder manufacturer. Seal laps with adhesive.

OR

Apply ribbons of hot roofing asphalt at spacing, temperature, and rate recommended by vapor-retarder manufacturer. Seal laps with hot roofing asphalt.

OR

Self-Adhering Sheet Vapor Retarder: Prime substrate if required by manufacturer. Install self-adhering sheet vapor retarder over area to receive vapor retarder, side and end lapping each sheet a minimum of 3-1/2 inches (90 mm) and 6 inches (150 mm), respectively. Seal laps by rolling.

OR

Built-up Vapor Retarder: Install two glass-fiber felt plies lapping each felt 19 inches (483 mm) over preceding felt. Embed each felt in a solid mopping of hot roofing asphalt. Glaze-coat completed surface with hot roofing asphalt. Apply hot roofing asphalt within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
2. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into built-up roofing.

E. Insulation Installation

1. Comply with built-up roofing manufacturer's written instructions for installing roof insulation.
2. Install one lapped base sheet course and mechanically fasten to substrate according to built-up roofing manufacturer's written instructions.
3. Nailer Strips: Mechanically fasten 4-inch nominal- (89-mm actual-) width wood nailer strips of same thickness as insulation perpendicular to sloped roof deck at the following spacing:
 - a. 16 feet (4.88 m) apart for roof slopes greater than 1 inch per 12 inches (1:12) but less than 3 inches per 12 inches (3:12).
 - b. 48 inches (1220 mm) apart for roof slopes greater 3 inches per 12 inches (3:12).
4. Insulation Cant Strips: Install and secure preformed 45-degree insulation cant strips at junctures of built-up roofing with vertical surfaces or angle changes greater than 45 degrees.
5. Install tapered insulation under area of roofing to conform to slopes indicated.
6. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - a. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
7. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.
 - a. Where installing composite and noncomposite board insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
8. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
9. Install tapered edge strips at perimeter edges of roof that do not terminate at vertical surfaces.
10. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
 - a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.



- b. Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
 - c. Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
OR
Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
11. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
- a. If Project is FM Global insured or if FM Approvals requirements are proposed as a performance standard, fasten insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
 - b. If number of fasteners will be based on ASCE/SEI 7's uplift pressure, fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.
12. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
- a. If Project is FM Global insured or if FM Approvals requirements are proposed as a performance standard, fasten first layer of insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
 - b. If number of fasteners will be based on ASCE/SEI 7's uplift pressure, fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
 - c. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
OR
Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
OR
Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
13. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together and fasten to roof deck, **as directed**. Tape joints if required by roofing manufacturer.
- a. Fasten cover boards according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
 - b. Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.
 - c. Apply hot roofing asphalt to underside and immediately bond cover board to substrate.

F. Built-Up Roofing Installation, General

1. Install roofing membrane according to roofing manufacturer's written instructions and applicable recommendations of ARMA/NRCA's "Quality Control Guidelines for the Application of Built-up Roofing."
- a. Install roofing system BU-3 **OR** 4 **OR** 5, **as directed**, -N **OR** I **OR** C, **as directed**, -A-A **OR** S **OR** M, **as directed**, according to roof assembly identification matrix and roof assembly layout illustrations in NRCA's "The NRCA Roofing and Waterproofing Manual" and requirements in this Section.
OR
Install roofing membrane according to roofing manufacturer's written instructions and applicable recommendations of ARMA/NRCA's "Quality Control Guidelines for the Application of Built-up Roofing" and as follows:
 - a. Deck Type: N (nailable) **OR** I (insulated) **OR** C (concrete or nonnailable), **as directed**.
 - b. Base Sheet: 1 **OR** 1, installed over sheathing paper, **as directed**.
 - c. Number of Ply Sheets: 2 **OR** 3 **OR** 4, **as directed**.



- d. Surfacing Type: A (aggregate) **OR** S (asphalt surfacing or coating) **OR** M (mineral-granule-surfaced cap sheet), **as directed**.
 - 1) Mineral-granule-surfaced cap sheet is in addition to number of ply sheets specified.
 2. Start installation of built-up roofing in presence of manufacturer's technical personnel.
 3. Where roof slope exceeds 1/2 inch per 12 inches (1:24) **OR** 3/4 inch per 12 inches (1:18), **as directed**, install built-up roofing sheets parallel with slope.
 - a. Backnail built-up roofing sheets to nailer strips **OR** substrate, **as directed**, according to roofing manufacturer's written instructions.
 4. Cooperate with testing agencies engaged or required to perform services for installing roofing.
 5. Coordinate installation of roofing so insulation and other components of built-up roofing not permanently exposed are not subjected to precipitation or left uncovered at the end of the workday or when rain is forecast.
 - a. Provide tie-offs at end of each day's work to cover exposed built-up roofing sheets and insulation with a course of coated felt set in roofing cement or hot roofing asphalt with joints and edges sealed.
 - b. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing.
 - c. Remove and discard temporary seals before beginning work on adjoining roofing.
 6. Asphalt Heating: Do not raise roofing asphalt temperature above equiviscous temperature range more than one hour before time of application. Do not exceed roofing asphalt manufacturer's recommended temperature limits during roofing asphalt heating. Do not heat roofing asphalt within 25 deg F (14 deg C) of flash point. Discard roofing asphalt maintained at a temperature exceeding finished blowing temperature for more than 4 hours.

OR

Asphalt Heating: Heat and apply SEBS-modified roofing asphalt according to roofing manufacturer's written instructions.
 7. Substrate-Joint Penetrations: Prevent roofing asphalt and adhesives from penetrating substrate joints, entering building, or damaging built-up roofing components or adjacent building construction.
- G. Roofing Membrane Installation
1. Loosely lay one course of sheathing paper, lapping edges and ends a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 2. Install lapped base sheet course, extending sheet over and terminating beyond cants. Attach base sheet as follows:
 - a. Mechanically fasten to substrate.

OR

Spot- or strip-mop to substrate with hot roofing asphalt.

OR

Adhere to substrate in a solid mopping of hot roofing asphalt, **as directed**.
 3. Install two **OR** three **OR** four, **as directed**, ply sheets starting at low point of roofing. Align ply sheets without stretching. Shingle side laps of ply sheets uniformly to achieve required number of plies throughout thickness of roofing membrane. Shingle in direction to shed water. Extend ply sheets over and terminate beyond cants.
 - a. Embed each ply sheet in a solid mopping of hot roofing asphalt applied at rate required by roofing manufacturer, to form a uniform membrane without ply sheets touching.
 4. Cap Sheet: Install lapped granulated cap sheet starting at low point of roofing. Offset laps from laps of preceding ply sheets and align cap sheet without stretching. Lap in direction to shed water. Extend cap sheet over and terminate beyond cants.
 - a. Embed cap sheet in a solid mopping of hot roofing asphalt applied at rate required by built-up roofing manufacturer.
 5. Aggregate Surfacing: Promptly after installing and testing roofing membrane, base flashing, and stripping, flood-coat roof surface with 60 lb/100 sq. ft. (3.0 kg/sq. m) of hot roofing asphalt. While flood coat is hot and fluid, cast the following average weight of aggregate in a uniform course:
 - a. Aggregate Weight: 400 lb/100 sq. ft. (20 kg/sq. m) **OR** 300 lb/100 sq. ft. (15 kg/sq. m), **as directed**.



- b. If aggregate surfacing is delayed, promptly apply glaze coat of hot roofing asphalt at a rate of 10 lb/100 sq. ft. (0.5 kg/sq. m).
- 6. Glaze-coat roofing membrane surface with hot roofing asphalt applied at a rate of 10 to 15 lb/100 sq. ft. (0.5 to 0.75 kg/sq. m).

H. Flashing And Stripping Installation

1. Install base flashing over cant strips and other sloping and vertical surfaces, at roof edges, and at penetrations through roof, and secure to substrates according to built-up roofing manufacturer's written instructions and as follows:
 - a. Prime substrates with asphalt primer if required by built-up roofing manufacturer.
 - b. Backer Sheet Application: Mechanically fasten backer sheet to walls or parapets. Adhere backer sheet over built-up roofing at cants in a solid mopping of hot roofing asphalt **OR** cold-applied adhesive, **as directed**.
OR
 Backer Sheet Application: Adhere backer sheet to substrate in a solid mopping of hot roofing asphalt **OR** cold-applied adhesive, **as directed**.
 - c. Flashing Sheet Application: Adhere flashing sheet to substrate in a solid mopping of hot roofing asphalt applied at not less than 425 deg F (218 deg C). Apply hot roofing asphalt to back of flashing sheet if recommended by roofing manufacturer.
OR
 Flashing Sheet Application: Adhere flashing sheet to substrate in cold-applied adhesive at rate required by roofing manufacturer.
OR
 Flashing Sheet Application: Adhere flashing sheet to substrate in asphalt roofing cement at rate required by roofing manufacturer.
OR
 Flashing Sheet Application: Torch apply flashing sheet to substrate.
2. Extend base flashing up walls or parapets a minimum of 8 inches (200 mm) above built-up roofing and 4 inches (100 mm) onto field of built-up roofing.
3. Mechanically fasten top of base flashing securely at terminations and perimeter of roofing.
 - a. Seal top termination of base flashing with a strip of glass-fiber fabric set in asphalt roofing cement.
4. Install stripping, according to roofing manufacturer's written instructions, where metal flanges and edgings are set on built-up roofing.
 - a. Flashing-Sheet Stripping: Install flashing-sheet stripping in a continuous coating of asphalt roofing cement or in a solid mopping of hot roofing asphalt applied at not less than 425 deg F (218 deg C), and extend onto roofing membrane.
OR
 Flashing-Sheet Stripping: Install flashing-sheet stripping by heat welding and extend onto roofing membrane.
OR
 Built-up Stripping: Install stripping of not less than two roofing membrane ply sheets, setting each ply in a continuous coating of asphalt roofing cement or in a solid mopping of hot roofing asphalt, and extend onto roofing membrane 4 inches (100 mm) and 6 inches (150 mm), respectively.
5. Roof Drains: Set 30-by-30-inch (760-by-760-mm) metal flashing in bed of asphalt roofing cement on completed built-up roofing. Cover metal flashing with built-up roofing cap-sheet stripping and extend a minimum of 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, beyond edge of metal flashing onto field of built-up roofing. Clamp built-up roofing, metal flashing, and stripping into roof-drain clamping ring.
 - a. Install stripping according to roofing manufacturer's written instructions.

I. Coating Installation



1. Apply coating to built-up roofing and base flashings according to manufacturer's written instructions, by spray, roller, or other suitable application method to provide a dry film thickness of not less than 20 mils (0.5 mm).
- J. Walkway Installation
1. Walkway Pads: Install walkway pads using units of size indicated or, if not indicated, of manufacturer's standard size, according to walkway pad manufacturer's written instructions.
 - a. Set walkway pads in additional pour coat of hot roofing asphalt after sweeping away loose aggregate surfacing.
 2. Walkway Cap Sheet Strips: Install walkway cap sheet strips, approximately 36 inches (900 mm) wide and in lengths not exceeding 10 feet (3 m), leaving a space of 6 inches (150 mm) between strips, over built-up roofing. Adhere in hot roofing asphalt.
 3. Roof-Paver Walkways: Install walkway roof pavers according to roofing manufacturer's written instructions in locations indicated, to form walkways. Leave 3 inches (75 mm) of space between adjacent roof pavers.
- K. Field Quality Control
1. Testing Agency: Perform roof tests and inspections and to prepare test reports.
 2. Test Cuts: Test specimens will be removed to evaluate problems observed during quality-assurance inspections of built-up roofing as follows:
 - a. Approximate quantities of components within built-up roofing will be determined according to ASTM D 3617.
 - b. Test specimens will be examined for interply voids according to ASTM D 3617 and to comply with criteria established in Appendix 3 of ARMA/NRCA's "Quality Control Guidelines for the Application of Built-up Roofing."
 - c. Repair areas where test cuts were made according to roofing manufacturer's written instructions.
 3. Repair or remove and replace components of built-up roofing where test results or inspections indicate that they do not comply with specified requirements.
 - a. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- L. Protecting And Cleaning
1. Protect built-up roofing from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and the Owner.
 2. Correct deficiencies in or remove built-up roofing that does not comply with requirements, repair substrates, and repair or reinstall roofing to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
 3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 51 13 00



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Task	Specification	Specification Description
07 51 13 00	07 46 23 00	Miscellaneous Carpentry
07 51 13 00	07 05 13 00	Built-Up Coal-Tar Roofing
07 51 13 00	07 53 16 00	EPDM Membrane Roofing
07 51 13 00	07 05 13 00b	APP-Modified Bituminous Membrane Roofing
07 51 13 00	07 05 13 00c	SBS-Modified Bituminous Membrane Roofing
07 51 13 00	07 05 13 00d	Preparation for Re-Roofing
07 52 13 00	07 05 13 00b	APP-Modified Bituminous Membrane Roofing
07 52 13 00	07 05 13 00d	Preparation for Re-Roofing
07 52 16 00	07 05 13 00c	SBS-Modified Bituminous Membrane Roofing
07 52 16 00	07 05 13 00d	Preparation for Re-Roofing



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**SECTION 07 53 16 00 - EPDM MEMBRANE ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for ethylene-propylene-diene-monomer (EPDM) roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Adhered EPDM membrane roofing system.
 - b. Mechanically fastened EPDM membrane roofing system.
 - c. Loosely laid and ballasted EPDM membrane roofing system.
 - d. Vapor retarder.
 - e. Roof insulation.
2. Section includes the installation of acoustical roof deck rib insulation strips furnished under Division 05 Section "Steel Decking".

C. Definitions

1. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definitions of terms related to roofing work in this Section.

D. Performance Requirements

1. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.
3. Roofing System Design: Provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
4. FM Approvals Listing: Provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals' markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120 **OR** Class 1A-135 **OR** Class 1A-150 **OR** Class 1A-165, **as directed**.
 - b. Hail Resistance: MH **OR** SH, **as directed**.
5. Energy Performance (for "cool-roof" performance): Provide roofing system with initial Solar Reflectance Index not less than 78 **OR** 29, **as directed**, when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency, **as directed**.
6. Energy Performance: Provide roofing system that is listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low **OR** steep, **as directed**, -slope roof products, **as directed**.
7. Energy Performance: Provide roofing system with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC-1.

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:



- a. Product Test Reports for Credit SS 7.2: For roof materials, documentation indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
 3. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.
 4. Samples: For each product included in the roofing system.
 5. Manufacturer Certificate: Signed by roofing manufacturer certifying that membrane roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of complying with performance requirements.
 6. Research/evaluation reports.
 7. Field quality-control reports.
 8. Maintenance data.
 9. Warranties: Sample of special warranties.
- F. Quality Assurance
1. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
 2. Source Limitations: Obtain components for membrane roofing system from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.
 3. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
 4. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 5. Preinstallation Roofing Conference: Conduct conference at Project site.
- G. Delivery, Storage, And Handling
1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
 2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
 - a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
 3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
 4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.
- H. Project Conditions
1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.
- I. Warranty
1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within 10 **OR** 15 **OR** 20, **as directed**, years from date of Final Completion.



1.2 PRODUCTS

A. EPDM Membrane Roofing

1. EPDM: ASTM D 4637, Type I, non-reinforced, **OR** Type II, scrim or fabric internally reinforced, **as directed**, uniform, flexible EPDM sheet.
 - a. Thickness: 45 mils (1.1 mm) **OR** 60 mils (1.5 mm) **OR** 75 mils (1.9 mm) **OR** 90 mils (2.2 mm), **as directed**, nominal.
 - b. Exposed Face Color: Black **OR** White on black, **as directed**.
2. Fabric-Backed EPDM: ASTM D 4637, Type III, non-reinforced, uniform, flexible EPDM sheet, laminated to a nonwoven polyester fabric backing except at selvages.
 - a. Composite Thickness: 90 mils (2.3 mm) **OR** 100 mils (2.5 mm) **OR** 105 mils (2.7 mm) **OR** 115 mils (2.9 mm), **as directed**, nominal.
 - b. Exposed Face Color: Black **OR** White on black, **as directed**.

B. Auxiliary Membrane Roofing Materials

1. General: Auxiliary membrane roofing materials recommended by roofing system manufacturer for intended use and compatible with membrane roofing.
 - a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
 - b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Gypsum Board and Panel Adhesives: 50 g/L.
 - 3) Multipurpose Construction Adhesives: 70 g/L.
 - 4) Fiberglass Adhesives: 80 g/L.
 - 5) Contact Adhesive: 80 g/L.
 - 6) Single-Ply Roof Membrane Sealants: 450 g/L.
 - 7) Nonmembrane Roof Sealants: 300 g/L.
 - 8) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 9) Sealant Primers for Porous Substrates: 775 g/L.
 - 10) Other Adhesives and Sealants: 250 g/L.
2. Sheet Flashing: 60-mil- (1.5-mm-) thick EPDM, partially cured or cured, according to application.
3. Protection Sheet: Epichlorohydrin or neoprene non-reinforced flexible sheet, 55- to 60-mil- (1.4- to 1.5-mm-) thick, recommended by EPDM manufacturer for resistance to hydrocarbons, non-aromatic solvents, grease, and oil.
4. Bonding Adhesive: Manufacturer's standard, water based, **as directed**.
5. Modified Asphaltic Fabric-Backed Membrane Adhesive: Roofing system manufacturer's standard modified asphalt, asbestos-free, cold-applied adhesive formulated for compatibility and use with fabric-backed membrane roofing.
6. Water-Based, Fabric-Backed Membrane Adhesive: Roofing system manufacturer's standard water-based, cold-applied adhesive formulated for compatibility and use with fabric-backed membrane roofing.
7. Low-Rise, Urethane, Fabric-Backed Membrane Adhesive: Roof system manufacturer's standard spray-applied, low-rise, two-component urethane adhesive formulated for compatibility and use with fabric-backed membrane roofing.
8. Seaming Material: Single-component, butyl splicing adhesive and splice cleaner **OR** Manufacturer's standard, synthetic-rubber polymer primer and 3-inch- (75-mm-) wide minimum, butyl splice tape with release film, **as directed**.
9. Lap Sealant: Manufacturer's standard, single-component sealant, colored to match membrane roofing, **as directed**.
10. Water Cutoff Mastic: Manufacturer's standard butyl mastic sealant.
11. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.
12. Metal Battens: Manufacturer's standard, aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1 inch wide by 0.05 inch thick (25 mm wide by 1.3 mm thick), prepunched.



13. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening membrane to substrate, and acceptable to roofing system manufacturer.
14. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, reinforced EPDM securement strips, T-joint covers, in-seam sealants, termination reglets, cover strips, and other accessories.
15. Liquid coating, specifically formulated for coating EPDM membrane roofing, as follows:
 - a. Type: Acrylic emulsion **OR** Hypalon, **as directed**.
 - b. Color: White **OR** Gray **OR** Tan **OR** As selected from manufacturer's full range, **as directed**.

C. Substrate Boards

1. Substrate Board: ASTM C 1396/C 1396M, Type X gypsum board, 5/8 inch (16 mm) thick.
OR
Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 728, perlite board, 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick, seal coated.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate panel to roof deck.

D. Vapor Retarder

1. Polyethylene Film: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
 - a. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
 - b. Adhesive: Manufacturer's standard lap adhesive, FM Approvals approved for vapor-retarder application.
2. Laminated Sheet: Kraft paper, two layers, laminated with asphalt and edge reinforced with woven fiberglass yarn with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and with manufacturer's standard adhesive, **as directed**.
3. Glass-Fiber Felts: ASTM D 2178, Type IV, asphalt impregnated.

E. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by EPDM membrane roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) **OR** Type X, 1.3-lb/cu. ft. (21-kg/cu. m), **as directed**, minimum density, square edged.
3. Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density.
4. Composite Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density, with factory-applied facings, as follows:
 - a. Facer: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, asphalt coated, 1/2 inch (13 mm) thick.
OR
Facer: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.



5. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 **OR** Type II, Class I, Grade 3, **as directed**, felt or glass-fiber mat facer on both major surfaces.
6. Composite Polyisocyanurate Board Insulation: ASTM C 1289, with factory-applied facing board on one major surface, as indicated below by type, and felt or glass-fiber mat facer on the other.
 - a. Type IV, cellulosic-fiber-insulation-board facer, Grade 2, 1/2 inch (13 mm) thick.
 - b. Type V, OSB facer, 7/16 inch (11 mm) thick.
 - c. Type VII, glass mat faced gypsum board facer, 1/4 inch (6 mm) thick.
7. Perlite Board Insulation: ASTM C 728, rigid, mineral-aggregate thermal insulation board composed of expanded perlite, cellulosic fibers, binders, and waterproofing agents with top surface seal coated.
8. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 2, fibrous-felted, rigid insulation boards of wood fiber or other cellulosic-fiber and water-resistant binders, asphalt impregnated, chemically treated for deterioration.
9. Cellular-Glass Board Insulation: ASTM C 552, Type IV, rigid, cellular-glass thermal board insulation faced with manufacturer's standard kraft-paper sheets.
10. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches (1:48) unless otherwise indicated.
11. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

F. Insulation Accessories

1. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards, **as directed**, to substrate, and acceptable to roofing system manufacturer.
3. Modified Asphaltic Insulation Adhesive: Insulation manufacturer's recommended modified asphalt, asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.
4. Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one- or multicomponent urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
5. Full-Spread Applied Insulation Adhesive: Insulation manufacturer's recommended spray-applied, low-rise, two-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
6. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, 1/2 inch (13 mm) thick.
OR
Cover Board: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
OR
Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Cover Board: ASTM C 1278/C 1278M, cellulosic-fiber reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
7. Protection Mat: Woven or nonwoven polypropylene, polyolefin, or polyester fabric, water permeable and resistant to UV degradation, type and weight as recommended by roofing system manufacturer for application.

G. Asphalt Materials

1. Roofing Asphalt: ASTM D 312, Type III or Type IV **OR** ASTM D 6152, SEBS modified, **as directed**.
2. Asphalt Primer: ASTM D 41.

H. Aggregate Ballast (for loosely laid and aggregate-ballasted installations)



1. Aggregate Ballast: Provide aggregate ballast that will withstand weather exposure without significant deterioration and will not contribute to membrane degradation, of the following type and size:
 - a. Aggregate Type: Smooth, washed, riverbed gravel or other acceptable smooth-faced stone **OR** Crushed gravel or crushed stone, **as directed**.
 - b. Size: ASTM D 448, Size 4, ranging in size from 3/4 to 1-1/2 inches (19 to 38 mm).
OR
Size: ASTM D 448, Size 2, ranging in size from 1-1/2 to 2-1/2 inches (38 to 63 mm).
OR
Size: ASTM D 448, Size 3, ranging in size from 1 to 2 inches (25 to 50 mm).
- I. Roof Pavers
 1. Lightweight Roof Pavers: Interlocking, lightweight concrete units, specially factory cast for use as roof ballast; grooved back, with four-way drainage capability; beveled, doweled, or otherwise profiled; and as follows:
 - a. Size: 8 by 16 inches (200 by 400 mm) **OR** 12 by 12 inches (300 by 300 mm) **OR** 12 by 16-1/2 inches (300 by 420 mm) **OR** 12 by 18 inches (300 by 450 mm), **as directed**.
 - b. Weight: At least 10 lb/sq. ft. (50 kg/sq. m) but not exceeding 18 lb/sq. ft. (90 kg/sq. m).
 - c. Compressive Strength: 2500 psi (17 MPa) **OR** 5000 psi (34 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.
 2. Rubber Roof Pavers: Interlocking, lightweight rubber units, 24 by 24 by 2-1/4 inches (600 by 600 by 57 mm), 6 lb/sq. ft. (30 kg/sq. m) specially manufactured for use as roof ballast; with grooved back for four-way drainage, beveled and doweled; and as follows:
 - a. Perimeter Securement Strip: Manufacturer's standard coated steel sheet channel **OR** aluminum sheet channel **OR** mill-finish aluminum sheet hold down **OR** coated aluminum sheet hold down, color as selected, **as directed**, and fasteners.
 - b. Color: Black **OR** Gray **OR** Terra cotta, **as directed**.
 3. Heavyweight Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 12 by 12 inches (300 by 300 mm) **OR** 18 by 18 inches (450 by 450 mm) **OR** 24 by 24 inches (600 by 600 mm), **as directed**. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m), **as directed**.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.
- J. Walkways
 1. Flexible Walkways: Factory-formed, nonporous, heavy-duty, solid-rubber, slip-resisting, surface-textured walkway pads **OR** rolls, **as directed**, approximately 3/16 inch (5 mm) thick, and acceptable to membrane roofing system manufacturer.
 2. Walkway Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 12 by 12 inches (300 by 300 mm) **OR** 18 by 18 inches (450 by 450 mm) **OR** 24 by 24 inches (600 by 600 mm), **as directed**. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m), **as directed**.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.



1.3 EXECUTION

A. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.
4. Install acoustical roof deck rib insulation strips, specified in Division 05 Section "Steel Decking", according to acoustical roof deck manufacturer's written instructions, immediately before installation of overlying construction and to remain dry.

B. Substrate Board

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - a. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.
OR
Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to membrane roofing system manufacturers' written instructions.

C. Vapor-Retarder Installation

1. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 - a. Continuously seal side and end laps with tape **OR** adhesive, **as directed**.
2. Laminate Sheet: Install laminate-sheet vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively. Bond vapor retarder to substrate as follows:
 - a. Apply adhesive at rate recommended by vapor-retarder manufacturer. Seal laps with adhesive.
OR
Apply ribbons of hot roofing asphalt at spacing, temperature, and rate recommended by vapor-retarder manufacturer. Seal laps with hot roofing asphalt.
3. Built-Up Vapor Retarder: Install two glass-fiber felt plies lapping each felt 19 inches (483 mm) over preceding felt. Embed each felt in a solid mopping of hot roofing asphalt. Glaze-coat completed surface with hot roofing asphalt. Apply hot roofing asphalt within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
4. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.

D. Insulation Installation

1. Coordinate installing membrane roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.
2. Comply with membrane roofing system and insulation manufacturer's written instructions for installing roof insulation.
3. Install tapered insulation under area of roofing to conform to slopes indicated.
4. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.



- a. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
5. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
6. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - a. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
7. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
 - a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
 - b. Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
 - c. Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.

OR

 Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
8. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. Fasten insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.

OR

 Fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.
9. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. Fasten first layer of insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.

OR

 Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
 - b. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.

OR

 Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.

OR

 Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
10. Loosely Laid Insulation: Loosely lay insulation units over substrate.
11. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together and fasten to roof deck, **as directed**.
 - a. Fasten cover boards according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.

OR

 Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.

E. Adhered Membrane Roofing Installation

1. Adhere membrane **OR** fabric-backed membrane, **as directed**, roofing over area to receive roofing according to membrane roofing system manufacturer's written instructions. Unroll membrane roofing and allow to relax before installing.



2. Start installation of membrane roofing in presence of membrane roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Bonding Adhesive: Apply to substrate and underside of membrane roofing at rate required by manufacturer and allow to partially dry before installing membrane roofing. Do not apply to splice area of membrane roofing.
5. Hot Roofing Asphalt: Apply a solid mopping of hot roofing asphalt to substrate at temperature and rate required by manufacturer and install fabric-backed membrane roofing. Do not apply to splice area of membrane roofing.

OR

Fabric-Backed Membrane Adhesive: Apply to substrate at rate required by manufacturer and install fabric-backed membrane roofing.

6. In addition to adhering, mechanically fasten membrane roofing securely at terminations, penetrations, and perimeters.
7. Apply membrane roofing with side laps shingled with slope of roof deck where possible.
8. Adhesive Seam Installation: Clean both faces of splice areas, apply splicing cement, and firmly roll side and end laps of overlapping membrane roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of membrane roofing terminations.
 - a. Apply a continuous bead of in-seam sealant before closing splice if required by membrane roofing system manufacturer.
9. Tape Seam Installation: Clean and prime both faces of splice areas, apply splice tape, and firmly roll side and end laps of overlapping membrane roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of membrane roofing terminations.
10. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
11. Spread sealant or mastic bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
12. Install membrane roofing and auxiliary materials to tie in to existing membrane roofing to maintain weather-tightness of transition and to not void warranty for existing membrane roofing system.
13. Adhere protection sheet over membrane roofing at locations indicated.

F. Mechanically Fastened Membrane Roofing Installation

1. Mechanically fasten membrane roofing over area to receive roofing according to roofing system manufacturer's written instructions. Unroll membrane roofing and allow to relax before installing.
 - a. For in-splice attachment, install membrane roofing with long dimension perpendicular to steel roof deck flutes.
2. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Mechanically fasten or adhere membrane roofing securely at terminations, penetrations, and perimeter of roofing.
5. Apply membrane roofing with side laps shingled with slope of roof deck where possible.
6. Adhesive Seam Installation: Clean both faces of splice areas, apply splicing cement, and firmly roll side and end laps of overlapping membrane roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of membrane roofing terminations.
 - a. Apply a continuous bead of in-seam sealant before closing splice if required by membrane roofing system manufacturer.
7. Tape Seam Installation: Clean and prime both faces of splice areas, apply splice tape, and firmly roll side and end laps of overlapping membrane roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of membrane roofing terminations.
8. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.



9. Spread sealant or mastic bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
10. In-Splice Attachment: Secure one edge of membrane roofing using fastening plates or metal battens centered within membrane splice and mechanically fasten membrane roofing to roof deck. Field splice seam.
OR
Through-Membrane Attachment: Secure membrane roofing using fastening plates or metal battens and mechanically fasten membrane roofing to roof deck. Cover battens and fasteners with a continuous cover strip.
11. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weather-tightness of transition and to not void warranty for existing membrane roofing system.
12. Adhere protection sheet over membrane roofing at locations indicated.

G. Loosely Laid And Ballasted Membrane Roofing Installation

1. Loosely lay membrane roofing over area to receive roofing according to roofing system manufacturer's written instructions. Unroll membrane roofing and allow to relax before installing.
 - a. Comply with requirements in SPRI RP-4 for System 1 **OR** System 2 **OR** System 3, **as directed**.
2. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing, without stretching, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Mechanically fasten or adhere perimeter of membrane roofing according to requirements in SPRI RP-4.
OR
Mechanically fasten or adhere membrane roofing at corners, perimeters, and transitions according to requirements in SPRI RP-4.
 - a. At corners and perimeters, omit aggregate ballast leaving membrane roofing exposed.
 - b. At corners and perimeters, adhere a second layer of membrane roofing
5. Apply membrane roofing with side laps shingled with slope of deck where possible.
6. Adhesive Seam Installation: Clean both faces of splice areas, apply splicing cement, and firmly roll side and end laps of overlapping membrane roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of membrane roofing terminations.
 - a. Apply a continuous bead of in-seam sealant before closing splice if required by membrane roofing system manufacturer.
7. Tape Seam Installation: Clean and prime both faces of splice areas, apply splice tape, and firmly roll side and end laps of overlapping membrane roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of membrane roofing terminations.
8. Leave seams uncovered until inspected by membrane roofing system manufacturer **OR** testing agency, **as directed**.
9. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
10. Spread sealant or mastic bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
11. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weather-tightness of transition and to not void warranty for existing membrane roofing system.
12. Adhere protection sheet over membrane roofing at locations indicated.
13. Install protection mat over membrane roofing, overlapping a minimum of 6 inches (150 mm). Install an additional protection mat layer at projections, pipes, vents, and drains, overlapping a minimum of 12 inches (300 mm).
14. Aggregate Ballast, **as directed**: Apply uniformly over membrane roofing at the rate required by membrane roofing system manufacturer, but not less than the following, spreading with care to minimize possibility of damage to membrane roofing system. Lay ballast as membrane roofing is installed, leaving membrane roofing ballasted at the end of the workday.



- a. Ballast Weight: Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m).
OR
Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m), at corners and perimeter; Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m), elsewhere.
OR
Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m).
- 15. Roof-Paver Ballast: Install lightweight **OR** heavyweight, **as directed**, roof-paver ballast according to manufacturer's written instructions.
OR
Roof-Paver Ballast: Install rubber roof-paver ballast according to manufacturer's written instructions, in locations indicated.
 - a. Install perimeter paver edge securement.
OR
Roof-Paver and Aggregate Ballast: Install heavyweight roof pavers according to manufacturer's written instructions on roof corners and perimeter.
 - b. Install Size 4 aggregate ballast elsewhere on roofing at a minimum rate of 10 lb/sq. ft. (50 kg/sq. m).
OR
Install Size 2 aggregate ballast elsewhere on roofing at a minimum rate of 13 lb/sq. ft. (65 kg/sq. m).
- H. Base Flashing Installation
 - 1. Install sheet flashings and preformed flashing accessories and adhere to substrates according to membrane roofing system manufacturer's written instructions.
 - 2. Apply bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply to seam area of flashing.
 - 3. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.
 - 4. Clean splice areas, apply splicing cement, and firmly roll side and end laps of overlapping sheets to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet flashing terminations.
 - 5. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars, **as directed**.
- I. Coating Installation
 - 1. Apply coatings to membrane roofing **OR** base flashings, **as directed**, according to manufacturer's written recommendations, by spray, roller, or other suitable application method.
- J. Walkway Installation
 - 1. Flexible Walkways: Install walkway products in locations indicated. Adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.
 - 2. Roof-Paver Walkways: Install walkway roof pavers according to manufacturer's written instructions in locations indicated, to form walkways. Leave 3 inches (75 mm) of space between adjacent roof pavers.
- K. Field Quality Control
 - 1. Testing Agency: Engage a qualified independent testing agency to perform inspections.
 - 2. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.
 - 3. Repair or remove and replace components of membrane roofing system where inspections indicate that they do not comply with specified requirements.
 - 4. Additional inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- L. Protecting And Cleaning



1. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to the Owner.
2. Correct deficiencies in or remove membrane roofing system that does not comply with requirements, repair substrates and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 53 16 00



Task	Specification	Specification Description
07 53 16 00	07 51 13 00	Built-Up Asphalt Roofing
07 53 16 00	07 05 13 00	Built-Up Coal-Tar Roofing
07 53 16 00	07 05 13 00a	CSPE Membrane Roofing
07 53 16 00	07 05 13 00d	Preparation for Re-Roofing
07 53 23 00	07 51 13 00	Built-Up Asphalt Roofing
07 53 23 00	07 05 13 00	Built-Up Coal-Tar Roofing
07 53 23 00	07 53 16 00	EPDM Membrane Roofing
07 53 23 00	07 05 13 00d	Preparation for Re-Roofing
07 53 29 00	07 51 13 00	Built-Up Asphalt Roofing
07 53 29 00	07 05 13 00	Built-Up Coal-Tar Roofing
07 53 29 00	07 53 16 00	EPDM Membrane Roofing
07 53 29 00	07 05 13 00d	Preparation for Re-Roofing



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**SECTION 07 54 19 00 - POLYVINYL-CHLORIDE (PVC) ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for polyvinyl-chloride (PVC) roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Adhered PVC membrane roofing system.
 - b. Mechanically fastened PVC membrane roofing system.
 - c. Loosely laid and ballasted PVC membrane roofing system.
 - d. Vapor retarder.
 - e. Roof insulation.
2. Section includes the installation of acoustical roof deck rib insulation strips furnished under Division 05 Section "Steel Decking".

C. Definitions

1. Roofing Terminology: See ASTM D 1079 and glossary in NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.

D. Performance Requirements

1. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.
3. Roofing System Design: Provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
4. FM Approvals Listing, **as directed**: Provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120 **OR** Class 1A-135 **OR** Class 1A-150 **OR** Class 1A-165, **as directed**.
 - b. Hail Resistance: MH **OR** SH, **as directed**.
5. Energy Performance: Provide roofing system with initial Solar Reflectance Index not less than 78 **OR** 29, **as directed**, when calculated according to ASTM E 1980, based on testing identical products by a qualified testing agency.
6. Energy Performance: Provide roofing system that is listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low **OR** steep, **as directed**, -slope roof products.
7. Energy Performance(for roofs that must comply with California Energy Commission's CEC-Title 24): Provide roofing system with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC-1.

E. Submittals

1. Product Data: For each type of product indicated.



2. LEED Submittals:
 - a. Product Data for Credit SS 7.2: For roof materials, indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
 3. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.
 4. Samples: For each product included in the roofing system.
 5. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of compliance with performance requirements.
 6. Research/evaluation reports.
 7. Field quality-control reports.
 8. Maintenance data.
 9. Warranties: Sample of special warranties.
- F. Quality Assurance
1. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
 2. Source Limitations: Obtain components for membrane roofing system from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.
 3. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
 4. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 5. Preinstallation Roofing Conference: Conduct conference at Project site.
- G. Delivery, Storage, And Handling
1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
 2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
 - a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
 3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
 4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.
- H. Project Conditions
1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.
- I. Warranty
1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within 10 **OR** 15, **as directed**, years from date of Final Completion.



1.2 PRODUCTS

A. PVC Membrane Roofing

1. PVC Sheet: ASTM D 4434, Type II, Grade I, glass fiber reinforced, felt backed.
 - a. Thickness: 48 mils (1.2 mm), minimum **OR** 60 mils (1.5 mm), nominal **OR** 72 mils (1.8 mm) **OR** 80 mils (2.0 mm) **OR** 96 mils (2.4 mm), **as directed**.
 - b. Exposed Face Color: Gray.**OR**

PVC Sheet: ASTM D 4434, Type III, fabric reinforced and fabric backed, **as directed**.

 - a. Thickness: 45 mils (1.1 mm), minimum **OR** 48 mils (1.2 mm) **OR** 50 mils (1.27 mm) **OR** 60 mils (1.5 mm), nominal **OR** 72 mils (1.8 mm) **OR** 80 mils (2.0 mm) **OR** 100 mils (2.5 mm), **as directed**.
 - b. Exposed Face Color: White **OR** Gray, **as directed**.**OR**

PVC Sheet: ASTM D 4434, Type IV, fabric reinforced and fabric backed, **as directed**.

 - a. Thickness: 36 mils (0.9 mm), minimum **OR** 40 mils (1.0 mm), nominal **OR** 50 mils (1.27 mm) **OR** 60 mils (1.5 mm), nominal **OR** 72 mils (1.8 mm) **OR** 80 mils (2.0 mm) **OR** 100 mils (2.5 mm), **as directed**.
 - b. Exposed Face Color: White **OR** Gray, **as directed**.

B. Auxiliary Membrane Roofing Materials

1. General: Auxiliary membrane roofing materials recommended by roofing system manufacturer for intended use, and compatible with membrane roofing.
 - a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
 - b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Gypsum Board and Panel Adhesives: 50 g/L.
 - 3) Multipurpose Construction Adhesives: 70 g/L.
 - 4) Fiberglass Adhesives: 80 g/L.
 - 5) Contact Adhesive: 80 g/L.
 - 6) Other Adhesives: 250 g/L.
 - 7) PVC Welding Compounds: 510 g/L.
 - 8) Adhesive Primer for Plastic: 650 g/L.
 - 9) Single-Ply Roof Membrane Sealants: 450 g/L.
 - 10) Nonmembrane Roof Sealants: 300 g/L.
 - 11) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 12) Sealant Primers for Porous Substrates: 775 g/L.
2. Sheet Flashing: Manufacturer's standard sheet flashing of same material, type, reinforcement, thickness, and color as PVC sheet membrane.
3. Bonding Adhesive: Manufacturer's standard, water based, **as directed**.
4. Slip Sheet: Manufacturer's standard, of thickness required for application.
5. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.
6. Metal Battens: Manufacturer's standard, aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1 inch wide by 0.05 inch (25 mm wide by 1.3 mm) thick, prepunched.
7. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening membrane to substrate, and acceptable to membrane roofing system manufacturer.
8. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, lap sealants, termination reglets, and other accessories.

C. Substrate Boards



1. Substrate Board: ASTM C 1396/C 1396M, Type X gypsum board, 5/8 inch (16 mm) thick.
OR
 Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick.
OR
 Substrate Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR
 Substrate Board: ASTM C 728, perlite board, 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick, seal coated.
2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate board to roof deck.

D. Vapor Retarder

1. Polyethylene Film: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
 - a. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
OR
 Adhesive: Manufacturer's standard lap adhesive, FM Approvals approved for vapor-retarder application.
2. Laminated Sheet: Kraft paper, two layers, laminated with asphalt and edge reinforced with woven fiberglass yarn with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and with manufacturer's standard adhesive, **as directed**.
3. Glass-Fiber Felts: ASTM D 2178, Type IV, asphalt impregnated.

E. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by PVC membrane roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) **OR** Type X, 1.3-lb/cu. ft. (21-kg/cu. m), **as directed**, minimum density, square edged.
3. Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density.
4. Composite Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density, with factory-applied facings, as follows:
 - a. Facer: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, asphalt coated, 1/2 inch (13 mm) thick.
OR
 Facer: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
5. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 **OR** Type II, Class I, Grade 3, **as directed**, felt or glass-fiber mat facer on both major surfaces.
6. Composite Polyisocyanurate Board Insulation: ASTM C 1289, with factory-applied facing board on one major surface, as indicated below by type, and felt or glass-fiber mat facer on the other.
 - a. Type IV, cellulosic-fiber-insulating-board facer, Grade 2, 1/2 inch (13 mm) thick.
 - b. Type V, OSB facer, 7/16 inch (11 mm) thick.
 - c. Type VII, glass mat faced gypsum board facer, 1/4 inch (6 mm) thick.
7. Perlite Board Insulation: ASTM C 728, rigid, mineral-aggregate thermal insulation board composed of expanded perlite, cellulosic fibers, binders, and waterproofing agents with top surface seal coated.



8. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 2, fibrous-felted, rigid insulation boards of wood fiber or other cellulosic-fiber and water-resistant binders, asphalt impregnated, chemically treated for deterioration.
 9. Cellular-Glass Board Insulation: ASTM C 552, Type IV, rigid, cellular-glass thermal board insulation faced with manufacturer's standard kraft-paper sheets.
 10. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches (1:48), **as directed**, unless otherwise indicated.
 11. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.
- F. Insulation Accessories
1. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.
 2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards, **as directed**, to substrate, and acceptable to roofing system manufacturer.
 3. Modified Asphaltic Insulation Adhesive: Insulation manufacturer's recommended modified asphalt, asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 4. Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one- or multicomponent urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 5. Full-Spread Applied Insulation Adhesive: Insulation manufacturer's recommended spray-applied, low-rise, two-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 6. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, 1/2 inch (13 mm) thick.
OR
Cover Board: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
OR
Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Cover Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
 7. Protection Mat: Woven or nonwoven polypropylene, polyolefin, or polyester fabric, water permeable and resistant to UV degradation, type and weight as recommended by roofing system manufacturer for application.
- G. Asphalt Materials
1. Roofing Asphalt: ASTM D 312, Type III or Type IV **OR** ASTM D 6152, SEBS modified, **as directed**.
 2. Asphalt Primer: ASTM D 41.
- H. Aggregate Ballast (for loosely laid and aggregate-ballasted installations)
1. Aggregate Ballast: Provide aggregate ballast that will withstand weather exposure without significant deterioration and will not contribute to membrane degradation, of the following type and size:
 - a. Aggregate Type: Smooth, washed, riverbed gravel or other acceptable smooth-faced stone **OR** Crushed gravel or crushed stone, **as directed**.
 - b. Size: ASTM D 448, Size 4, ranging in size from 3/4 to 1-1/2 inches (19 to 38 mm).
OR
Size: ASTM D 448, Size 2, ranging in size from 1-1/2 to 2-1/2 inches (38 to 63 mm).
OR
Size: ASTM D 448, Size 3, ranging in size from 1 to 2 inches (25 to 50 mm).



I. Roof Pavers

1. Lightweight Roof Pavers: Interlocking, lightweight concrete units, specially factory cast for use as roof ballast; grooved back, with four-way drainage capability; beveled, doweled, or otherwise profiled; and as follows:
 - a. Size: 8 by 16 inches (200 by 400 mm) **OR** 12 by 12 inches (300 by 300 mm) **OR** 12 by 16-1/2 inches (300 by 420 mm) **OR** 12 by 18 inches (300 by 450 mm), **as directed**.
 - b. Weight: At least 10 lb/sq. ft. (50 kg/sq. m) but not exceeding 18 lb/sq. ft. (90 kg/sq. m).
 - c. Compressive Strength: 2500 psi (17 MPa) **OR** 5000 psi (34 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.
2. Heavyweight Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 12 by 12 inches (300 by 300 mm) **OR** 18 by 18 inches (450 by 450 mm) **OR** 24 by 24 inches (600 by 600 mm), **as directed**. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m), **as directed**.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.

J. Walkways

1. Flexible Walkways: Factory-formed, nonporous, heavy-duty, solid-rubber, slip-resisting, surface-textured walkway pads **OR** rolls, **as directed**, approximately 3/16 inch (5 mm) thick, and acceptable to membrane roofing system manufacturer.
2. Walkway Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 12 by 12 inches (300 by 300 mm) **OR** 18 by 18 inches (450 by 450 mm) **OR** 24 by 24 inches (600 by 600 mm), **as directed**. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m), **as directed**.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.

1.3 EXECUTION

A. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.
4. Install acoustical roof deck rib insulation strips, specified in Division 05 Section "Steel Decking", according to acoustical roof deck manufacturer's written instructions, immediately before installation of overlying construction and to remain dry.

B. Substrate Board

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.



- a. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.

OR

Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to membrane roofing system manufacturers' written instructions.

C. Vapor-Retarder Installation

1. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 - a. Continuously seal side and end laps with tape **OR** adhesive, **as directed**.
2. Laminate Sheet: Install laminate-sheet vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively. Bond vapor retarder to substrate as follows:
 - a. Apply adhesive at rate recommended by vapor-retarder manufacturer. Seal laps with adhesive.
OR
Apply ribbons of hot roofing asphalt at spacing, temperature, and rate recommended by vapor-retarder manufacturer. Seal laps with hot roofing asphalt.
3. Built-up Vapor Retarder: Install two glass-fiber felt plies lapping each felt 19 inches (483 mm) over preceding felt. Embed each felt in a solid mopping of hot roofing asphalt. Glaze-coat completed surface with hot roofing asphalt. Apply hot roofing asphalt within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
4. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.

D. Insulation Installation

1. Coordinate installing membrane roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.
2. Comply with membrane roofing system and insulation manufacturer's written instructions for installing roof insulation.
3. Install tapered insulation under area of roofing to conform to slopes indicated.
4. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.
 - a. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
5. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
6. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - a. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
7. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
 - a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
 - b. Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
 - c. Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
 - d. Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.



8. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. Fasten insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.
 9. Mechanically Fastened and Adhered Insulation: Install each layer of insulation and secure first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. Fasten first layer of insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
 - b. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
OR
Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
OR
Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
 10. Loosely Laid Insulation: Loosely lay insulation units over substrate.
 11. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together and fasten to roof deck, **as directed**.
 - a. Fasten cover boards according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.
 12. Install slip sheet over insulation **OR** cover board, **as directed**, and immediately beneath membrane roofing.
- E. Adhered Membrane Roofing Installation
1. Adhere membrane roofing over area to receive roofing and install according to membrane roofing system manufacturer's written instructions.
 - a. Install sheet according to ASTM D 5036.
 2. Start installation of membrane roofing in presence of membrane roofing system manufacturer's technical personnel.
 3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
 4. Bonding Adhesive: Apply to substrate and underside of membrane roofing at rate required by manufacturer and allow to partially dry before installing membrane roofing. Do not apply to splice area of membrane roofing.
 5. In addition to adhering, mechanically fasten membrane roofing securely at terminations, penetrations, and perimeter of roofing.
 6. Apply membrane roofing with side laps shingled with slope of roof deck where possible.
 7. Seams: Clean seam areas, overlap membrane roofing, and hot-air weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation.
 - a. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - b. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
 - c. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.



8. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
 9. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing membrane roofing system.
- F. Mechanically Fastened Membrane Roofing Installation
1. Mechanically fasten membrane roofing over area to receive roofing and install according to roofing system manufacturer's written instructions.
 - a. Install sheet according to ASTM D 5082.
 - b. For in-splice attachment, install membranes roofing with long dimension perpendicular to steel roof deck flutes.
 2. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.
 3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
 4. Mechanically fasten or adhere membrane roofing securely at terminations, penetrations, and perimeter of roofing.
 5. Apply membrane roofing with side laps shingled with slope of roof deck where possible.
 6. In-Seam Attachment: Secure one edge of PVC sheet using fastening plates or metal battens centered within membrane seam and mechanically fasten PVC sheet to roof deck.
 7. Seams: Clean seam areas, overlap membrane roofing, and hot-air weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation.
 - a. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - b. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
 - c. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
 8. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
 9. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing membrane roofing system.
- G. Loosely Laid And Ballasted Membrane Roofing Installation
1. Loosely lay membrane roofing over area to receive roofing and install according to roofing system manufacturer's written instructions.
 - a. Comply with requirements in SPRI RP-4 for System 1 **OR** System 2 **OR** System 3, **as directed**.
 2. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.
 3. Accurately align membrane roofing, without stretching, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
 4. Mechanically fasten or adhere perimeter of membrane roofing according to requirements in SPRI RP-4.
OR
Mechanically fasten **OR** adhere, **as directed**, membrane roofing at corners, perimeters, and transitions according to requirements in SPRI RP-4.
 - a. At corners and perimeters, omit aggregate ballast leaving membrane roofing exposed.
OR
At corners and perimeters, adhere a second layer of membrane roofing.
 5. Apply membrane roofing with side laps shingled with slope of deck where possible.
 6. Seams: Clean seam areas, overlap membrane roofing, and hot-air weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation.
 - a. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - b. Verify field strength of seams a minimum of twice daily and repair seam sample areas.



- c. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
 7. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
 8. Install membrane roofing and auxiliary materials to tie in to existing roofing.
 9. Install protection mat over membrane roofing, overlapping a minimum of 6 inches (150 mm). Install an additional protection mat layer at projections, pipes, vents, and drains, overlapping a minimum of 12 inches (300 mm).
 10. Aggregate Ballast: Apply uniformly over membrane roofing at the rate required by membrane roofing system manufacturer, but not less than the following, spreading with care to minimize possibility of damage to membrane roofing system. Lay ballast as membrane roofing is installed, leaving membrane roofing ballasted at the end of the workday.
 - a. Ballast Weight: Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m).
OR
 Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m), at corners and perimeter; Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m), elsewhere.
OR
 Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m).
 11. Roof-Paver Ballast: Install lightweight **OR** heavyweight, **as directed**, roof-paver ballast according to manufacturer's written instructions.
OR
 Roof-Paver and Aggregate Ballast: Install heavyweight roof pavers according to manufacturer's written instructions on roof corners and perimeter.
 - a. Install Size 4 aggregate ballast elsewhere on roofing at a minimum rate of 10 lb/sq. ft. (50 kg/sq. m).
OR
 Install Size 2 aggregate ballast elsewhere on roofing at a minimum rate of 13 lb/sq. ft. (65 kg/sq. m).
- H. Base Flashing Installation
1. Install sheet flashings and preformed flashing accessories and adhere to substrates according to membrane roofing system manufacturer's written instructions.
 2. Apply bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply to seam area of flashing.
 3. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.
 4. Clean seam areas, overlap, and firmly roll sheet flashings into the adhesive. Hot-air weld side and end laps to ensure a watertight seam installation.
 5. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars, **as directed**.
- I. Walkway Installation
1. Flexible Walkways: Install walkway products in locations indicated. Heat weld to substrate or adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.
 2. Roof-Paver Walkways: Install walkway roof pavers according to manufacturer's written instructions in locations indicated, to form walkways. Leave 3 inches (75 mm) of space between adjacent roof pavers.
- J. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 2. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.
 3. Repair or remove and replace components of membrane roofing system where inspections indicate that they do not comply with specified requirements.



4. Additional inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- K. Protecting And Cleaning
1. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to the Owner.
 2. Correct deficiencies in or remove membrane roofing system that does not comply with requirements; repair substrates; and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
 3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 54 19 00



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Task	Specification	Specification Description
07 54 19 00	07 05 13 00d	Preparation for Re-Roofing



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**SECTION 07 54 23 00 - THERMOPLASTIC POLYOLEFIN (TPO) ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for thermoplastic polyolefin (TPO) roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Adhered TPO membrane roofing system.
 - b. Mechanically fastened TPO membrane roofing system.
 - c. Loosely laid and ballasted TPO membrane roofing system.
 - d. Vapor retarder.
 - e. Roof insulation.
2. Section includes the installation of acoustical roof deck rib insulation strips furnished under Division 05 Section "Steel Decking".

C. Definitions

1. TPO: Thermoplastic polyolefin.
2. Roofing Terminology: See ASTM D 1079 and glossary in NRCA's "The NRCA Roofing and Waterproofing Manual" for definitions of terms related to roofing work in this Section.

D. Performance Requirements

1. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.
2. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.
3. Roofing System Design: Provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.
4. FM Approvals Listing, **as directed**: Provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR** Class 1A-75 **OR** Class 1A-90 **OR** Class 1A-105 **OR** Class 1A-120 **OR** Class 1A-135 **OR** Class 1A-150 **OR** Class 1A-165, **as directed**.
 - b. Hail Resistance: MH **OR** SH, **as directed**.
5. Energy Performance: Provide roofing system with initial Solar Reflectance Index not less than 78 **OR** 29, **as directed**, when calculated according to ASTM E 1980, based on testing identical products by a qualified testing agency.
6. Energy Performance: Provide roofing system that is listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low **OR** steep, **as directed**, -slope roof products.
7. Energy Performance (for roofs that must comply with California Energy Commission's CEC-Title 24): Provide roofing system with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC-1.

E. Submittals



1. Product Data: For each type of product indicated.
 2. LEED Submittals:
 - a. Product Data for Credit SS 7.2: For roof materials, indicating that roof materials comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
 3. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.
 4. Samples: For each product included in the roofing system.
 5. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of compliance with performance requirements.
 6. Research/evaluation reports.
 7. Field quality-control reports.
 8. Maintenance data.
 9. Warranties: Sample of special warranties.
- F. Quality Assurance
1. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
 2. Source Limitations: Obtain components for membrane roofing system from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.
 3. Exterior Fire-Test Exposure: ASTM E 108, Class A **OR** Class B **OR** Class C, **as directed**; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.
 4. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 5. Preinstallation Roofing Conference: Conduct conference at Project site.
- G. Delivery, Storage, And Handling
1. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
 2. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
 - a. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
 3. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
 4. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.
- H. Project Conditions
1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.
- I. Warranty



1. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within 10 **OR** 15, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. TPO Membrane Roofing

1. Fabric-Reinforced Thermoplastic Polyolefin Sheet: ASTM D 6878, internally fabric or scrim reinforced, uniform, flexible fabric backed, **as directed**, TPO sheet.
 - a. Thickness: 45 mils (1.1 mm) **OR** 60 mils (1.5 mm), **as directed**, nominal.
 - b. Exposed Face Color: Black **OR** Gray **OR** Tan **OR** White, **as directed**.

B. Auxiliary Membrane Roofing Materials

1. General: Auxiliary membrane roofing materials recommended by roofing system manufacturer for intended use, and compatible with membrane roofing.
 - a. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
 - b. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1) Plastic Foam Adhesives: 50 g/L.
 - 2) Gypsum Board and Panel Adhesives: 50 g/L.
 - 3) Multipurpose Construction Adhesives: 70 g/L.
 - 4) Fiberglass Adhesives: 80 g/L.
 - 5) Contact Adhesive: 80 g/L.
 - 6) Other Adhesives: 250 g/L.
 - 7) Single-Ply Roof Membrane Sealants: 450 g/L.
 - 8) Nonmembrane Roof Sealants: 300 g/L.
 - 9) Sealant Primers for Nonporous Substrates: 250 g/L.
 - 10) Sealant Primers for Porous Substrates: 775 g/L.
2. Sheet Flashing: Manufacturer's standard unreinforced thermoplastic polyolefin sheet flashing, 55 mils (1.4 mm) thick, minimum, of same color as sheet membrane.
3. Bonding Adhesive: Manufacturer's standard, water based, **as directed**.
4. Slip Sheet: Manufacturer's standard, of thickness required for application.
5. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.
6. Metal Battens: Manufacturer's standard, aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1 inch wide by 0.05 inch thick (25 mm wide by 1.3 mm thick), prepunched.
7. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening membrane to substrate, and acceptable to membrane roofing system manufacturer.
8. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, lap sealants, termination reglets, and other accessories.

C. Substrate Boards

1. Substrate Board: ASTM C 1396/C 1396M, Type X gypsum board, 5/8 inch (16 mm) thick.
OR
Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** Type X, 5/8 inch (16 mm), **as directed**, thick.
OR
Substrate Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
OR



Substrate Board: ASTM C 728, perlite board, 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick, seal coated.

2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate board to roof deck.

D. Vapor Retarder

1. Polyethylene Film: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).
 - a. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
OR
Adhesive: Manufacturer's standard lap adhesive, FM Approvals approved for vapor-retarder application.
2. Laminated Sheet: Kraft paper, two layers, laminated with asphalt and edge reinforced with woven fiberglass yarn with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and with manufacturer's standard adhesive, **as directed**.
3. Glass-Fiber Felts: ASTM D 2178, Type IV, asphalt impregnated.

E. Roof Insulation

1. General: Preformed roof insulation boards manufactured or approved by TPO membrane roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Approvals-approved roof insulation, **as directed**.
2. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) **OR** Type X, 1.3-lb/cu. ft. (21-kg/cu. m), **as directed**, minimum density, square edged.
3. Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density.
4. Composite Molded-Polystyrene Board Insulation: ASTM C 578, Type II, 1.35-lb/cu. ft. (22-kg/cu. m) **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) **OR** Type IX, 1.8-lb/cu. ft. (29-kg/cu. m), **as directed**, minimum density, with factory-applied facings, as follows:
 - a. Facer: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, asphalt coated, 1/2 inch (13 mm) thick.
OR
Facer: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
5. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 **OR** Type II, Class I, Grade 3, **as directed**, felt or glass-fiber mat facer on both major surfaces.
6. Composite Polyisocyanurate Board Insulation: ASTM C 1289, with factory-applied facing board on one major surface, as indicated below by type, and felt or glass-fiber mat facer on the other.
 - a. Type IV, cellulosic-fiber-insulating-board facer, Grade 2, 1/2 inch (13 mm) thick.
 - b. Type V, OSB facer, 7/16 inch (11 mm) thick.
 - c. Type VII, glass mat faced gypsum board facer, 1/4 inch (6 mm) thick.
7. Perlite Board Insulation: ASTM C 728, rigid, mineral-aggregate thermal insulation board composed of expanded perlite, cellulosic fibers, binders, and waterproofing agents with top surface seal coated.
8. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 2, fibrous-felted, rigid insulation boards of wood fiber or other cellulosic-fiber and water-resistant binders, asphalt impregnated, chemically treated for deterioration.
9. Cellular-Glass Board Insulation: ASTM C 552, Type IV, rigid, cellular-glass thermal board insulation faced with manufacturer's standard kraft-paper sheets.
10. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches (1:48) unless otherwise indicated.
11. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

F. Insulation Accessories



1. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.
 2. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards, **as directed**, to substrate, and acceptable to roofing system manufacturer.
 3. Modified Asphaltic Insulation Adhesive: Insulation manufacturer's recommended modified asphalt, asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 4. Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one- or multicomponent urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 5. Full-Spread Applied Insulation Adhesive: Insulation manufacturer's recommended spray-applied, low-rise, two-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.
 6. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, 1/2 inch (13 mm) thick.
OR
Cover Board: DOC PS 2, Exposure 1, OSB, 7/16 inch (11 mm) thick.
OR
Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick, factory primed, **as directed**.
OR
Cover Board: ASTM C 1278/C 1278M, cellulosic-fiber-reinforced, water-resistant gypsum substrate, 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), **as directed**, thick.
 7. Protection Mat: Woven or nonwoven polypropylene, polyolefin, or polyester fabric, water permeable and resistant to UV degradation, type and weight as recommended by roofing system manufacturer for application.
- G. Asphalt Materials
1. Roofing Asphalt: ASTM D 312, Type III or Type IV **OR** ASTM D 6152, SEBS modified, **as directed**.
 2. Asphalt Primer: ASTM D 41.
- H. Aggregate Ballast (for loosely laid and aggregate-ballasted installations)
1. Aggregate Ballast: Provide aggregate ballast that will withstand weather exposure without significant deterioration and will not contribute to membrane degradation, of the following type and size:
 - a. Aggregate Type: Smooth, washed, riverbed gravel or other acceptable smooth-faced stone **OR** Crushed gravel or crushed stone, **as directed**.
 - b. Size: ASTM D 448, Size 4, ranging in size from 3/4 to 1-1/2 inches (19 to 38 mm).
OR
Size: ASTM D 448, Size 2, ranging in size from 1-1/2 to 2-1/2 inches (38 to 63 mm).
OR
Size: ASTM D 448, Size 3, ranging in size from 1 to 2 inches (25 to 50 mm).
- I. Roof Pavers
1. Lightweight Roof Pavers: Interlocking, lightweight concrete units, specially factory cast for use as roof ballast; grooved back, with four-way drainage capability; beveled, doweled, or otherwise profiled; and as follows:
 - a. Size: 8 by 16 inches (200 by 400 mm) **OR** 12 by 12 inches (300 by 300 mm) **OR** 12 by 16-1/2 inches (300 by 420 mm) **OR** 12 by 18 inches (300 by 450 mm), **as directed**.
 - b. Weight: At least 10 lb/sq. ft. (50 kg/sq. m) but not exceeding 18 lb/sq. ft. (90 kg/sq. m).
 - c. Compressive Strength: 2500 psi (17 MPa) **OR** 5000 psi (34 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.



2. Heavyweight Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 12 by 12 inches (300 by 300 mm) **OR** 18 by 18 inches (450 by 450 mm) **OR** 24 by 24 inches (600 by 600 mm), **as directed**. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m), **as directed**.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.

J. Walkways

1. Flexible Walkways: Factory-formed, nonporous, heavy-duty, solid-rubber, slip-resisting, surface-textured walkway pads **OR** rolls, **as directed**, approximately 3/16 inch (5 mm) thick, and acceptable to membrane roofing system manufacturer.
2. Walkway Roof Pavers: Heavyweight, hydraulically pressed, concrete units, square edged **OR** with top edges beveled 3/16 inch (5 mm), **as directed**, factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:
 - a. Size: 12 by 12 inches (300 by 300 mm) **OR** 18 by 18 inches (450 by 450 mm) **OR** 24 by 24 inches (600 by 600 mm), **as directed**. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch (1.6 mm) in length, height, and thickness.
 - b. Weight: 18 lb/sq. ft. (90 kg/sq. m) **OR** 22 lb/sq. ft. (110 kg/sq. m), **as directed**.
 - c. Compressive Strength: 7500 psi (52 MPa) **OR** 6500 psi (45 MPa), **as directed**, minimum.
 - d. Colors and Textures: As selected from manufacturer's full range.

1.3 EXECUTION

A. Preparation

1. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
2. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
3. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.
4. Install acoustical roof deck rib insulation strips, specified in Division 05 Section "Steel Decking", according to acoustical roof deck manufacturer's written instructions, immediately before installation of overlying construction and to remain dry.

B. Substrate Board

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - a. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.
OR
Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to membrane roofing system manufacturers' written instructions.

C. Vapor-Retarder Installation



1. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
 - a. Continuously seal side and end laps with tape **OR** adhesive, **as directed**.
2. Laminate Sheet: Install laminate-sheet vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively. Bond vapor retarder to substrate as follows:
 - a. Apply adhesive at rate recommended by vapor-retarder manufacturer. Seal laps with adhesive.
OR
Apply ribbons of hot roofing asphalt at spacing, temperature, and rate recommended by vapor-retarder manufacturer. Seal laps with hot roofing asphalt.
3. Built-up Vapor Retarder: Install two glass-fiber felt plies lapping each felt 19 inches (483 mm) over preceding felt. Embed each felt in a solid mopping of hot roofing asphalt. Glaze-coat completed surface with hot roofing asphalt. Apply hot roofing asphalt within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
4. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.

D. Insulation Installation

1. Coordinate installing membrane roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.
2. Comply with membrane roofing system and insulation manufacturer's written instructions for installing roof insulation.
3. Install tapered insulation under area of roofing to conform to slopes indicated.
4. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.
 - a. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
5. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.
6. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - a. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
7. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
 - a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
 - b. Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
 - c. Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
 - d. Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
8. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. Fasten insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.



9. Mechanically Fastened and Adhered Insulation: Install each layer of insulation and secure first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
 - a. Fasten first layer of insulation according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
 - b. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
OR
Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
OR
Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
10. Loosely Laid Insulation: Loosely lay insulation units over substrate.
11. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together and fasten to roof deck, **as directed**.
 - a. Fasten cover boards according to requirements in FM Approvals' "RoofNav" for specified Windstorm Resistance Classification.
OR
Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.
12. Install slip sheet over insulation **OR** cover board, **as directed**, and immediately beneath membrane roofing.

E. Adhered Membrane Roofing Installation

1. Adhere membrane roofing over area to receive roofing and install according to membrane roofing system manufacturer's written instructions.
2. Start installation of membrane roofing in presence of membrane roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Bonding Adhesive: Apply to substrate and underside of membrane roofing at rate required by manufacturer and allow to partially dry before installing membrane roofing. Do not apply to splice area of membrane roofing.
5. In addition to adhering, mechanically fasten membrane roofing securely at terminations, penetrations, and perimeter of roofing.
6. Apply membrane roofing with side laps shingled with slope of roof deck where possible.
7. Seams: Clean seam areas, overlap membrane roofing, and hot-air weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation.
 - a. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - b. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
 - c. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
8. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
9. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing membrane roofing system, **as directed**.

F. Mechanically Fastened Membrane Roofing Installation



1. Mechanically fasten membrane roofing over area to receive roofing and install according to roofing system manufacturer's written instructions.
 - a. For in-splice attachment, install membranes roofing with long dimension perpendicular to steel roof deck flutes.
2. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Mechanically fasten or adhere membrane roofing securely at terminations, penetrations, and perimeter of roofing.
5. Apply membrane roofing with side laps shingled with slope of roof deck where possible.
6. In-Seam Attachment: Secure one edge of TPO sheet using fastening plates or metal battens centered within membrane seam and mechanically fasten TPO sheet to roof deck.
7. Seams: Clean seam areas, overlap membrane roofing, and hot-air weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation.
 - a. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - b. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
 - c. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
8. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
9. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing membrane roofing system.

G. Loosely Laid And Ballasted Membrane Roofing Installation

1. Loosely lay membrane roofing over area to receive roofing and install according to roofing system manufacturer's written instructions.
 - a. Comply with requirements in SPRI RP-4 for System 1 **OR** System 2 **OR** System 3, **as directed**.
2. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.
3. Accurately align membrane roofing, without stretching, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
4. Mechanically fasten or adhere perimeter of membrane roofing according to requirements in SPRI RP-4.
OR
Mechanically fasten **OR** adhere, **as directed**, membrane roofing at corners, perimeters, and transitions according to requirements in SPRI RP-4.
 - a. At corners and perimeters, omit aggregate ballast leaving membrane roofing exposed.
OR
At corners and perimeters, adhere a second layer of membrane roofing.
5. Apply membrane roofing with side laps shingled with slope of deck where possible.
6. Seams: Clean seam areas, overlap membrane roofing, and hot-air weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation.
 - a. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
 - b. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
 - c. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.
7. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.
8. Install membrane roofing and auxiliary materials to tie in to existing roofing.
9. Install protection mat over membrane roofing, overlapping a minimum of 6 inches (150 mm). Install an additional protection mat layer at projections, pipes, vents, and drains, overlapping a minimum of 12 inches (300 mm).



10. Aggregate Ballast: Apply uniformly over membrane roofing at the rate required by membrane roofing system manufacturer, but not less than the following, spreading with care to minimize possibility of damage to membrane roofing system. Lay ballast as membrane roofing is installed, leaving membrane roofing ballasted at the end of the workday.
- a. Ballast Weight: Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m).
OR
 Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m), at corners and perimeter; Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m), elsewhere.
OR
 Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m).
11. Roof-Paver Ballast: Install lightweight **OR** heavyweight, **as directed**, roof-paver ballast according to manufacturer's written instructions.
- OR**
- Roof-Paver and Aggregate Ballast: Install heavyweight roof pavers according to manufacturer's written instructions on roof corners and perimeter.
- a. Install Size 4 aggregate ballast elsewhere on roofing at a minimum rate of 10 lb/sq. ft. (50 kg/sq. m).
OR
 Install Size 2 aggregate ballast elsewhere on roofing at a minimum rate of 13 lb/sq. ft. (65 kg/sq. m).
- H. Base Flashing Installation
1. Install sheet flashings and preformed flashing accessories and adhere to substrates according to membrane roofing system manufacturer's written instructions.
 2. Apply bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply to seam area of flashing.
 3. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.
 4. Clean seam areas, overlap, and firmly roll sheet flashings into the adhesive. Hot-air weld side and end laps to ensure a watertight seam installation.
 5. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars, **as directed**.
- I. Walkway Installation
1. Flexible Walkways: Install walkway products in locations indicated. Heat weld to substrate or adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.
 2. Roof-Paver Walkways: Install walkway roof pavers according to manufacturer's written instructions in locations indicated, to form walkways. Leave 3 inches (75 mm) of space between adjacent roof pavers.
- J. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 2. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.
 3. Repair or remove and replace components of membrane roofing system where inspections indicate that they do not comply with specified requirements.
 4. Additional inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- K. Protecting And Cleaning
1. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to the Owner.



2. Correct deficiencies in or remove membrane roofing system that does not comply with requirements; repair substrates; and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of Final Completion and according to warranty requirements.
3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 54 23 00



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Task	Specification	Specification Description
07 54 23 00	07 05 13 00d	Preparation for Re-Roofing



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**SECTION 07 56 00 00 - COATED FOAMED ROOFING**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for coated foamed roofing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Spray-applied, polyurethane foam insulation.
 - b. Elastomeric roof coatings.
 - c. Mineral granules.
 - d. Aggregate.
 - e. Walkways.

C. Performance Requirements

1. Watertightness: Provide coated foamed roofing that is watertight and will not permit the passage of water.
2. Material Compatibility: Provide polyurethane foam, elastomeric coatings, and miscellaneous roofing materials that are compatible with one another and able to bond to substrate under conditions of service and application required, as demonstrated by coated foamed roofing manufacturer based on testing and field experience.
3. Roofing System Design: Provide a coated foamed roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to SEI/ASCE 7.
4. FMG Listing: Provide roofing system and component materials that comply with requirements in FMG 4450 for steel roof decks and FMG 4470 for roof covers as part of a foamed roofing system and that are listed in FMG's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FMG markings.
 - a. Fire/Windstorm Classification: Class 1A-60 **OR 75 OR 90 OR 105 OR 120, as directed.**
 - b. Hail-Resistance Classification: MH **OR SH, as directed.**
5. Energy Performance: Provide roofing system with Solar Reflectance Index not less than 78 **OR 29, as directed**, when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Test Reports for Credit SS 7.2: For roof materials, documentation indicating that roof materials comply with Solar Reflectance Index requirement.
3. Samples: For each exposed product and for each color and texture specified.
4. Research/evaluation reports.
5. Maintenance data.
6. Warranty: Sample of special warranty.
7. Warranty: Sample of special warranty.

E. Quality Assurance

1. Installer Qualifications: A qualified installer who is approved, authorized, or licensed by roof coating manufacturer for installation of manufacturer's product over polyurethane foam.



- a. Engage an installer who participates in and who has fulfilled requirements of the SPFA Accreditation Program for company accreditation and individual applicator accreditation for personnel assigned to work on Project.
2. Source Limitations: Obtain polyurethane foam materials from single source or producer and coating products from single, coated foamed roofing manufacturer.
3. Fire-Test-Response Characteristics: Provide coated foamed roofing systems with the fire-test-response characteristics indicated, as determined by testing identical systems per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
 - a. Surface-Burning Characteristics: Maximum flame-spread and smoke-developed indexes of 75 and 450, respectively; ASTM E 84.
 - b. Exterior Fire-Test Exposure: ASTM E 108; Class A.
 - c. Fire-Resistance Ratings: ASTM E 119, determined for coated polyurethane foam roofing as part of a roof assembly.
4. Comply with recommendations in NRCA's "Quality Control Guidelines for the Application of Spray Polyurethane Foam Roofing."
5. Comply with recommendations in SPFA AY 104, "Spray Polyurethane Foam Systems for New and Remedial Roofing."
6. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Deliver materials to Project site in original containers with seals unbroken, labeled with manufacturer's name, product brand name and type, date of manufacture, shelf life, and directions for storing and mixing with other components.
2. Store materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by manufacturer. Protect stored materials from direct sunlight.
3. Remove and replace material that cannot be applied within its stated shelf life.

G. Warranty

1. Special Warranty: Coated foamed roofing manufacturer's standard form in which manufacturer agrees to repair or replace coated foamed roofing that does not comply with requirements or that does not remain watertight within five **OR 10, as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Polyurethane Foam

1. Polyurethane Foam: Rigid cellular polyurethane, spray applied, produced by the catalyzed chemical reaction of polyisocyanates with polyhydroxyls, with stabilizers, fire retardants, and blowing agents added; and complying with ASTM C 1029, Type III, as certified by a qualified independent testing agency.
 - a. In-Place Density: 2.8 to 3.0 lb/cu. ft. (44.9 to 48.1 kg/cu. m); ASTM D 1622.
 - b. Surface-Burning Characteristic: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1) Flame-Spread Index: 75 or less.

B. Urethane Coatings

1. Urethane Coatings: Liquid urethane elastomeric coating system, specifically formulated for coating spray polyurethane roofing, of the following composition, coat type, and topcoat color and complying with specified performance and physical requirements.
 - a. Base-Coat Composition and Type: One-component **OR** Two-component, **as directed**, aromatic urethane.



- b. Topcoat Composition and Type: One-component **OR** Two-component, **as directed**, aromatic **OR** aliphatic, **as directed**, urethane.
 - c. Topcoat Color: White **OR** Gray **OR** Tan **OR** Copper **OR** Black, **as directed**.
 - d. Topcoat Color at Walkways: White **OR** Gray **OR** Tan **OR** Copper **OR** Black, **as directed**.
 - e. Tensile Strength: 400 psi (2.8 MPa) per ASTM D 412.
 - f. Elongation: 300 percent at 75 deg F (24 deg C) per ASTM D 412.
 - g. Permanent Set at Break: 30 percent maximum per ASTM D 412.
 - h. Tear Resistance: 100 lbf/inch (17.5 kN/m) per ASTM D 1004.
 - i. Water Absorption: 3 percent maximum by weight, 168 hours at 75 deg F (24 deg C) per ASTM D 471.
 - j. Permeance:
 - 1) Minimum 0.7 perms (40.2 ng/Pa x s x sq. m) at 20 mils (0.5 mm) thick per ASTM E 96.
OR
Minimum 5.0 perms (286 ng/Pa x s x sq. m) at 20 mils (0.5 mm) thick per ASTM E 96.
- C. Silicone Coatings
- 1. Silicone Coatings: Liquid silicone elastomeric coating system, complying with ASTM D 6694 and specifically formulated for coating spray polyurethane roofing.
 - a. Base-Coat and Topcoat Composition: One-component **OR** Two-component, **as directed**, silicone.
 - b. Topcoat Color: White **OR** Gray, **as directed**.
 - c. Topcoat Color at Walkways: White **OR** Gray, **as directed**.
 - d. Permeance: Minimum 5.0 perms (286 ng/Pa x s x sq. m) at 20 mils (0.5 mm) thick per ASTM E 96.
- D. Acrylic Coatings
- 1. Acrylic Coatings: Liquid acrylic elastomeric emulsion coating system, complying with ASTM D 6083 and specifically formulated for coating spray polyurethane roofing.
 - a. Topcoat Color: White **OR** Gray **OR** Buff, **as directed**.
 - b. Topcoat Color at Walkways: White **OR** Gray **OR** Buff, **as directed**.
 - c. Permeance: Minimum 5.0 perms (286 ng/Pa x s x sq. m) at 20 mils (0.5 mm) thick per ASTM E 96.
- E. Substrate Board
- 1. Thermal Barrier:
 - a. Glass-mat, water-resistant gypsum board, ASTM C 1177/C 1177M, 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 5/8 inch (16 mm), Type X, **as directed**.
 - b. ASTM C 36/C 36M, 5/8-inch (16-mm) gypsum board base, Type X.
 - 2. Recovery Board and Fasteners: As recommended by polyurethane foam manufacturer, and meeting the requirements of Division 07 Section "Preparation For Re-roofing".
 - 3. Thermal-Barrier Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FMG 4470, and designed and sized for fastening thermal barrier to substrate.
- F. Auxiliary Materials
- 1. Primer: Polyurethane foam manufacturer's standard factory-formulated primer.
 - 2. Vapor Retarder: Fluid applied **OR** Bituminous membrane **OR** As recommended by coated foamed roofing manufacturer, **as directed**.
 - 3. Mineral Granules: Ceramic-coated roofing granules, No. 11 screen size with 100 percent passing No. 8 (2.36-mm) sieve and 98 percent of mass retained by No. 40 (0.42-mm) sieve.
 - a. Color: Buff white **OR** Gray **OR** Green **OR** Red, **as directed**.
 - 4. Aggregate: Coarse mineral aggregate, 3/4 inch (19 mm) maximum, ASTM D 1863, No. 7 or No. 67 gradation.



5. Reinforcement: Flexible polyester or fiberglass mat of weight, type, and composition recommended by roof coating manufacturer for embedment in liquid coating.
6. Walkway Pads: Factory formed of nonwoven PVC strands, porous, UV stabilized, of 5/16-inch (8-mm) nominal thickness, and approved by roof coating manufacturer. Provide pad sizes indicated.
 - a. Color: Yellow **OR** Gray **OR** Blue **OR** Orange **OR** Green, **as directed**.
7. Sealant: ASTM C 920, Class 25, Use NT, Grade NS, Type M, multicomponent urethane **OR** Type S, one-component, neutral- or acid-curing silicone, **as directed**, and as recommended by coated foamed roofing manufacturer for substrate and joint conditions and for compatibility with roofing materials.
8. Sheet Flashing and Accessories: Types recommended by coated foamed roofing manufacturer, provided at locations indicated and as recommended by coated foamed roofing manufacturer.

1.3 EXECUTION

A. Substrate Board

1. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
 - a. Fasten thermal barrier to top flanges of steel deck according to recommendations in FMG's "Approval Guide" for specified Windstorm Resistance Classification.
 - b. Fasten thermal barrier to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to coated foamed roofing manufacturer's written instructions.
 - c. Install recovery board according to coated foamed roofing manufacturer's written instructions and the requirements of Division 07 Section "Preparation For Re-roofing". Fasten through existing roofing to roof structure as indicated. Space fasteners for wind-uplift conditions at Project site **OR** as indicated, **as directed**.

B. Surface Preparation

1. Clean and prepare substrate according to coated foamed roofing manufacturer's written instructions. Provide clean, dust-free, dew-free, and dry substrate for coated foamed roofing application.
2. Remove grease, oil, form-release agents, curing compounds, and other contaminants from substrate.
3. Prepare substrate for recovering according to Division 07 Section "Preparation For Re-roofing" and to coated foamed roofing manufacturer's written instructions.
4. Cover and mask adjoining surfaces not receiving coated foamed roofing to prevent overspray or spillage affecting other construction. Close off roof drains, removing roof-drain plugs when no work is being done or when rain is forecast.
 - a. Remove masking after polyurethane foam application and remask adjoining substrates before coating.
5. Prime substrate if recommended by coated foamed roofing manufacturer.
6. Fill, cover, or tape joints and cracks in substrate that exceed a width of 1/4 inch (6 mm). Remove dust and dirt from joints and cracks before applying polyurethane foam.
7. Install vapor retarder according to coated foamed roofing manufacturer's written instructions.

C. Polyurethane Foam Application

1. General: Mix and apply polyurethane foam according to ASTM D 5469 and coated foamed roofing manufacturer's written instructions.
 - a. Fill irregularities and areas of ponding.
 - b. Apply the required full thickness of polyurethane foam in any specific area on same day.
 - c. Apply only the area of polyurethane foam that can be covered on same day with required base coating.
 - d. Apply polyurethane foam to avoid overspray beyond immediate area of work.



2. Apply polyurethane foam in lift thicknesses not less than 1/2 inch (13 mm) and not more than 1-1/2 inches (38 mm).
3. Uniformly apply total thickness of polyurethane foam indicated, but not less than 1 inch (25 mm), to a surface tolerance of plus 1/4 inch (6 mm) and no minus.
4. Apply polyurethane foam to roof penetrations, terminations, and vertical surfaces as indicated. Unless otherwise indicated, extend polyurethane foam at least 4 inches (100 mm) above elevation of adjacent roof field.
5. Surface Finish: Provide finished surface of polyurethane foam within the following range of surface textures as defined by ASTM D 5469:
 - a. Texture: Smooth to orange peel **OR** coarse orange peel **OR** rippling verge of popcorn, **as directed**.
6. Remove and replace polyurethane foam not complying with minimum surface-texture limitations. Remove defective thickness and prepare and reapply polyurethane foam with acceptable, uniform results.

D. Coating Application

1. Allow polyurethane foam substrate to cure for a minimum of two hours and remove dust, dirt, water, and other contaminants before applying coating.
2. Apply coating system to polyurethane foam, in two or more coats and according to roof coating manufacturer's written instructions, by spray, roller, or other suitable application method.
3. Apply base coat and one or more topcoats to obtain a uniform, seamless membrane free of blisters and pinholes. Apply each coat at right angles to preceding coat, using contrasting colors for successive coats.
 - a. Apply base coat on same day as polyurethane foam is applied and allow it to cure.
 - b. Apply topcoat(s) after removing dust, dirt, water, and other contaminants from base coat.
 - c. Urethane Coating: Apply base coat and topcoat to a minimum dry film thickness recommend by coated foamed roofing manufacturer **OR** of 25 mils (0.64 mm) **OR** of 30 mils (0.76 mm) **OR** of 35 mils (0.89 mm), **as directed**.
 - d. Silicone Coating: Apply base coat and topcoat to a minimum dry film thickness recommend by coated foamed roofing manufacturer **OR** of 20 mils (0.50 mm) **OR** of 22 mils (0.56 mm) **OR** of 26 mils (0.66 mm) **OR** of 30 mils (0.76 mm), **as directed**.
 - e. Acrylic Coating: Apply base coat and topcoat to a minimum dry film thickness recommend by coated foamed roofing manufacturer **OR** of 25 mils (0.64 mm) **OR** of 28 mils (0.71 mm) **OR** of 32 mils (0.81 mm), **as directed**.
4. Apply coating system at wall terminations and vertical surfaces to extend beyond polyurethane foam by 4 inches (100 mm), minimum.
5. Mineral Granules: Apply mineral granules over wet topcoat using pressure equipment at the rate of 0.5 lb/sq. ft. (2.45 kg/sq. m). Remove excess granules after topcoat has cured.
6. Sealant: Apply sealant to perimeter and other terminations where indicated or required by coated foamed roofing manufacturer.
7. Walkways: Install roof walkways in pattern and locations indicated. Mask off completed roof coating adjacent to walkways and apply one or two additional topcoats to achieve a minimum dry film thickness recommended by coated foamed roofing manufacturer. Spread mineral granules uniformly at a rate of 0.5 lb/sq. ft. (2.45 kg/sq. m) into final wet coating. Remove masking and excess granules after topcoat has cured.
8. Walkways: Install roof walkways in pattern and locations indicated. Mask off completed roof coating adjacent to walkways and apply one additional topcoat to achieve a minimum dry film thickness recommended by coated foamed roofing manufacturer. Lay reinforcing fabric into wet coating and apply another topcoat, completely filling fabric. Spread mineral granules uniformly at a rate of 0.5 lb/sq. ft. (2.45 kg/sq. m) into final wet coating. Remove masking and excess granules after topcoat has cured.
9. Walkways: Install walkway pads in pattern and locations indicated. Adhere walkway pads to substrate with compatible adhesive according to coated foamed roofing manufacturer's written instructions.
10. Aggregate: Apply aggregate uniformly over coated polyurethane foam at coated foamed roofing manufacturer's recommended rate, but not less than 6 lb/sq. ft. (29 kg/sq. m) and a minimum



thickness of 3/4 inch (19 mm). Spread with care to prevent puncturing coating and to minimize damage to substrate foam.

- E. Field Quality Control
 - 1. Correct deficiencies in, or remove, foam or coatings that do not comply with requirements; fill and repair substrates and reapply materials.
 - 2. Additional testing, at Contractor's expense, will be performed to determine compliance of corrected Work with requirements.
 - 3. Refill cores, repair slits, and recoat test areas.
- F. Repair And Recoating
 - 1. Repair and recoat coated foamed roofing according to ASTM D 6705 and coated foamed roofing manufacturer's written instructions.
- G. Curing, Protecting, And Cleaning
 - 1. Cure coatings according to coated foamed roofing manufacturer's written instructions, taking care to prevent contamination and damage during application stages and curing. Do not permit traffic on uncured coatings.
 - 2. Protect coated foamed roofing from damage and wear during remainder of construction period.
 - 3. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 56 00 00



Task	Specification	Specification Description
07 56 00 00	07 51 13 00	Built-Up Asphalt Roofing
07 56 00 00	07 05 13 00	Built-Up Coal-Tar Roofing
07 56 00 00	07 53 16 00	EPDM Membrane Roofing
07 58 00 00	07 51 13 00	Built-Up Asphalt Roofing



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**SECTION 07 62 00 00 - SHEET METAL FLASHING AND TRIM**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for sheet metal flashing and trim. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:

a. Manufactured Products:

- 1) Manufactured through-wall flashing and counterflashing.
- 2) Manufactured reglets and counterflashing.

b. Formed Products:

- 1) Formed roof drainage sheet metal fabrications.
- 2) Formed low-slope roof sheet metal fabrications.
- 3) Formed steep-slope roof sheet metal fabrications.
- 4) Formed wall sheet metal fabrications.
- 5) Formed equipment support flashing.
- 6) Formed overhead-piping safety pans.

C. Performance Requirements

1. General: Sheet metal flashing and trim assemblies as indicated shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.
2. Fabricate and install roof edge flashing and copings capable of resisting the following forces according to recommendations in FMG Loss Prevention Data Sheet 1-49:
 - a. Wind Zone 1: For velocity pressures of 10 to 20 lbf/sq. ft. (0.48 to 0.96 kPa): 40-lbf/sq. ft. (1.92-kPa) perimeter uplift force, 60-lbf/sq. ft. (2.87-kPa) corner uplift force, and 20-lbf/sq. ft. (0.96-kPa) outward force.
 - b. Wind Zone 1: For velocity pressures of 21 to 30 lbf/sq. ft. (1.00 to 1.44 kPa): 60-lbf/sq. ft. (2.87-kPa) perimeter uplift force, 90-lbf/sq. ft. (4.31-kPa) corner uplift force, and 30-lbf/sq. ft. (1.44-kPa) outward force.
 - c. Wind Zone 2: For velocity pressures of 31 to 45 lbf/sq. ft. (1.48 to 2.15 kPa): 90-lbf/sq. ft. (4.31-kPa) perimeter uplift force, 120-lbf/sq. ft. (5.74-kPa) corner uplift force, and 45-lbf/sq. ft. (2.15-kPa) outward force.
 - d. Wind Zone 3: For velocity pressures of 46 to 104 lbf/sq. ft. (2.20 to 4.98 kPa): 208-lbf/sq. ft. (9.96-kPa) perimeter uplift force, 312-lbf/sq. ft. (14.94-kPa) corner uplift force, and 104-lbf/sq. ft. (4.98-kPa) outward force.
3. Thermal Movements: Provide sheet metal flashing and trim that allows for thermal movements from ambient and surface temperature changes.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show installation layouts of sheet metal flashing and trim, including plans, elevations, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled work.



- a. Include details for forming, joining, supporting, and securing sheet metal flashing and trim, including pattern of seams, termination points, fixed points, expansion joints, expansion-joint covers, edge conditions, special conditions, and connections to adjoining work.
3. Samples: For each exposed product and for each finish specified.
4. Maintenance data.
5. Warranty: Sample of special warranty.

E. Quality Assurance

1. Sheet Metal Flashing and Trim Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" unless more stringent requirements are specified or shown on Drawings.
2. Copper Sheet Metal Standard: Comply with CDA's "Copper in Architecture Handbook." Conform to dimensions and profiles shown unless more stringent requirements are indicated.
3. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 - a. Build mockup of typical roof eave, including built-in gutter, fascia, fascia trim, and apron flashing, approximately 10 feet (3.0 m) long, including supporting construction cleats, seams, attachments, underlayment, and accessories.
4. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage. Store sheet metal flashing and trim materials away from uncured concrete and masonry.
2. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to the extent necessary for the period of sheet metal flashing and trim installation.

G. Warranty

1. Special Warranty on Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within 20 **OR** 10, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Sheet Metals

1. General: Protect mechanical and other finishes on exposed surfaces from damage by applying a strippable, temporary protective film before shipping.
2. Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 or H01 temper.
 - a. Non-Patinated Exposed Finish: Mill.
 - b. Non-Patinated, Exposed, Lacquered Finish: Finish designations for copper alloys comply with the system defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
 - 1) Brushed Satin (Lacquered): M32-06x (Mechanical Finish: directionally textured, medium satin; with clear organic coating); coating of "Incralac," waterborne **OR** solvent-borne, **as directed**, methyl methacrylate copolymer lacquer with UV inhibitor, applied by air spray in two coats per manufacturer's written instructions to a total thickness of 1 mil (0.025 mm).
 - 2) Mirror Polished (Lacquered): M22-06x (Mechanical Finish: buffed, specular; with clear organic coating); coating of "Incralac," waterborne **OR** solvent-borne, **as directed**, air-drying, methyl methacrylate copolymer lacquer with UV inhibitor, applied by air spray in two coats per manufacturer's written instructions to a total thickness of 1 mil (0.025 mm).
 - c. Pre-Patinated Copper-Sheet Finish: Dark brown **OR** Verdigris, **as directed**, pre-patinated according to ASTM B 882.



3. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer for finish required, with temper as required to suit forming operations and performance required.
 - a. As-Milled Finish: Mill **OR** One-side bright mill **OR** Standard one-side bright **OR** Standard two-side bright, **as directed**, finish.
 - b. Alclad Finish: Metallurgically bonded surfacing to both sides, forming a composite aluminum sheet with reflective luster.
 - c. Surface: Smooth, flat **OR** Embossed, **as directed**.
 - d. Factory Prime Coating: Where painting after installation is indicated, pretreat with white or light-colored, factory-applied, baked-on epoxy primer coat; minimum dry film thickness of 0.2 mil (0.005 mm).
 - e. Clear Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.
 - f. Color Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm or thicker.
 - 1) Color: Champagne **OR** Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black, **as directed**.
 - 2) Color Range: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
 - g. Exposed Coil-Coated Finishes:
 - 1) Two-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat.
 - 2) Three-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat.
 - 3) Four-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats.
 - 4) Mica Fluoropolymer: AAMA 620. Two-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat.
 - 5) Metallic Fluoropolymer: AAMA 620. Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat.
 - 6) FEVE Fluoropolymer: AAMA 620. Two-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat.
 - 7) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mils (0.97 mm) for topcoat.
 - h. Color: As selected from manufacturer's full range.
 - i. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
4. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304, dead soft, fully annealed.
 - a. Finish: 2D (dull, cold rolled) **OR** 2B (bright, cold rolled) **OR** 3 (coarse, polished directional satin) **OR** 4 (polished directional satin), **as directed**.
 - b. Surface: Smooth, flat **OR** Embossed, **as directed**.
5. Zinc-Tin Alloy-Coated Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304, dead-soft, fully annealed stainless-steel sheet of minimum uncoated thickness indicated; coated on both sides with a zinc-tin alloy (50 percent zinc, 50 percent tin), with factory-applied gray preweathering.
6. Zinc-Tin Alloy-Coated Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 temper, of minimum uncoated weight (thickness) indicated; coated on both sides with a zinc-tin alloy (50 percent zinc, 50 percent tin).
7. Metallic-Coated Steel Sheet: Restricted flatness steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.



- a. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - b. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - c. Surface: Smooth, flat **OR** Embossed, **as directed**, and mill phosphatized for field painting **OR** and with manufacturer's standard clear acrylic coating on both sides, **as directed**.
 - d. Exposed Coil-Coated Finish:
 - 1) Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat.
 - 2) Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat.
 - 3) Four-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat and clear coats.
 - 4) Mica Fluoropolymer: AAMA 621. Two-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat.
 - 5) Metallic Fluoropolymer: AAMA 621. Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat.
 - 6) FEVE Fluoropolymer: AAMA 621. Two-coat fluoropolymer finish containing 100 percent fluorinated ethylene vinyl ether resin in color coat.
 - 7) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - 8) Plastisol: Epoxy primer and vinyl plastisol topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 3.8 mils (0.97 mm) for topcoat.
 - e. Color: As selected from manufacturer's full range.
 - f. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
8. Zinc Sheet: Zinc, 99 percent pure, alloyed with a maximum of 1 percent copper and titanium; with manufacturer's standard factory-applied, flexible, protective back coating.
- a. Finish: Bright rolled **OR** Preweathered gray **OR** Preweathered black, **as directed**.

B. Underlayment Materials

1. Polyethylene Sheet: 6-mil- (0.15-mm-) thick polyethylene sheet complying with ASTM D 4397.
2. Felt: ASTM D 226, Type II (No. 30), asphalt-saturated organic felt, nonperforated.
3. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils (0.76 to 1.0 mm) thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
 - a. Thermal Stability: ASTM D 1970; stable after testing at 240 deg F (116 deg C).
 - b. Low-Temperature Flexibility: ASTM D 1970; passes after testing at minus 20 deg F (29 deg C).
4. Slip Sheet: Building paper, 3-lb/100 sq. ft. (0.16-kg/sq. m) minimum, rosin sized.

C. Miscellaneous Materials

1. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.
2. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.
 - a. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.



- 1) Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating.
 - 2) Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.
 - 3) Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.
 - b. Fasteners for Copper **OR** Zinc-Tin Alloy-Coated Copper, **as directed**, Sheet: Copper, hardware bronze or Series 300 stainless steel.
 - c. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
 - d. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.
 - e. Fasteners for Zinc-Tin Alloy-Coated Stainless-Steel Sheet: Series 300 stainless steel.
 - f. Fasteners for Zinc-Coated (Galvanized) **OR** Aluminum-Zinc Alloy-Coated, **as directed**, Steel Sheet: Hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329 or Series 300 stainless steel.
 - g. Fasteners for Zinc Sheet: Hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329 or Series 300 stainless steel.
 3. Solder:
 - a. For Copper: ASTM B 32, Grade Sn50, 50 percent tin and 50 percent lead.
 - b. For Stainless Steel: ASTM B 32, Grade Sn60, with an acid flux of type recommended by stainless-steel sheet manufacturer.
 - c. For Zinc-Tin Alloy-Coated Stainless Steel **OR** Copper, **as directed**: ASTM B 32, 100 percent tin.
 - d. For Zinc-Coated (Galvanized) Steel: ASTM B 32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead.
 - e. For Zinc: ASTM B 32, 40 percent tin and 60 percent lead with low antimony, as recommended by manufacturer.
 4. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
 5. Elastomeric Sealant: ASTM C 920, elastomeric polyurethane **OR** polysulfide **OR** silicone, **as directed**, polymer sealant; low modulus; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.
 6. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.
 7. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.
 8. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.
 9. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required for application.
- D. Manufactured Sheet Metal Flashing And Trim
1. Through-Wall Ribbed Sheet Metal Flashing: Manufacture through-wall sheet metal flashing for embedment in masonry with ribs at 3-inch (75-mm) intervals along length of flashing to provide an integral mortar bond. Manufacture through-wall flashing with snaplock receiver on exterior face to receive counterflashing **OR** interlocking counterflashing on exterior face, of same metal as reglet, **as directed**.
 - a. Copper: 10 oz. (0.34 mm thick) minimum for fully concealed flashing; 16 oz. (0.55 mm thick) elsewhere.
 - b. Stainless Steel: 0.016 inch (0.40 mm) thick.
 2. Reglets: Units of type, material, and profile indicated, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory-mitered and -welded corners and junctions **OR** with interlocking counterflashing on exterior face, of same metal as reglet, **as directed**.
 - a. Material: Stainless steel, 0.019 inch (0.48 mm) thick **OR** Copper, 16 oz./sq. ft. (0.55 mm thick) **OR** Aluminum, 0.024 inch (0.61 mm) thick **OR** Galvanized steel, 0.022 inch (0.56 mm) thick, **as directed**.



- b. Surface-Mounted Type: Provide with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.
- c. Stucco Type: Provide with upturned fastening flange and extension leg of length to match thickness of applied finish materials.
- d. Concrete Type: Provide temporary closure tape to keep reglet free of concrete materials, special fasteners for attaching reglet to concrete forms, and guides to ensure alignment of reglet section ends.
- e. Masonry Type: Provide with offset top flange for embedment in masonry mortar joint.
- f. Accessories:
 - 1) Flexible-Flashing Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counterflashing or where Drawings show reglet without metal counterflashing.
 - 2) Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing lower edge.
- g. Finish: Mill **OR** With manufacturer's standard color coating, **as directed**.

E. Fabrication, General

1. General: Custom fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, geometry, metal thickness, and other characteristics of item indicated. Fabricate items at the shop to greatest extent possible.
 - a. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
 - b. Obtain field measurements for accurate fit before shop fabrication.
 - c. Form sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.
 - d. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces exposed to view.
2. Fabrication Tolerances:
 - a. Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.
OR
Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."
3. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant.
4. Expansion Provisions: Where lapped expansion provisions cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with butyl sealant concealed within joints.
5. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.
6. Fabricate cleats and attachment devices of sizes as recommended by SMACNA's "Architectural Sheet Metal Manual" and by FMG Loss Prevention Data Sheet 1-49, **as directed**, for application, but not less than thickness of metal being secured.
7. Seams:
 - a. Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.
OR
Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength.
8. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints where necessary for strength.



9. Do not use graphite pencils to mark metal surfaces.

F. Roof Drainage Sheet Metal Fabrications

1. Hanging Gutters: Fabricate to cross section indicated, complete with end pieces, outlet tubes, and other accessories as required. Fabricate in minimum 96-inch- (2400-mm-) long sections. Furnish flat-stock gutter spacers and gutter brackets fabricated from same metal as gutters, of size recommended by SMACNA but not less than twice the gutter thickness. Fabricate expansion joints, expansion-joint covers, gutter bead reinforcing bars, and gutter accessories from same metal as gutters.
 - a. Gutter Style: SMACNA designation A **OR B OR C OR D OR E OR F OR G OR H OR I OR J OR K OR L, as directed.**
 - b. Expansion Joints: Lap type **OR** Butt type **OR** Butt type with cover plate **OR** Built in, **as directed.**
 - c. Accessories: Continuous removable leaf screen with sheet metal frame and hardware cloth screen **OR** Wire ball downspout strainer **OR** Valley baffles, **as directed.**
 - d. Gutters with Girth up to 15 Inches (380 mm): Fabricate from the following materials:
 - 1) Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 2) Aluminum: 0.032 inch (0.81 mm) thick.
 - 3) Stainless Steel: 0.016 inch (0.40 mm) thick.
 - 4) Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - 5) Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 6) Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - 7) Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - 8) Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 - e. Gutters with Girth 16 to 20 Inches (410 to 510 mm): Fabricate from the following materials:
 - 1) Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 2) Aluminum: 0.040 inch (1.02 mm) thick.
 - 3) Stainless Steel: 0.019 inch (0.48 mm) thick.
 - 4) Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - 5) Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 6) Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - 7) Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - 8) Zinc: 0.039 inch (1.00 mm) **OR** 0.048 inch (1.25 mm), **as directed**, thick.
 - f. Gutters with Girth 21 to 25 Inches (530 to 640 mm): Fabricate from the following materials:
 - 1) Copper: 20 oz./sq. ft. (0.68 mm thick).
 - 2) Aluminum: 0.050 inch (1.27 mm) thick.
 - 3) Stainless Steel: 0.025 inch (0.64 mm) thick.
 - 4) Zinc-Tin Alloy-Coated Stainless Steel: 0.024 inch (0.61 mm) thick.
 - 5) Zinc-Tin Alloy-Coated Copper: 20 oz./sq. ft. (0.68 mm thick).
 - 6) Galvanized Steel: 0.034 inch (0.86 mm) thick.
 - 7) Aluminum-Zinc Alloy-Coated Steel: 0.034 inch (0.86 mm) thick.
 - 8) Zinc: 0.048 inch (1.25 mm) **OR** 0.059 inch (1.50 mm), **as directed**, thick.
 - g. Gutters with Girth 26 to 30 Inches (660 to 760 mm): Fabricate from the following materials:
 - 1) Copper: 24 oz./sq. ft. (0.82 mm thick).
 - 2) Aluminum: 0.063 inch (1.60 mm) thick.
 - 3) Stainless Steel: 0.031 inch (0.79 mm) thick.
 - 4) Zinc-Tin Alloy-Coated Copper: 24 oz./sq. ft. (0.82 mm thick).
 - 5) Galvanized Steel: 0.040 inch (1.02 mm) thick.
 - 6) Aluminum-Zinc Alloy-Coated Steel: 0.040 inch (1.02 mm) thick.
 - h. Gutters with Girth 31 to 35 Inches (790 to 890 mm): Fabricate from the following materials:
 - 1) Copper: 24 oz./sq. ft. (0.82 mm thick).
 - 2) Stainless Steel: 0.038 inch (0.95 mm) thick.
 - 3) Zinc-Tin Alloy-Coated Copper: 25 oz./sq. ft. (0.87 mm thick).
 - 4) Galvanized Steel: 0.052 inch (1.32 mm) thick.
 - 5) Aluminum-Zinc Alloy-Coated Steel: 0.052 inch (1.32 mm) thick.



2. Built-in Gutters: Fabricate to cross section indicated, with riveted and soldered joints, complete with end pieces, outlet tubes, and other special accessories as required. Fabricate in minimum 96-inch- (2400-mm-) long sections. Fabricate expansion joints and accessories from same metal as gutters unless otherwise indicated.
 - a. Fabricate gutters with built-in expansion joints and gutter-end expansion joints at walls.
 - b. Accessories: Continuous removable leaf screen with sheet metal frame and hardware cloth screen **OR** Bronze wire ball downspout strainer **OR** Wire ball downspout strainer, **as directed**.
 - c. Fabricate from the following materials:
 - 1) Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 2) Stainless Steel: 0.016 inch (0.40 mm) thick.
 - 3) Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - 4) Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 5) Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
3. Downspouts: Fabricate round **OR** rectangular **OR** open-face, **as directed**, downspouts complete with mitered elbows. Furnish with metal hangers, from same material as downspouts, and anchors.
 - a. Fabricated Hanger Style: SMACNA figure designation 1-35A **OR** 1-35B **OR** 1-35C **OR** 1-35D **OR** 1-35E **OR** 1-35F **OR** 1-35G **OR** 1-35H **OR** 1-35I **OR** 1-35J, **as directed**.
 - b. Manufactured Hanger Style: SMACNA figure designation 1-34A **OR** 1-34B **OR** 1-34C **OR** 1-34D **OR** 1-34E, **as directed**.
 - c. Hanger Style: **<Insert description>**.
 - d. Fabricate from the following materials:
 - 1) Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 2) Aluminum: 0.024 inch (0.61 mm) thick.
 - 3) Stainless Steel: 0.016 inch (0.40 mm) thick.
 - 4) Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - 5) Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 6) Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - 7) Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - 8) Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
4. Parapet Scuppers: Fabricate scuppers of dimensions required with closure flange trim to exterior, 4-inch- (100-mm-) wide wall flanges to interior, and base extending 4 inches (100 mm) beyond cant or tapered strip into field of roof. Fasten gravel guard angles to base of scupper. Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
5. Conductor Heads: Fabricate conductor heads with flanged back and stiffened top edge and of dimensions and shape indicated complete with outlet tubes, exterior flange trim, and built-in overflows. Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.016 inch (0.40 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
6. Splash Pans: Fabricate from the following materials:



- a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.040 inch (1.02 mm) thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
- G. Low-Slope Roof Sheet Metal Fabrications
1. Roof-Edge Flashing (Gravel Stop) and Fascia Cap: Fabricate in minimum 96-inch- (2400-mm-) long, but not exceeding 10-foot- (3-m-) long, sections. Furnish with 6-inch- (150-mm-) wide, joint cover plates.
 - a. Joint Style: Lap, 4 inches (100 mm) wide **OR** Butt, with 12-inch- (300-mm-) wide, concealed backup plate **OR** Butt, with 6-inch- (150-mm-) wide, exposed cover plates **OR** Butt, with 12-inch- (300-mm-) wide, concealed backup plate and 6-inch- (150-mm-) wide, exposed cover plates, **as directed**.
 - b. Fabricate with scuppers spaced 10 feet (3 m) apart, of dimensions required with 4-inch- (100-mm-) wide flanges and base extending 4 inches (100 mm) beyond cant or tapered strip into field of roof. Fasten gravel guard angles to base of scupper.
 - c. Fabricate from the following materials:
 - 1) Copper: 20 oz./sq. ft. (0.68 mm thick).
 - 2) Aluminum: 0.050 inch (1.27 mm) thick.
 - 3) Stainless Steel: 0.019 inch (0.48 mm) thick.
 - 4) Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - 5) Zinc-Tin Alloy-Coated Copper: 20 oz./sq. ft. (0.68 mm thick).
 - 6) Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - 7) Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - 8) Zinc: 0.048 inch (1.25 mm) **OR** 0.059 inch (1.50 mm), **as directed**, thick.
 2. Copings: Fabricate in minimum 96-inch- (2400-mm-) long, but not exceeding 10-foot- (3-m-) long, sections. Fabricate joint plates of same thickness as copings. Furnish with continuous cleats to support edge of external leg and drill elongated holes for fasteners on interior leg. Miter corners, seal, and solder or weld watertight.
 - a. Coping Profile: SMACNA figure designation 3-4A **OR** 3-4B **OR** 3-4C **OR** 3-4D **OR** 3-4E **OR** 3-4F **OR** 3-4G, **as directed**.
 - b. Joint Style: Butt, with 12-inch- (300-mm-) wide, concealed backup plate **OR** Butt, with 6-inch- (150-mm-) wide, exposed cover plates **OR** Butt, with 12-inch- (300-mm-) wide, concealed backup plate and 6-inch- (150-mm-) wide, exposed cover plates, **as directed**.
 - c. Fabricate from the following materials:
 - 1) Copper: 24 oz./sq. ft. (0.82 mm thick).
 - 2) Aluminum: 0.050 inch (1.27 mm) thick.
 - 3) Stainless Steel: 0.025 inch (0.64 mm) thick.
 - 4) Zinc-Tin Alloy-Coated Stainless Steel: 0.024 inch (0.61 mm) thick.
 - 5) Zinc-Tin Alloy-Coated Copper: 24 oz./sq. ft. (0.82 mm thick).
 - 6) Galvanized Steel: 0.040 inch (1.02 mm) thick.
 - 7) Aluminum-Zinc Alloy-Coated Steel: 0.040 inch (1.02 mm) thick.
 - 8) Zinc: 0.048 inch (1.25 mm) **OR** 0.059 inch (1.50 mm), **as directed**, thick.
 3. Roof and Roof to Wall Transition **OR** Roof to Roof Edge Flashing (Gravel Stop) Transition **OR** Roof to Roof Edge Flashing (Gravel Stop) and Fascia Cap Transition, **as directed**, Expansion-Joint Cover: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.050 inch (1.27 mm) thick.
 - c. Stainless Steel: 0.025 inch (0.64 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.024 inch (0.61 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick)>.
 - f. Galvanized Steel: 0.034 inch (0.86 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.034 inch (0.86 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.



4. Base Flashing: Fabricate from the following materials:
 - a. Copper: 20 oz./sq. ft. (0.68 mm thick)>.
 - b. Aluminum: 0.040 inch (1.02 mm) thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 20 oz./sq. ft. (0.68 mm thick)>.
 - f. Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 5. Counterflashing: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick)>.
 - f. Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 6. Flashing Receivers: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.016 inch (0.40 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 7. Roof-Penetration Flashing: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - c. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - d. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - e. Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - f. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - g. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 8. Roof-Drain Flashing: Fabricate from the following materials:
 - a. Copper: 12 oz./sq. ft. (0.41 mm thick).
 - b. Stainless Steel: 0.016 inch (0.40 mm) thick.
 - c. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
- H. Steep-Slope Roof Sheet Metal Fabrications
1. Apron, Step, Cricket, and Backer Flashing: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.016 inch (0.40 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 2. Valley Flashing: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - c. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - d. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).



- e. Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - f. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - g. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 3. Drip Edges: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.016 inch (0.40 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 4. Eave, Rake, Ridge, and Hip Flashing: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.016 inch (0.40 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 5. Counterflashing: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 6. Flashing Receivers: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.016 inch (0.40 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
 7. Roof-Penetration Flashing: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - c. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - d. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick)>.
 - e. Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - f. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - g. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
- I. Wall Sheet Metal Fabrications
1. Through-Wall Flashing: Fabricate continuous flashings in minimum 96-inch- (2400-mm-) long, but not exceeding 12-foot- (3.6-m-) long, sections, under copings, at shelf angles, and where indicated. Fabricate discontinuous lintel, sill, and similar flashings to extend 6 inches (150 mm) beyond each side of wall openings. Form with 2-inch- (50-mm-) high, end dams where flashing is discontinuous. Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Stainless Steel: 0.016 inch (0.40 mm) thick.



- c. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
- d. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
- e. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
- 2. Opening Flashings in Frame Construction: Fabricate head, sill, jamb, and similar flashings to extend 4 inches (100 mm) beyond wall openings. Form head and sill flashing with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.032 inch (0.81 mm) thick.
 - c. Stainless Steel: 0.016 inch (0.40 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.015 inch (0.38 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.022 inch (0.56 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.
- 3. Wall Expansion-Joint Cover: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Aluminum: 0.040 inch (1.02 mm) thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - d. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - e. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - f. Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - g. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
 - h. Zinc: 0.032 inch (0.80 mm) **OR** 0.039 inch (1.00 mm), **as directed**, thick.

J. Miscellaneous Sheet Metal Fabrications

- 1. Equipment Support Flashing: Fabricate from the following materials:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - c. Zinc-Tin Alloy-Coated Stainless Steel: 0.018 inch (0.46 mm) thick.
 - d. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. (0.55 mm thick).
 - e. Galvanized Steel: 0.028 inch (0.71 mm) thick.
 - f. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
- 2. Overhead-Piping Safety Pans: Fabricate from the following materials:
 - a. Copper: 24 oz./sq. ft. (0.82 mm thick).
 - b. Stainless Steel: 0.025 inch (0.64 mm) thick.
 - c. Zinc-Tin Alloy-Coated Stainless Steel: 0.024 inch (0.61 mm) thick.
 - d. Zinc-Tin Alloy-Coated Copper: 24 oz./sq. ft. (0.82 mm thick).
 - e. Galvanized Steel: 0.040 inch (1.02 mm) thick.
 - f. Aluminum-Zinc Alloy-Coated Steel: 0.040 inch (1.02 mm) thick.

1.3 EXECUTION

A. Underlayment Installation

- 1. General: Install underlayment as indicated on Drawings.
- 2. Polyethylene Sheet: Install polyethylene sheet with adhesive for anchorage to minimize use of mechanical fasteners under sheet metal flashing and trim. Apply in shingle fashion to shed water, with lapped and taped joints of not less than 2 inches (50 mm).
- 3. Felt Underlayment: Install felt underlayment with adhesive for temporary anchorage to minimize use of mechanical fasteners under sheet metal flashing and trim. Apply in shingle fashion to shed water, with lapped joints of not less than 2 inches (50 mm).
- 4. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free. Apply primer if required by underlayment manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation; use primer rather than nails for installing underlayment at low temperatures. Apply in shingle fashion to shed water, with end laps of not



less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps with roller. Cover underlayment within 14 days.

B. Installation, General

1. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
 - a. Install sheet metal flashing and trim true to line and levels indicated. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.
 - b. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
 - c. Space cleats not more than 12 inches (300 mm) apart. Anchor each cleat with two fasteners. Bend tabs over fasteners.
 - d. Install exposed sheet metal flashing and trim without excessive oil canning, buckling, and tool marks.
 - e. Install sealant tape where indicated.
 - f. Torch cutting of sheet metal flashing and trim is not permitted.
 - g. Do not use graphite pencils to mark metal surfaces.
2. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by SMACNA.
 - a. Coat back side of uncoated aluminum and stainless-steel sheet metal flashing and trim with bituminous coating where flashing and trim will contact wood, ferrous metal, or cementitious construction.
 - b. Underlayment: Where installing metal flashing directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet or install a course of polyethylene sheet.
3. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (600 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently watertight, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with sealant concealed within joints.
4. Fastener Sizes: Use fasteners of sizes that will penetrate wood sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood screws **OR** metal decking not less than recommended by fastener manufacturer to achieve maximum pull-out resistance, **as directed**.
5. Seal joints as shown and as required for watertight construction.
 - a. Where sealant-filled joints are used, embed hooked flanges of joint members not less than 1 inch (25 mm) into sealant. Form joints to completely conceal sealant. When ambient temperature at time of installation is moderate, between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F (4 deg C).
 - b. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants".
6. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter. Pre-tin edges of sheets to be soldered to a width of 1-1/2 inches (38 mm), except reduce pre-tinning where pre-tinned surface would show in completed Work.
 - a. Do not solder metallic-coated steel and aluminum sheet.
 - b. Pre-tinning is not required for zinc-tin alloy-coated stainless steel and zinc-tin alloy-coated copper.
 - c. Do not use torches for soldering. Heat surfaces to receive solder and flow solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.



- d. Stainless-Steel Soldering: Tin edges of uncoated sheets using solder recommended for stainless steel and acid flux. Promptly remove acid flux residue from metal after tinning and soldering. Comply with solder manufacturer's recommended methods for cleaning and neutralization.
- e. Copper Soldering: Tin edges of uncoated copper sheets using solder for copper.
- 7. Rivets: Rivet joints in uncoated aluminum **OR** zinc, **as directed**, where indicated and where necessary for strength.

C. Roof Drainage System Installation

1. General: Install sheet metal roof drainage items to produce complete roof drainage system according to SMACNA recommendations and as indicated. Coordinate installation of roof perimeter flashing with installation of roof drainage system.
2. Hanging Gutters: Join sections with riveted and soldered joints or with lapped joints sealed with sealant. Provide for thermal expansion. Attach gutters at eave or fascia to firmly anchored gutter brackets **OR** straps **OR** twisted straps, **as directed**, spaced not more than 36 inches (900 mm) apart. Provide end closures and seal watertight with sealant. Slope to downspouts.
 - a. Fasten gutter spacers to front and back of gutter.
 - b. Loosely lock straps to front gutter bead and anchor to roof deck.
 - c. Anchor and loosely lock back edge of gutter to continuous cleat **OR** eave or apron flashing, **as directed**.
 - d. Anchor back of gutter that extends onto roof deck with cleats spaced not more than 24 inches (600 mm) apart.
 - e. Anchor gutter with spikes and ferrules spaced not more than 24 inches (600 mm) **OR** 30 inches (750 mm), **as directed**, apart.
 - f. Install gutter with expansion joints at locations indicated, but not exceeding, 50 feet (15.24 m) apart. Install expansion-joint caps.
 - g. Install continuous gutter screens on gutters with noncorrosive fasteners, removable **OR** hinged to swing open, **as directed**, for cleaning gutters.
3. Built-in Gutters: Join sections with riveted and soldered or lapped joints sealed with sealant. Provide for thermal expansion. Slope to downspouts. Provide end closures and seal watertight with sealant.
 - a. Install felt underlayment layer in built-in gutter trough and extend to drip edge at eaves and under felt underlayment on roof sheathing. Lap sides a minimum of 2 inches (50 mm) over underlying course. Lap ends a minimum of 4 inches (100 mm). Stagger end laps between succeeding courses at least 72 inches (1830 mm). Fasten with roofing nails. Install slip sheet over felt underlayment.
 - b. Anchor and loosely lock back edge of gutter to continuous cleat **OR** eave or apron flashing, **as directed**.
 - c. Anchor back of gutter that extends onto roof deck with cleats spaced not more than 24 inches (600 mm) apart.
 - d. Install gutter with expansion joints at locations indicated, but not exceeding, 50 feet (15.24 m) apart. Install expansion-joint caps.
4. Downspouts: Join sections with 1-1/2-inch (38-mm) telescoping joints.
 - a. Provide hangers with fasteners designed to hold downspouts securely to walls. Locate hangers at top and bottom and at approximately 60 inches (1500 mm) o.c. in between.
 - b. Provide elbows at base of downspout to direct water away from building.
 - c. Connect downspouts to underground drainage system indicated.
5. Splash Pans: Install where downspouts discharge on low-slope roofs. Set in asphalt roofing cement **OR** elastomeric sealant, **as directed**, compatible with roofing membrane.
6. Parapet Scuppers: Install scuppers where indicated through parapet. Continuously support scupper, set to correct elevation, and seal flanges to interior wall face, over cants or tapered edge strips, and under roofing membrane.
 - a. Anchor scupper closure trim flange to exterior wall and solder or seal with elastomeric sealant to scupper.
 - b. Loosely lock front edge of scupper with conductor head.



- c. Solder or seal with elastomeric sealant exterior wall scupper flanges into back of conductor head.
 7. Conductor Heads: Anchor securely to wall with elevation of conductor head rim 1 inch (25 mm) below scupper **OR** gutter, **as directed**, discharge.
 8. Expansion-Joint Covers: Install expansion-joint covers at locations and of configuration indicated. Lap joints a minimum of 4 inches (100 mm) in direction of water flow.
- D. Roof Flashing Installation
1. General: Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, set units true to line, and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 2. Roof Edge Flashing:
 - a. Anchor to resist uplift and outward forces according to recommendations in SMACNA's "Architectural Sheet Metal Manual" and as indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at staggered 3-inch (75-mm) centers.
OR
Anchor to resist uplift and outward forces according to recommendations in FMG Loss Prevention Data Sheet 1-49 for specified wind zone and as indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at 24-inch (600-mm) **OR** 16-inch (400-mm), **as directed**, centers.
 3. Copings: Anchor to resist uplift and outward forces according to recommendations in SMACNA's "Architectural Sheet Metal Manual" and as indicated.
 - a. Interlock exterior bottom edge of coping with continuous cleat anchored to substrate at 24-inch (600-mm) **OR** 16-inch (400-mm), **as directed**, centers.
 - b. Anchor interior leg of coping with washers and screw fasteners through slotted holes at 24-inch (600-mm) centers.
 4. Copings: Anchor to resist uplift and outward forces according to recommendations in FMG Loss Prevention Data Sheet 1-49 for specified wind zone and as indicated.
 - a. Interlock exterior bottom edge of coping with continuous cleat anchored to substrate at 24-inch (600-mm) **OR** 16-inch (400-mm), **as directed**, centers.
 - b. Anchor interior leg of coping with screw fasteners and washers at 24-inch (600-mm) **OR** 20-inch (500-mm), **as directed**, centers.
 5. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending a minimum of 4 inches (100 mm) over base flashing. Install stainless-steel draw band and tighten.
 6. Counterflashing: Coordinate installation of counterflashing with installation of base flashing. Insert counterflashing in reglets or receivers and fit tightly to base flashing. Extend counterflashing 4 inches (100 mm) over base flashing. Lap counterflashing joints a minimum of 4 inches (100 mm) and bed with sealant. Secure in a waterproof manner by means of snap-in installation and sealant or lead wedges and sealant **OR** interlocking folded seam or blind rivets and sealant **OR** anchor and washer at 36-inch (900-mm) centers, **as directed**.
 7. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric **OR** butyl, **as directed**, sealant and clamp flashing to pipes that penetrate roof.
- E. Wall Flashing Installation
1. General: Install sheet metal wall flashing to intercept and exclude penetrating moisture according to SMACNA recommendations and as indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.
 2. Through-Wall Flashing: Installation of through-wall flashing is specified in Division 04 Section(s) "Unit Masonry" **OR** "Stone Masonry", **as directed**.
 3. Reglets: Installation of reglets is specified in Division 03 Section(s) "Cast-in-place Concrete" **OR** Division 04 Section(s) "Unit Masonry", **as directed**.



4. Opening Flashings in Frame Construction: Install continuous head, sill, jamb, and similar flashings to extend 4 inches (100 mm) beyond wall openings.

F. Miscellaneous Flashing Installation

1. Overhead-Piping Safety Pans: Suspend pans independent from structure above as indicated on Drawings. Pipe and install drain line to plumbing waste or drainage system.
2. Equipment Support Flashing: Coordinate installation of equipment support flashing with installation of roofing and equipment. Weld or seal flashing with elastomeric sealant to equipment support member.

G. Erection Tolerances

1. Installation Tolerances:
 - a. Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

OR

Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."

H. Cleaning And Protection

1. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
2. Clean and neutralize flux materials. Clean off excess solder.
3. Clean off excess sealants.
4. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of installation, remove unused materials and clean finished surfaces. Maintain in a clean condition during construction.
5. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 62 00 00

**SECTION 07 63 00 00 - COMMON WORK RESULTS FOR FIRE SUPPRESSION**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for fire suppression. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Piping materials and installation instructions common to most piping systems.
 - b. Mechanical sleeve seals.
 - c. Sleeves.
 - d. Escutcheons.
 - e. Grout.
 - f. Fire-suppression equipment and piping demolition.
 - g. Equipment installation requirements common to equipment sections.
 - h. Painting and finishing.
 - i. Concrete bases.
 - j. Supports and anchorages.

C. Definitions

1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
5. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
6. The following are industry abbreviations for plastic materials:
 - a. CPVC: Chlorinated polyvinyl chloride plastic.
7. The following are industry abbreviations for rubber materials:
 - a. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - b. NBR: Acrylonitrile-butadiene rubber.

D. Submittals

1. Welding certificates.

E. Quality Assurance

1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
2. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.



3. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

F. Delivery, Storage, And Handling

1. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.2 PRODUCTS

A. Pipe, Tube, And Fittings

1. Refer to individual Division 28 for pipe, tube, and fitting materials and joining methods.
2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

B. Joining Materials

1. Refer to individual Division 28 for special joining materials not listed below.
2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - 1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - 2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - b. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
4. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
5. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
6. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
7. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
8. Solvent Cements for Joining CPVC Plastic Piping: ASTM F 493.

C. Mechanical Sleeve Seals

1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

D. Sleeves

1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
2. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.



3. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.
5. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
6. PVC Pipe: ASTM D 1785, Schedule 40.
7. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

E. Escutcheons

1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Type: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
4. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
5. One-Piece, Stamped-Steel Type: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Type: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Type: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

F. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Fire-Suppression Demolition

1. Refer to Division 01 Section(s) "Cutting And Patching" AND Division 02 Section(s) "Selective Structure Demolition" for general demolition requirements and procedures.
2. Disconnect, demolish, and remove fire-suppression systems, equipment, and components indicated to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to the Owner.
3. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.



B. Piping Systems - Common Requirements

1. Install piping according to the following requirements and Division 28 specifying piping systems.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping to permit valve servicing.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Install piping to allow application of insulation.
11. Select system components with pressure rating equal to or greater than system operating pressure.
12. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 2) Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - 3) Insulated Piping: One-piece, stamped-steel type with spring clips.
 - 4) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a) One-piece, cast-brass type with polished chrome-plated finish.
OR
One-piece, stamped-steel type.
 - 5) Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a) One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
OR
One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
 - 6) Bare Piping in Unfinished Service Spaces:
 - a) One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
One-piece, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw **OR** spring clips, **as directed**.
 - 7) Bare Piping in Equipment Rooms:
 - a) One-piece, cast-brass type.

One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
 - 8) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
 - b. Existing Piping: Use the following:
 - c. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
 - d. Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - 1) Split-casting, cast-brass type with chrome-plated finish.
OR
Split-plate, stamped-steel type with concealed hinge and spring clips.



- f. Bare Piping at Ceiling Penetrations in Finished Spaces:
 - 1) Split-casting, cast-brass type with chrome-plated finish.
OR
Split-plate, stamped-steel type with concealed hinge and set screw.
 - g. Bare Piping in Unfinished Service Spaces:
 - 1) Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
 - h. Bare Piping in Equipment Rooms:
 - 1) Split-casting, cast-brass type.
OR
Split-plate, stamped-steel type with set screw or spring clips.
 - i. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
13. Sleeves are not required for core-drilled holes.
14. Permanent sleeves are not required for holes formed by removable PE sleeves.
15. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
16. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
- a. Cut sleeves to length for mounting flush with both surfaces.
 - 1) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - b. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - c. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - 1) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - 2) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
 - 3) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
 - a) Seal space outside of sleeve fittings with grout.
 - d. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
17. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- a. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - b. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
 - c. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
18. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- a. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.



19. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
20. Verify final equipment locations for roughing-in.
21. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

C. Piping Joint Construction

1. Join pipe and fittings according to the following requirements and Division 28 specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Para. 1.1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
10. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

D. Painting

1. Painting of fire-suppression systems, equipment, and components is specified in Division 09 Section(s) "Exterior Painting" AND "Interior Painting".
2. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

E. Concrete Bases

1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.



- g. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

- F. Erection Of Metal Supports And Anchorages
 - 1. Refer to Division 05 Section "Metal Fabrications" for structural steel.
 - 2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.
 - 3. Field Welding: Comply with AWS D1.1.

- G. Erection Of Wood Supports And Anchorages
 - 1. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor fire-suppression materials and equipment.
 - 2. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
 - 3. Attach to substrates as required to support applied loads.

- H. Grouting
 - 1. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.
 - 2. Clean surfaces that will come into contact with grout.
 - 3. Provide forms as required for placement of grout.
 - 4. Avoid air entrapment during placement of grout.
 - 5. Place grout, completely filling equipment bases.
 - 6. Place grout on concrete bases and provide smooth bearing surface for equipment.
 - 7. Place grout around anchors.
 - 8. Cure placed grout.

END OF SECTION 07 63 00 00



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**SECTION 07 63 00 00a - COMMON WORK RESULTS FOR PLUMBING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for plumbing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Piping materials and installation instructions common to most piping systems.
 - b. Transition fittings.
 - c. Dielectric fittings.
 - d. Mechanical sleeve seals.
 - e. Sleeves.
 - f. Escutcheons.
 - g. Grout.
 - h. Plumbing demolition.
 - i. Equipment installation requirements common to equipment sections.
 - j. Painting and finishing.
 - k. Concrete bases.
 - l. Supports and anchorages.

C. Definitions

1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
5. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
6. The following are industry abbreviations for plastic materials:
 - a. ABS: Acrylonitrile-butadiene-styrene plastic.
 - b. CPVC: Chlorinated polyvinyl chloride plastic.
 - c. PE: Polyethylene plastic.
 - d. PVC: Polyvinyl chloride plastic.
7. The following are industry abbreviations for rubber materials:
 - a. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - b. NBR: Acrylonitrile-butadiene rubber.

D. Submittals

1. Welding certificates.

E. Quality Assurance

1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."



2. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
3. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

F. Delivery, Storage, And Handling

1. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.2 PRODUCTS

A. Pipe, Tube, And Fittings

1. Refer to individual Division 14 for pipe, tube, and fitting materials and joining methods.
2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

B. Joining Materials

1. Refer to individual Division 14 for special joining materials not listed below.
2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - 1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - 2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - b. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
4. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
5. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
6. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
7. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
8. Solvent Cements for Joining Plastic Piping:
 - a. ABS Piping: ASTM D 2235.
 - b. CPVC Piping: ASTM F 493.
 - c. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - d. PVC to ABS Piping Transition: ASTM D 3138.
9. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

C. Transition Fittings

1. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
 - a. Underground Piping NPS 1-1/2 (DN 40) and Smaller: Manufactured fitting or coupling.



- b. Underground Piping NPS 2 (DN 50) and Larger: AWWA C219, metal sleeve-type coupling.
 - c. Aboveground Pressure Piping: Pipe fitting.
 2. Plastic-to-Metal Transition Fittings: CPVC **OR** PVC, **as directed**, one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
 3. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
 4. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC **OR** PVC, **as directed**, four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
 5. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
- D. Dielectric Fittings
1. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
 2. Insulating Material: Suitable for system fluid, pressure, and temperature.
 3. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
 4. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
 5. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - a. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.
 6. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
 7. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
- E. Mechanical Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.
- F. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
 2. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
 3. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
 4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.
 5. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
 6. PVC Pipe: ASTM D 1785, Schedule 40.



7. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

G. Escutcheons

1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Type: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
4. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
5. One-Piece, Stamped-Steel Type: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Type: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Type: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

H. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Plumbing Demolition

1. Refer to Division 01 Section(s) "Cutting And Patching" AND Division 02 Section(s) "Selective Structure Demolition" for general demolition requirements and procedures.
2. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to the Owner.
3. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

B. Piping Systems - Common Requirements

1. Install piping according to the following requirements and Division 14 specifying piping systems.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.



3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping to permit valve servicing.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Install piping to allow application of insulation.
11. Select system components with pressure rating equal to or greater than system operating pressure.
12. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 2) Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - 3) Insulated Piping: One-piece, stamped-steel type with spring clips.
 - 4) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a) One-piece, cast-brass type with polished chrome-plated finish.
OR
One-piece, stamped-steel type.
 - 5) Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a) One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
OR
One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
 - 6) Bare Piping in Unfinished Service Spaces:
 - a) One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
One-piece, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw **OR** spring clips, **as directed**.
 - 7) Bare Piping in Equipment Rooms:
 - a) One-piece, cast-brass type.
OR
One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
 - 8) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
 - b. Existing Piping: Use the following:
 - 1) Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
 - 2) Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - 3) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a) Split-casting, cast-brass type with chrome-plated finish.
OR
Split-plate, stamped-steel type with concealed hinge and spring clips.
 - 4) Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a) Split-casting, cast-brass type with chrome-plated finish.
OR
Split-plate, stamped-steel type with concealed hinge and set screw.
 - 5) Bare Piping in Unfinished Service Spaces:
 - a) Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR



- Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
- 6) Bare Piping in Equipment Rooms:
 - a) Split-casting, cast-brass type.
OR
Split-plate, stamped-steel type with set screw or spring clips.
 - 7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
13. Sleeves are not required for core-drilled holes.
 14. Permanent sleeves are not required for holes formed by removable PE sleeves.
 15. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
 16. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
 - a. Cut sleeves to length for mounting flush with both surfaces.
 - 1) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - b. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - c. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - 1) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - 2) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
 - 3) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
 - a) Seal space outside of sleeve fittings with grout.
 - d. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
 17. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - a. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - b. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
 - c. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
 18. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - a. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
 19. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
 20. Verify final equipment locations for roughing-in.
 21. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.



- C. Piping Joint Construction
1. Join pipe and fittings according to the following requirements and Division 14 specifying piping systems.
 2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
 5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
 6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
 7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Para. 1.1 "Quality Assurance" Article.
 8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
 9. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - c. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - d. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - e. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - f. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.
 10. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
 11. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
 12. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - a. Plain-End Pipe and Fittings: Use butt fusion.
 - b. Plain-End Pipe and Socket Fittings: Use socket fusion.
 13. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- D. Piping Connections
1. Make connections according to the following, unless otherwise indicated:
 - a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - c. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 - d. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.
- E. Equipment Installation - Common Requirements
1. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.



2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
3. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.

F. Painting

1. Painting of plumbing systems, equipment, and components is specified in Division 09 Section(s) "Exterior Painting" AND "Interior Painting".
2. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

G. Concrete Bases

1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - g. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

H. Erection Of Metal Supports And Anchorages

1. Refer to Division 05 Section "Metal Fabrications" for structural steel.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
3. Field Welding: Comply with AWS D1.1.

I. Erection Of Wood Supports And Anchorages

1. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
2. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
3. Attach to substrates as required to support applied loads.

J. Grouting

1. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
2. Clean surfaces that will come into contact with grout.
3. Provide forms as required for placement of grout.
4. Avoid air entrapment during placement of grout.
5. Place grout, completely filling equipment bases.
6. Place grout on concrete bases and provide smooth bearing surface for equipment.
7. Place grout around anchors.
8. Cure placed grout.



END OF SECTION 07 63 00 00a



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**SECTION 07 63 00 00b - COMMON WORK RESULTS FOR HVAC**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for HVAC. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Piping materials and installation instructions common to most piping systems.
 - b. Transition fittings.
 - c. Dielectric fittings.
 - d. Mechanical sleeve seals.
 - e. Sleeves.
 - f. Escutcheons.
 - g. Grout.
 - h. HVAC demolition.
 - i. Equipment installation requirements common to equipment sections.
 - j. Painting and finishing.
 - k. Concrete bases.
 - l. Supports and anchorages.

C. Definitions

1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
5. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
6. The following are industry abbreviations for plastic materials:
 - a. CPVC: Chlorinated polyvinyl chloride plastic.
 - b. PE: Polyethylene plastic.
 - c. PVC: Polyvinyl chloride plastic.
7. The following are industry abbreviations for rubber materials:
 - a. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - b. NBR: Acrylonitrile-butadiene rubber.

D. Submittals

1. Welding certificates.

E. Quality Assurance

1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
2. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."



- a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
3. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

F. Delivery, Storage, And Handling

1. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.2 PRODUCTS

A. Pipe, Tube, And Fittings

1. Refer to individual Division 21 for pipe, tube, and fitting materials and joining methods.
2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

B. Joining Materials

1. Refer to individual Division 21 for special joining materials not listed below.
2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - 1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - 2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - b. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
4. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
5. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
6. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
7. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
8. Solvent Cements for Joining Plastic Piping:
 - a. CPVC Piping: ASTM F 493.
 - b. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
9. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

C. Transition Fittings

1. Plastic-to-Metal Transition Fittings: CPVC **OR** PVC, **as directed**, one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
2. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
3. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC **OR** PVC, **as directed**, four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.



- D. Dielectric Fittings
1. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
 2. Insulating Material: Suitable for system fluid, pressure, and temperature.
 3. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
 4. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
 5. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - a. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.
 6. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
 7. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
- E. Mechanical Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.
- F. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
 2. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
 3. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
 4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.
 5. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
 6. PVC Pipe: ASTM D 1785, Schedule 40.
 7. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.
- G. Escutcheons
1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
 2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
 3. One-Piece, Cast-Brass Type: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
 4. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.



5. One-Piece, Stamped-Steel Type: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Type: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Type: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

H. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. HVAC Demolition

1. Refer to Division 01 Section(s) "Cutting And Patching" AND Division 02 Section(s) "Selective Structure Demolition" for general demolition requirements and procedures.
2. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - c. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - d. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
 - e. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - f. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - g. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to the Owner.
3. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

B. Piping Systems - Common Requirements

1. Install piping according to the following requirements and Division 21 specifying piping systems.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping to permit valve servicing.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.



10. Install piping to allow application of insulation.
11. Select system components with pressure rating equal to or greater than system operating pressure.
12. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 2) Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - 3) Insulated Piping: One-piece, stamped-steel type with spring clips.
 - 4) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a) One-piece, cast-brass type with polished chrome-plated finish.
OR
One-piece, stamped-steel type.
 - 5) Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a) One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
OR
One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
 - 6) Bare Piping in Unfinished Service Spaces:
 - a) One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
One-piece, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw **OR** spring clips, **as directed**.
 - 7) Bare Piping in Equipment Rooms:
 - a) One-piece, cast-brass type.
OR
One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
 - 8) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
 - b. Existing Piping: Use the following:
 - 1) Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
 - 2) Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - 3) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a) Split-casting, cast-brass type with chrome-plated finish.
OR
Split-plate, stamped-steel type with concealed hinge and spring clips.
 - 4) Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a) Split-casting, cast-brass type with chrome-plated finish.
OR
Split-plate, stamped-steel type with concealed hinge and set screw.
 - 5) Bare Piping in Unfinished Service Spaces:
 - a) Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
 - 6) Bare Piping in Equipment Rooms:
 - a) Split-casting, cast-brass type.
OR
Split-plate, stamped-steel type with set screw or spring clips.
 - 7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
13. Sleeves are not required for core-drilled holes.
14. Permanent sleeves are not required for holes formed by removable PE sleeves.



15. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
16. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
 - a. Cut sleeves to length for mounting flush with both surfaces.
 - 1) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - b. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - c. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - 1) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - 2) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
 - 3) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
 - a) Seal space outside of sleeve fittings with grout.
 - d. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
17. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - a. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - b. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
 - c. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
18. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - a. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
19. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
20. Verify final equipment locations for roughing-in.
21. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

C. Piping Joint Construction

1. Join pipe and fittings according to the following requirements and Division 21 specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.



6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
 7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Para. 1.1 "Quality Assurance" Article.
 8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
 9. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - c. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - d. PVC Nonpressure Piping: Join according to ASTM D 2855.
 10. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
 11. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
 12. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - a. Plain-End Pipe and Fittings: Use butt fusion.
 - b. Plain-End Pipe and Socket Fittings: Use socket fusion.
 13. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- D. Piping Connections
1. Make connections according to the following, unless otherwise indicated:
 - a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - c. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 - d. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.
- E. Equipment Installation - Common Requirements
1. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
 2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
 3. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
 4. Install equipment to allow right of way for piping installed at required slope.
- F. Painting
1. Painting of HVAC systems, equipment, and components is specified in Division 09 Section(s) "Exterior Painting" AND "Interior Painting".
 2. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.



G. Concrete Bases

1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - g. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

H. Erection Of Metal Supports And Anchorages

1. Refer to Division 05 Section "Metal Fabrications" for structural steel.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
3. Field Welding: Comply with AWS D1.1.

I. Erection Of Wood Supports And Anchorages

1. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.
2. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
3. Attach to substrates as required to support applied loads.

J. Grouting

1. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
2. Clean surfaces that will come into contact with grout.
3. Provide forms as required for placement of grout.
4. Avoid air entrapment during placement of grout.
5. Place grout, completely filling equipment bases.
6. Place grout on concrete bases and provide smooth bearing surface for equipment.
7. Place grout around anchors.
8. Cure placed grout.

END OF SECTION 07 63 00 00b



Task	Specification	Specification Description
07 63 00 00	07 62 00 00	Sheet Metal Flashing And Trim
07 65 16 00	07 51 13 00	Built-Up Asphalt Roofing
07 65 16 00	07 05 13 00	Built-Up Coal-Tar Roofing
07 65 16 00	07 53 16 00	EPDM Membrane Roofing
07 65 16 00	07 56 00 00	Coated Foamed Roofing
07 71 13 00	07 62 00 00	Sheet Metal Flashing And Trim



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**SECTION 07 71 23 00 - MANUFACTURED ROOF SPECIALTIES**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for manufactured roof specialties. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Copings.
 - b. Roof-edge flashings.
 - c. Roof-edge drainage systems.
 - d. Reglets and counterflashings.

C. Performance Requirements

1. General Performance: Roof specialties shall withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.
2. FM Approvals' Listing (if Project is FM Global insured or if FM Approvals' requirements set a minimum quality standard): Manufacture and install copings and roof-edge flashings that are listed in FM Approvals' "RoofNav" and approved for windstorm classification, Class 1-60 **OR** Class 1-75 **OR** Class 1-90 **OR** Class 1-105 **OR** Class 1-120, **as directed**. Identify materials with FM Approvals' markings.
3. SPRI Wind Design Standard (if Project is governed by the IBC or if SPRI ES-1 sets a minimum quality standard): Manufacture and install copings and roof-edge flashings tested according to SPRI ES-1 and capable of resisting the following design pressures:
 - a. Design Pressure: As indicated on Drawings **OR** As directed.
4. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, hole elongation, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Provide clips that resist rotation and avoid shear stress as a result of thermal movements. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

D. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Shop Drawings: For roof specialties. Include plans, elevations, expansion-joint locations, keyed details, and attachments to other work. Distinguish between plant- and field-assembled work. Include the following:
 - a. Details for expansion and contraction; locations of expansion joints, including direction of expansion and contraction.
 - b. Pattern of seams and layout of fasteners, cleats, clips, and other attachments.
 - c. Details of termination points and assemblies, including fixed points.
 - d. Details of special conditions.
3. Samples: For copings **OR** roof-edge flashings **OR** roof-edge drainage systems **OR** reglets and counterflashings, **as directed**, made from 12-inch (300-mm) lengths of full-size components including fasteners, cover joints, accessories, and attachments.
4. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for copings and roof-edge flashings.



5. Maintenance Data: For roofing specialties to include in maintenance manuals.
6. Warranty: Sample of special warranty.

E. Quality Assurance

1. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Do not store roof specialties in contact with other materials that might cause staining, denting, or other surface damage. Store roof specialties away from uncured concrete and masonry.
2. Protect strippable protective covering on roof specialties from exposure to sunlight and high humidity, except to extent necessary for the period of roof specialties installation.

G. Warranty

1. Special Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace roof specialties that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - a. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:
 - 1) Color fading more than 5 Hunter units when tested according to ASTM D 2244.
 - 2) Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
 - 3) Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - b. Finish Warranty Period: 20 **OR** 10, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Exposed Metals

1. Copper Sheet: ASTM B 370, cold-rolled copper sheet, H00 or H01 temper.
 - a. Non-Patinated Exposed Finish: Mill.
 - b. Pre-Patinated Copper-Sheet Finish: Pre-patinated according to ASTM B 882.
2. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer for finish required, with temper to suit forming operations and performance required.
 - a. Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 - b. Mill Finish: As manufactured.
 - c. Exposed Coil-Coated Finishes: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 1) Two-Coat Fluoropolymer: AAMA 620. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.
 - 2) Three-Coat Fluoropolymer: AAMA 620. System consisting of primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent PVDF resin by weight.
 - 3) Concealed Surface: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
 - d. Clear Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.
 - e. Color Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm or thicker.
3. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy and temper recommended by manufacturer for type of use and finish indicated, finished as follows:
 - a. Exposed High-Performance Organic Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.



- 1) Two-Coat Fluoropolymer: AAMA 2604 **OR** AAMA 2605, **as directed**. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.
 - 2) Three-Coat Fluoropolymer: AAMA 2605. System consisting of primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent PVDF resin by weight.
 - b. Clear Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.
 - c. Color Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm or thicker.
 4. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304.
 5. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation.
 - a. Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 - b. Mill-Phosphatized Finish: Manufacturer's standard for field painting.
 - c. Exposed Coil-Coated Finishes: Prepainted by the coil-coating process to comply with ASTM A 755/A 755M. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 1) Two-Coat Fluoropolymer: AAMA 621. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.
 - 2) Three-Coat Fluoropolymer: AAMA 621. System consisting of primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent PVDF resin by weight.
- B. Concealed Metals
1. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy and temper recommended by manufacturer for type of use and structural performance indicated, mill finished.
 2. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy and temper recommended by manufacturer for type of use and structural performance indicated, mill finished.
 3. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304.
 4. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation.
- C. Underlayment Materials
1. Felt: ASTM D 226, Type II (No. 30), asphalt-saturated organic felt, nonperforated.
 2. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils (0.76 to 1.0 mm) thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
 - a. Thermal Stability: ASTM D 1970; stable after testing at 240 deg F (116 deg C).
 - b. Low-Temperature Flexibility: ASTM D 1970; passes after testing at minus 20 deg F (29 deg C).
 3. Polyethylene Sheet: 6-mil- (0.15-mm-) thick polyethylene sheet complying with ASTM D 4397.
 4. Slip Sheet: Building paper, 3-lb/100 sq. ft. (0.16-kg/sq. m) minimum, rosin sized.
- D. Miscellaneous Materials
1. General: Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.
 2. Fasteners: Manufacturer's recommended fasteners, suitable for application and designed to meet performance requirements. Furnish the following unless otherwise indicated:
 - a. Exposed Penetrating Fasteners: Gasketed screws with hex washer heads matching color of sheet metal.
 - b. Fasteners for Copper Sheet: Copper, hardware bronze, or passivated Series 300 stainless steel.
 - c. Fasteners for Aluminum: Aluminum or Series 300 stainless steel.
 - d. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.



- e. Fasteners for Zinc-Coated (Galvanized) Steel Sheet: Series 300 stainless steel or hot-dip zinc-coated steel according to ASTM A 153/A 153M or ASTM F 2329.
- 3. Elastomeric Sealant: ASTM C 920, elastomeric polyurethane **OR** silicone, **as directed**, polymer sealant of type, grade, class, and use classifications required by roofing-specialty manufacturer for each application.
- 4. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.
- 5. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.
- 6. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required for application.
- 7. Solder for Copper: ASTM B 32, lead-free solder **OR** Grade Sn50, 50 percent tin and 50 percent lead, **as directed**.

E. Copings

- 1. Copings: Manufactured coping system consisting of formed-metal coping cap in section lengths not exceeding 12 feet (3.6 m), concealed anchorage; corner units, end cap units, and concealed splice plates with same finish as coping caps.
 - a. Coping-Cap Material: Copper, 20 oz./sq. ft. (0.68 mm thick) **OR** weight (thickness) as required to meet performance requirements, **as directed**.
 - 1) Finish: Non-patinated, mill **OR** Pre-patinated dark brown **OR** Pre-patinated verdigris, **as directed**.

OR

Coping-Cap Material: Formed **OR** Extruded, **as directed**, aluminum, 0.040 inch (1.02 mm) thick **OR** 0.050 inch (1.27 mm) thick **OR** 0.063 inch (1.60 mm) thick **OR** 0.080 inch (2.03 mm) thick **OR** 0.125 inch (3.18 mm) thick **OR** thickness as required to meet performance requirements, **as directed**.

 - 1) Finish: Mill **OR** Two-coat fluoropolymer **OR** Three-coat fluoropolymer **OR** Clear anodic **OR** Color anodic, **as directed**.
 - 2) Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

OR

Coping-Cap Material: Zinc-coated steel, nominal 0.028-inch (0.71-mm) thickness **OR** 0.034-inch (0.86-mm) thickness **OR** thickness as required to meet performance requirements, **as directed**.

 - 1) Finish: Mill phosphatized for field painting **OR** Two-coat fluoropolymer **OR** Three-coat fluoropolymer, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
- b. Corners: Factory mitered and soldered **OR** continuously welded **OR** mechanically clinched and sealed watertight, **as directed**.
- c. Special Fabrications: Radiussed sections **OR** Arched sections **OR** Bullnose face leg **OR** Two-way sloped coping cap, **as directed**.
- d. Coping-Cap Attachment Method: Snap-on **OR** Face leg hooked to continuous cleat with back leg fastener exposed, **as directed**, fabricated from coping-cap material.
- e. Snap-on-Coping Anchor Plates: Concealed, galvanized-steel sheet, 12 inches (300 mm) wide, with integral cleats.

OR

Face Leg Cleats: Concealed, continuous galvanized-steel sheet **OR** stainless steel, **as directed**.

F. Roof-Edge Flashings

- 1. Canted Roof-Edge and Fascia **OR** Fascia and Gravel Stop, **as directed**: Manufactured, two-piece, roof-edge fascia consisting of snap-on **OR** compression-clamped, **as directed**, metal fascia cover in section lengths not exceeding 12 feet (3.6 m) and a continuous formed



- galvanized-steel sheet cant, 0.028 inch (0.71 mm) thick, minimum, with extended vertical leg terminating in a drip-edge cleat. Provide matching corner units.
- a. Fascia Cover: Fabricated from the following exposed metal:
 - 1) Formed Aluminum: 0.040 inch (1.02 mm) thick **OR** 0.050 inch (1.27 mm) thick **OR** 0.063 inch (1.60 mm) thick **OR** Thickness as required to meet performance requirements, **as directed**.
 - 2) Extruded Aluminum: 0.080 inch (2.03 mm) thick **OR** Thickness as required to meet performance requirements, **as directed**.
 - 3) Zinc-Coated Steel: Nominal 0.028-inch (0.71-mm) thickness **OR** 0.034-inch (0.86-mm) thickness **OR** thickness as required to meet performance requirements, **as directed**.
 - b. Corners: Factory mitered and soldered **OR** continuously welded **OR** mechanically clinched and sealed watertight, **as directed**.
 - c. Splice Plates: Concealed **OR** Exposed, **as directed**, of same material, finish, and shape as fascia cover.
 - d. Special Fabrications: Radiussed sections **OR** Arched sections **OR** Bullnose fascia cover **OR** Cornice fascia cover **OR** Cove fascia cover, **as directed**.
 - e. Fascia Accessories: Fascia extenders with continuous hold-down cleats **OR** Wall cap **OR** Soffit trim **OR** Overflow scuppers **OR** Overflow scuppers with perforated screens **OR** Spillout scuppers **OR** Downspout scuppers with integral conductor head and downspout adapters **OR** Downspout scuppers with integral conductor head and downspout adapters and perforated screens, **as directed**.
2. Roof-Edge Fascia: Manufactured, two-piece, roof-edge fascia consisting of snap-on metal fascia cover in section lengths not exceeding 12 feet (3.6 m) and a continuous formed- or extruded-aluminum anchor bar with integral drip-edge cleat to engage fascia cover. Provide matching corner units.
- a. Fascia Cover: Fabricated from the following exposed metal:
 - 1) Formed Aluminum: 0.032 inch (0.81 mm) thick **OR** 0.040 inch (1.02 mm) thick **OR** 0.050 inch (1.27 mm) thick **OR** 0.063 inch (1.60 mm) thick **OR** Thickness as required to meet performance requirements, **as directed**.
 - 2) Zinc-Coated Steel: Nominal 0.028 inch (0.71 mm) thick **OR** 0.034 inch (0.86 mm) thick **OR** thickness as required to meet performance requirements, **as directed**.
 - b. Corners: Factory mitered and soldered **OR** continuously welded **OR** mechanically clinched and sealed watertight, **as directed**.
 - c. Splice Plates: Concealed **OR** Exposed, **as directed**, of same material, finish, and shape as fascia cover.
 - d. Special Fabrications: Radiussed sections **OR** Arched sections **OR** Bullnose fascia cover **OR** Cornice fascia cover **OR** Cove fascia cover, **as directed**.
 - e. Fascia Accessories: Fascia extenders with continuous hold-down cleats **OR** Wall cap **OR** Soffit trim **OR** Overflow scuppers **OR** Overflow scuppers with perforated screens **OR** Spillout scuppers **OR** Downspout scuppers with integral conductor head and downspout adapters **OR** Downspout scuppers with integral conductor head and downspout adapters and perforated screens, **as directed**.
3. One-Piece Gravel Stops: Manufactured, one-piece, metal gravel stop in section lengths not exceeding 12 feet (3.6 m), with a horizontal flange and vertical leg, drain-through, **as directed**, fascia terminating in a drip edge, **as directed**, and concealed splice plates of same material, finish, and shape as gravel stop. Provide matching corner units.
- a. Fabricate from the following exposed metal:
 - 1) Copper: 16 oz./sq. ft. (0.55 mm thick) **OR** Weight (thickness) as required to meet performance requirements, **as directed**.
 - 2) Formed Aluminum: 0.032 inch (0.81 mm) thick **OR** 0.040 inch (1.02 mm) thick **OR** 0.050 inch (1.27 mm) thick **OR** Thickness as required to meet performance requirements, **as directed**.
 - 3) Extruded Aluminum: 0.080 inch (2.03 mm) thick **OR** Thickness as required to meet performance requirements, **as directed**.



- 4) Stainless Steel: 0.025 inch (0.64 mm) thick **OR** Thickness as required to meet performance requirements, **as directed**.
- 5) Zinc-Coated Steel: Nominal 0.028-inch (0.71-mm) thickness **OR** 0.034-inch (0.86-mm) thickness **OR** thickness as required to meet performance requirements, **as directed**.
- b. Corners: Factory mitered and soldered **OR** continuously welded **OR** mechanically clinched and sealed watertight, **as directed**.
- c. Accessories: Fascia extenders with continuous hold-down cleats **OR** Wall cap **OR** Soffit trim, **as directed**.
4. Copper Finish: Non-patinated, mill **OR** Pre-patinated dark brown **OR** Pre-patinated verdigris, **as directed**.
5. Aluminum Finish: Mill **OR** Two-coat fluoropolymer **OR** Three-coat fluoropolymer **OR** Clear anodic **OR** Color anodic, **as directed**.
 - a. Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
6. Stainless-Steel Finish: No. 2B (bright, cold rolled) **OR** No. 3 (coarse, polished directional satin) **OR** No. 4 (bright, polished directional satin), **as directed**.
7. Zinc-Coated Steel Finish: Mill phosphatized for field painting **OR** Two-coat fluoropolymer **OR** Three-coat fluoropolymer, **as directed**.
 - a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

G. Roof-Edge Drainage Systems

1. Gutters: Manufactured in uniform section lengths not exceeding 12 feet (3.6 m), with matching corner units, ends, outlet tubes, and other accessories. Elevate back edge at least 1 inch (25 mm) above front edge. Furnish flat-stock gutter straps, gutter brackets, expansion joints, and expansion-joint covers fabricated from same metal as gutters.
 - a. Fabricate from the following exposed metal:
 - 1) Copper: 16 oz./sq. ft. (0.55 mm thick) **OR** 20 oz./sq. ft. (0.68 mm thick), **as directed**.
 - 2) Formed Aluminum: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm) **OR** 0.063 inch (1.60 mm), **as directed**, thick.
 - 3) Zinc-Coated Steel: Nominal 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, thickness.
 - b. Gutter Profile: Style A **OR** Style B **OR** Style F **OR** Style G **OR** Style H **OR** Style I **OR** Style K **OR** Style K highback **OR** Half-round single bead **OR** Half-round highback **OR** Quarter round **OR** Ogee **OR** As indicated, **as directed**, according to SMACNA's "Architectural Sheet Metal Manual."
 - c. Embossed Surface: Embossed with design as indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - d. Applied Fascia Cover (Concealed Gutter): Exposed, formed copper, 16 oz./sq. ft. (0.55 mm thick) **OR** aluminum, 0.040 inch (1.02 mm) thick, **as directed**, with factory-mitered corners, ends, and concealed splice joints.
 - e. Corners: Factory mitered and soldered **OR** continuously welded **OR** mechanically clinched and sealed watertight, **as directed**.
 - f. Gutter Supports: Gutter brackets **OR** Straps **OR** Spikes and ferrules **OR** Manufacturer's standard supports as selected by the Owner, **as directed**, with finish matching the gutters.
 - g. Special Fabrications: Radiussed sections.
 - h. Gutter Accessories: Continuous screened leaf guard with sheet metal frame **OR** Continuous hinged leaf guard of solid metal designed to shed leaves **OR** Continuous snap-in plastic leaf guard **OR** Bronze wire ball downspout strainer **OR** Wire ball downspout strainer **OR** Flat ends **OR** Bullnose ends for half-round gutter, **as directed**.
2. Downspouts: Plain round **OR** Corrugated round **OR** Plain rectangular **OR** Corrugated rectangular **OR** Open-face rectangular, **as directed**, complete with machine-cripped **OR** mitered **OR**



- smooth-curve, **as directed**, elbows, manufactured from the following exposed metal. Furnish with metal hangers, from same material as downspouts, and anchors.
- a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Formed Aluminum: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.050 inch (1.27 mm) **OR** 0.063 inch (1.60 mm), **as directed**, thick.
 - c. Extruded Aluminum: 0.125 inch (3.18 mm) thick.
 - d. Zinc-Coated Steel: Nominal 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, thickness.
3. Parapet Scuppers: Manufactured with closure flange trim to exterior, 4-inch- (100-mm-) wide wall flanges to interior, and base extending 4 inches (100 mm) beyond cant or tapered strip into field of roof. Fasten gravel guard angles to base of scuppers, **as directed**.
- a. Fabricate from the following exposed metal:
 - 1) Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 2) Formed Aluminum: 0.032 inch (0.81 mm) thick.
 - 3) Stainless Steel: 0.019 inch (0.48 mm) thick.
 - 4) Zinc-Coated Steel: Nominal 0.028-inch (0.71-mm) thickness.
4. Conductor Heads: Manufactured conductor heads, each with flanged back and stiffened top edge and of dimensions and shape indicated, complete with outlet tube that nests into upper end of downspout, exterior flange trim, **as directed**, and built-in overflow, **as directed**.
- a. Fabricate from the following exposed metal:
 - 1) Copper: 16 oz./sq. ft. (0.55 mm thick).
 - 2) Formed Aluminum: 0.032 inch (0.81 mm) thick.
 - 3) Stainless Steel: 0.016 inch (0.40 mm) thick.
 - 4) Zinc-Coated Steel: Nominal 0.028-inch (0.71-mm) thickness.
5. Splash Pans: Fabricate from the following exposed metal:
- a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Formed Aluminum: 0.040 inch (1.02 mm) thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) thick.
 - d. Zinc-Coated Steel: Nominal 0.028-inch (0.71-mm) thickness.
6. Copper Finish: Non-patinated, mill **OR** Pre-patinated dark brown **OR** Pre-patinated verdigris, **as directed**.
7. Aluminum Finish: Mill **OR** Two-coat fluoropolymer **OR** Three-coat fluoropolymer **OR** Clear anodic **OR** Color anodic, **as directed**.
- a. Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As indicated by manufacturer's designations **OR** As selected from manufacturer's full rang, **as directed**.
8. Stainless-Steel Finish: No. 2B (bright, cold rolled, unpolished) **OR** No. 3 (coarse, polished directional satin) **OR** No. 4 (bright, polished directional satin), **as directed**.
9. Zinc-Coated Steel Finish: Mill phosphatized for field painting **OR** Two-coat fluoropolymer **OR** Three-coat fluoropolymer, **as directed**.
- a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
- H. Reglets And Counterflashings
1. Reglets: Manufactured units formed to provide secure interlocking of separate reglet and counterflashing pieces, from the following exposed metal:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Formed Aluminum: 0.024 inch (0.61 mm) **OR** 0.050 inch (1.27 mm), **as directed**, thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) **OR** 0.025 inch (0.64 mm), **as directed**, thick.
 - d. Zinc-Coated Steel: Nominal 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm), **as directed**, thickness.
 - e. Corners: Factory mitered and soldered **OR** continuously welded **OR** mechanically clinched and sealed watertight, **as directed**.
 - f. Surface-Mounted Type: Provide reglets with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.



- g. Stucco Type, Embedded: Provide reglets with upturned fastening flange and extension leg of length to match thickness of applied finish materials.
 - h. Concrete Type, Embedded: Provide temporary closure tape to keep reglet free of concrete materials, special fasteners for attaching reglet to concrete forms, and guides to ensure alignment of reglet section ends.
 - i. Masonry Type, Embedded: Provide reglets with offset top flange for embedment in masonry mortar joint.
 - j. Multiuse Type, Embedded: For multiuse embedment in cast-in-place concrete **OR** masonry mortar joints, **as directed**.
2. Counterflashings: Manufactured units of heights to overlap top edges of base flashings by 4 inches (100 mm) and in lengths not exceeding 12 feet (3.6 m) designed to snap into reglets or through-wall-flashing receiver and compress against base flashings with joints lapped, from the following exposed metal:
 - a. Copper: 16 oz./sq. ft. (0.55 mm thick).
 - b. Formed Aluminum: 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - c. Stainless Steel: 0.019 inch (0.48 mm) **OR** 0.025 inch (0.64 mm), **as directed**, thick.
 - d. Zinc-Coated Steel: Nominal 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm), **as directed**, thickness.
 3. Accessories:
 - a. Flexible-Flashing Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counterflashing or where reglet is provided separate from metal counterflashing.
 - b. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing lower edge.
 4. Copper Finish: Non-patinated, mill **OR** Pre-patinated dark brown **OR** Pre-patinated verdigris, **as directed**.
 5. Aluminum Finish: Mill **OR** Two-coat fluoropolymer **OR** Three-coat fluoropolymer **OR** Clear anodic **OR** Color anodic, **as directed**.
 - a. Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 6. Stainless-Steel Finish: No. 2B (bright, cold rolled, unpolished) **OR** No. 3 (coarse, polished directional satin) **OR** No. 4 (bright, polished directional satin), **as directed**.
 7. Zinc-Coated Steel Finish: Mill phosphatized for field painting **OR** Two-coat fluoropolymer **OR** Three-coat fluoropolymer, **as directed**.
 - a. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
- I. General Finish Requirements
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 2. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 3. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.
2. Examine walls, roof edges, and parapets for suitable conditions for roof specialties.
3. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
4. Proceed with installation only after unsatisfactory conditions have been corrected.



- B. Underlayment Installation
1. Felt Underlayment: Install with adhesive for temporary anchorage to minimize use of mechanical fasteners under roof specialties. Apply in shingle fashion to shed water, with lapped joints of not less than 2 inches (50 mm).
 2. Self-Adhering Sheet Underlayment: Install wrinkle free. Apply primer if required by underlayment manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation; use primer rather than nails for installing underlayment at low temperatures. Apply in shingle fashion to shed water. Overlap edges not less than 3-1/2 inches (90 mm). Roll laps with roller. Cover underlayment within 14 days.
 3. Polyethylene Sheet: Install with adhesive for temporary anchorage to minimize use of mechanical fasteners under roof specialties. Apply in shingle fashion to shed water, with lapped and taped joints of not less than 2 inches (50 mm).
 4. Slip Sheet: Install with tape or adhesive for temporary anchorage to minimize use of mechanical fasteners under roof specialties. Apply in shingle fashion to shed water, with lapped joints of not less than 2 inches (50 mm).
- C. Installation, General
1. General: Install roof specialties according to manufacturer's written instructions. Anchor roof specialties securely in place, with provisions for thermal and structural movement. Use fasteners, solder, protective coatings, separators, sealants, and other miscellaneous items as required to complete roof-specialty systems.
 - a. Install roof specialties level, plumb, true to line and elevation; with limited oil-canning and without warping, jogs in alignment, buckling, or tool marks.
 - b. Provide uniform, neat seams with minimum exposure of solder and sealant.
 - c. Install roof specialties to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before manufacture.
 - d. Torch cutting of roof specialties is not permitted.
 - e. Do not use graphite pencils to mark metal surfaces.
 2. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
 - a. Coat concealed side of uncoated aluminum and stainless-steel roof specialties with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
 - b. Underlayment: Where installing metal flashing directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet **OR** self-adhering, high-temperature sheet underlayment **OR** polyethylene sheet, **as directed**.
 - c. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof specialties for waterproof performance.
 3. Expansion Provisions: Allow for thermal expansion of exposed roof specialties.
 - a. Space movement joints at a maximum of 12 feet (3.6 m) with no joints within 18 inches (450 mm) of corners or intersections unless otherwise shown on Drawings.
 - b. When ambient temperature at time of installation is between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures.
 4. Fastener Sizes: Use fasteners of sizes that will penetrate wood blocking or sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood screws **OR** substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance, **as directed**.
 5. Seal joints with elastomeric **OR** butyl, **as directed**, sealant as required by roofing-specialty manufacturer.
 6. Seal joints as required for watertight construction. Place sealant to be completely concealed in joint. Do not install sealants at temperatures below 40 deg F (4 deg C).
 7. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter. Pre-tin edges of sheets to be soldered to a width of 1-1/2 inches (38 mm) except reduce pre-tinning where pre-tinned surface would show in completed Work. Tin edges of uncoated copper sheets using solder for copper. Do not use torches for soldering. Heat surfaces to receive solder and flow



solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.

D. Coping Installation

1. Install cleats, anchor plates, and other anchoring and attachment accessories and devices with concealed fasteners.
2. Anchor copings to meet performance requirements.
 - a. Interlock face and back leg drip edges of snap-on coping cap into cleated anchor plates anchored to substrate at 30-inch (760-mm) centers **OR** 40-inch (1015-mm) centers **OR** manufacturer's required spacing that meets performance requirements, **as directed**.
 - b. Interlock face leg drip edge into continuous cleat anchored to substrate at 24-inch (600-mm) centers **OR** 16-inch (400-mm) centers **OR** manufacturer's required spacing that meets performance requirements, **as directed**. Anchor back leg of coping with screw fasteners and elastomeric washers at 24-inch (600-mm) centers **OR** 16-inch (400-mm) centers **OR** manufacturer's required spacing that meets performance requirements, **as directed**.

E. Roof-Edge Flashing Installation

1. Install cleats, cants, and other anchoring and attachment accessories and devices with concealed fasteners.
2. Anchor roof edgings with manufacturer's required devices, fasteners, and fastener spacing to meet performance requirements.

F. Roof-Edge Drainage-System Installation

1. General: Install components to produce a complete roof-edge drainage system according to manufacturer's written instructions. Coordinate installation of roof perimeter flashing with installation of roof-edge drainage system.
2. Gutters: Join and seal gutter lengths. Allow for thermal expansion. Attach gutters to firmly anchored gutter supports spaced not more than 12 inches (305 mm) **OR** 24 inches (610 mm) **OR** 30 inches (762 mm), **as directed**, apart. Attach ends with rivets and seal with sealant **OR** solder, **as directed**, to make watertight. Slope to downspouts.
 - a. Install gutter with expansion joints at locations indicated but not exceeding 50 feet (15.2 m) apart. Install expansion joint caps.
 - b. Install continuous leaf guards on gutters with noncorrosive fasteners, removable **OR** hinged to swing open, **as directed**, for cleaning gutters.
3. Downspouts: Join sections with manufacturer's standard telescoping joints. Provide hangers with fasteners designed to hold downspouts securely to walls and 1 inch (25 mm) away from walls; locate fasteners at top and bottom and at approximately 60 inches (1500 mm) o.c.
 - a. Provide elbows at base of downspout to direct water away from building.
OR
Connect downspouts to underground drainage system indicated.
4. Splash Pans: Install where downspouts discharge on low-slope roofs. Set in asphalt roofing cement **OR** elastomeric sealant, **as directed**.
5. Parapet Scuppers: Install scuppers through parapet where indicated. Continuously support scupper, set to correct elevation, and seal flanges to interior wall face, over cants or tapered edge strips, and under roofing membrane.
 - a. Anchor scupper closure trim flange to exterior wall and seal or solder to scupper.
 - b. Loosely lock front edge of scupper with conductor head.
 - c. Seal or solder exterior wall scupper flanges into back of conductor head.
6. Conductor Heads: Anchor securely to wall with elevation of conductor top edge 1 inch (25 mm) below scupper **OR** gutter, **as directed**, discharge.

G. Reglet And Counterflashing Installation

1. General: Coordinate installation of reglets and counterflashings with installation of base flashings.



2. Embedded Reglets: See Division 03 Section "Cast-in-place Concrete" and Division 04 Section "Unit Masonry" for installation of reglets.
3. Surface-Mounted Reglets: Install reglets to receive flashings where flashing without embedded reglets is indicated on Drawings. Install at height so that inserted counterflashings overlap 4 inches (100 mm) over top edge of base flashings.
4. Counterflashings: Insert counterflashings into reglets or other indicated receivers; ensure that counterflashings overlap 4 inches (100 mm) over top edge of base flashings. Lap counterflashing joints a minimum of 4 inches (100 mm) and bed with elastomeric **OR** butyl, **as directed**, sealant. Fit counterflashings tightly to base flashings.

H. Cleaning And Protection

1. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
2. Clean and neutralize flux materials. Clean off excess solder and sealants.
3. Remove temporary protective coverings and strippable films as roof specialties are installed. On completion of installation, clean finished surfaces including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain roof specialties in a clean condition during construction.
4. Replace roof specialties that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION 07 71 23 00



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Task	Specification	Specification Description
07 71 23 00	01 22 16 00	No Specification Required
07 71 23 00	05 73 00 00	Miscellaneous Ornamental Metals
07 71 23 00	07 62 00 00	Sheet Metal Flashing And Trim
07 71 26 00	07 62 00 00	Sheet Metal Flashing And Trim



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**SECTION 07 72 13 00 - PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for packaged, outdoor, central-station air-handling units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:
 - a. Direct-expansion cooling.
 - b. Heat-pump refrigeration components.
 - c. Hot-gas reheat.
 - d. Electric-heating coils.
 - e. Gas furnace.
 - f. Economizer outdoor- and return-air damper section.
 - g. Integral, space temperature controls.
 - h. Roof curbs.

C. Definitions

1. DDC: Direct-digital controls.
2. ECM: Electrically commutated motor.
3. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
4. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
5. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
6. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
7. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
8. VVT: Variable-air volume and temperature.

D. Performance Requirements

1. Delegated Design: Design RTU supports to comply with wind and seismic, **as directed**, performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Wind-Restraint Performance:
 - a. Basic Wind Speed: **<Insert value>**.
 - b. Building Classification Category: **I OR II OR III OR IV, as directed**.
 - c. Minimum 10 lb/sq. ft (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
3. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.



- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

E. Submittals

1. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Wiring Diagrams: Power, signal, and control wiring.
4. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.
 - b. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 - c. Wind- and Seismic-Restraint Details, **as directed**: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
5. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Manufacturer Seismic Qualification Certification: Submit certification that RTUs, accessories, and components will withstand seismic forces defined in "Performance Requirements" Article and in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Field quality-control test reports.
8. Operation and maintenance data.
9. Warranty: Special warranty specified in this Section.

F. Quality Assurance

1. ARI Compliance:
 - a. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
 - b. Comply with ARI 270 for testing and rating sound performance for RTUs.
2. ASHRAE Compliance:
 - a. Comply with ASHRAE 15 for refrigeration system safety.
 - b. Comply with ASHRAE 33 for methods of testing cooling and heating coils.



- c. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.
5. UL Compliance: Comply with UL 1995.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Compressors: Manufacturer's standard, but not less than five **OR 10, as directed**, years from date of Final Completion.
 - b. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than five **OR 10 OR 15 OR 20, as directed**, years from date of Final Completion.
 - c. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Final Completion.
 - d. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Final Completion.

1.2 PRODUCTS

A. Casing

1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
2. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - a. Exterior Casing Thickness: 0.052 inch (1.3 mm) **OR** 0.0626 inch (1.6 mm) **OR** 0.079 inch (2.0 mm), **as directed**, thick.
3. Inner Casing Fabrication Requirements:
 - a. Inside Casing: Galvanized steel, 0.034 inch (0.86 mm) **OR** 0.028 inch (0.7 mm), **as directed**, thick, perforated 40 percent free area, **as directed**.
4. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C 1071, Type I.
 - b. Thickness: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**.
 - c. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
 - d. Liner Adhesive: Comply with ASTM C 916, Type I.
5. Condensate Drain Pans: Formed sections of galvanized-steel **OR** stainless-steel, **as directed**, sheet, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1, **as directed**.
 - a. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
 - b. Drain Connections: Threaded nipple both sides of drain pan, **as directed**.
 - c. Pan-Top Surface Coating: Corrosion-resistant compound for galvanized-steel drain pans.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Fans

1. Direct-Driven Supply-Air Fans: Double width, forward curved **OR** backward inclined, **as directed**, centrifugal; with permanently lubricated, multispeed **OR** ECM, **as directed**, motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

**OR**

Belt-Driven Supply-Air Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the casing. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

2. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.
3. Relief-Air Fan: Propeller **OR** Forward curved **OR** Backward inclined, **as directed**, shaft mounted on permanently lubricated motor.
4. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fan-mounted frame and RTU-mounted frame are anchored to building structure.
5. Fan Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

C. Coils

1. Supply-Air Refrigerant Coil:
 - a. Aluminum-plate **OR** Copper-plate, **as directed**, fin and seamless internally grooved, **as directed**, copper tube in steel casing with equalizing-type vertical distributor.
 - b. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
 - c. Coil Split: Interlaced.
 - d. Baked phenolic **OR** Cathodic epoxy, **as directed**, coating.
 - e. Condensate Drain Pan: Galvanized steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, formed with pitch and drain connections complying with ASHRAE 62.1, **as directed**.
2. Outdoor-Air Refrigerant Coil:
 - a. Aluminum-plate **OR** Copper-plate, **as directed**, fin and seamless internally grooved, **as directed**, copper tube in steel casing with equalizing-type vertical distributor.
 - b. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
 - c. Baked phenolic **OR** Cathodic epoxy, **as directed**, coating.
3. Hot-Gas Reheat Refrigerant Coil:
 - a. Aluminum-plate **OR** Copper-plate, **as directed**, fin and seamless internally grooved, **as directed**, copper tube in steel casing with equalizing-type vertical distributor.
 - b. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
 - c. Baked phenolic **OR** Cathodic epoxy, **as directed**, coating.
4. Electric-Resistance Heating:
 - a. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
 - b. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box.
 - c. Overcurrent Protection: Manual-reset thermal cutouts, factory wired in each heater stage.
 - d. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:
 - 1) Magnetic **OR** Mercury, **as directed**, contactors.
 - 2) Step Controller: Pilot lights and override toggle switch for each step.
 - 3) SCR Controller: Pilot lights operate on load ratio, a minimum of five steps.
 - 4) Time-delay relay.
 - 5) Airflow proving switch.

**D. Refrigerant Circuit Components**

1. Number of Refrigerant Circuits: One **OR** Two, **as directed**.
2. Compressor: Hermetic, reciprocating **OR** Semihermetic, reciprocating **OR** Hermetic, scroll, **as directed**, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater, **as directed**.
3. Refrigeration Specialties:
 - a. Refrigerant: R-407C **OR** R-410A, **as directed**.
 - b. Expansion valve with replaceable thermostatic element.
 - c. Refrigerant filter/dryer.
 - d. Manual-reset high-pressure safety switch.
 - e. Automatic-reset low-pressure safety switch.
 - f. Minimum off-time relay.
 - g. Automatic-reset compressor motor thermal overload.
 - h. Brass service valves installed in compressor suction and liquid lines.
 - i. Low-ambient kit high-pressure sensor.
 - j. Hot-gas reheat solenoid valve with a replaceable magnetic coil.
 - k. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
 - l. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

E. Air Filtration

1. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
 - a. Glass Fiber: Minimum 80 percent arrestance, and MERV 5.
 - b. Pleated: Minimum 90 percent arrestance, and MERV 7.

F. Gas Furnace

1. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.
 - a. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: Stainless steel.
 - a. Fuel: Natural **OR** Propane, **as directed**, gas.
 - b. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
 - c. High-Altitude Model **OR** Kit, **as directed**: For Project elevations more than 2000 feet (610 m) above sea level.
3. Heat-Exchanger and Drain Pan: Stainless steel.
4. Venting: Gravity vented with vertical extension, **as directed**.
OR
Power Vent: Integral, motorized centrifugal fan interlocked with gas valve with vertical extension, **as directed**.
5. Safety Controls:
 - a. Gas Control Valve: Single stage **OR** Two stage **OR** Modulating, **as directed**.
 - b. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

G. Dampers

1. Outdoor-Air Damper: Linked damper blades, for 0 to 25 percent outdoor air, with manual **OR** motorized, **as directed**, damper filter.
2. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
 - a. Damper Motor: Modulating with adjustable minimum position.
 - b. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1, with bird screen and hood.

H. Electrical Power Connection



1. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit, **as directed**, and control-circuit transformer with built-in overcurrent protection.

I. Controls

1. Control equipment and sequence of operation are specified in Division 23 Section "Instrumentation And Control For Hvac".
2. Basic Unit Controls:
 - a. Control-voltage transformer.
 - b. Wall-mounted thermostat or sensor with the following features:
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) Fan-speed switch.
 - 4) Manual **OR** Automatic, **as directed**, changeover.
 - 5) Adjustable deadband.
 - 6) Concealed **OR** Exposed, **as directed**, set point.
 - 7) Concealed **OR** Exposed, **as directed**, indication.
 - 8) Degree F **OR** Degree C, **as directed**, indication.
 - 9) Unoccupied-period-override push button.
 - 10) Data entry and access port to input temperature and humidity, **as directed**, set points, occupied and unoccupied periods, and output room temperature and humidity, **as directed**, supply-air temperature, operating mode, and status.
 - c. Wall-mounted humidistat or sensor with the following features:
 - 1) Concealed **OR** Exposed, **as directed**, set point.
 - 2) Concealed **OR** Exposed, **as directed**, indication.
 - d. Remote Wall **OR** Unit, **as directed**, -Mounted Annunciator Panel for Each Unit:
 - 1) Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
 - 2) DDC controller or programmable timer and interface with HVAC instrumentation and control system.
 - 3) Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
3. Electronic **OR** DDC, **as directed**, Controller:
 - a. Controller shall have volatile-memory backup.
 - b. Safety Control Operation:
 - 1) Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
 - 2) Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F (54 deg C) enters unit. Provide additional contacts for alarm interface to fire alarm control panel.
 - 3) Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Division 28 Section(s) "Digital, Addressable Fire-alarm System" **OR** "Zoned (dc Loop) Fire-alarm System", **as directed**.
 - 4) Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F (4 deg C).
 - 5) Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
 - c. Scheduled Operation: Occupied and unoccupied periods on seven-day **OR** 365-day, **as directed**, clock with a minimum of two **OR** four, **as directed**, programmable periods per day.
 - d. Unoccupied Period:
 - 1) Heating Setback: 10 deg F (5.6 deg C).
 - 2) Cooling Setback: System off.
 - 3) Override Operation: Two hours.
 - e. Supply Fan Operation:



- 1) Occupied Periods: Run fan continuously.
- 2) Unoccupied Periods: Cycle fan to maintain setback temperature.
- f. Refrigerant Circuit Operation:
 - 1) Occupied Periods: Cycle or stage compressors, and operate hot-gas bypass, **as directed**, to match compressor output to cooling load to maintain room **OR** discharge, **as directed**, temperature and humidity, **as directed**. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
 - 2) Unoccupied Periods: Compressors off **OR** Cycle compressors and condenser fans for heating to maintain setback temperature, **as directed**.
 - 3) Switch reversing valve for heating or cooling mode on air-to-air heat pump.
- g. Hot-Gas Reheat-Coil Operation:
 - 1) Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles compressor.
 - 2) Unoccupied Periods: Reheat not required.
- h. Gas Furnace Operation:
 - 1) Occupied Periods: Cycle **OR** Stage **OR** Modulate, **as directed**, burner to maintain room **OR** discharge, **as directed**, temperature.
 - 2) Unoccupied Periods: Cycle burner to maintain setback temperature.
- i. Electric-Heating-Coil Operation:
 - 1) Occupied Periods: Cycle **OR** Stage **OR** Modulate, **as directed**, coil to maintain room **OR** discharge, **as directed**, temperature.
 - 2) Unoccupied Periods: Energize coil to maintain setback temperature.
 - 3) Operate supplemental electric heating coil with compressor for heating with outdoor temperature below 25 deg F (minus 4 deg C).
- j. Fixed Minimum Outdoor-Air Damper Operation:
 - 1) Occupied Periods: Open to 25 percent.
 - 2) Unoccupied Periods: Close the outdoor-air damper.
- k. Economizer Outdoor-Air Damper Operation:
 - 1) Occupied Periods: Open to 10 **OR** 25, **as directed**, percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II. Controller shall permit air-side economizer operation when outdoor air is less than 60 deg F (15 deg C). Use outdoor-air temperature **OR** mixed-air and outdoor-air temperature **OR** outdoor-air enthalpy **OR** mixed-air temperature and select between outdoor-air and return-air enthalpy, **as directed**, to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper, **as directed**. During economizer cycle operation, lock out cooling.
 - 2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
 - 3) Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from 2- to 10-V dc **OR** 4 to 20 mA, **as directed**.
- l. Carbon Dioxide Sensor Operation:
 - 1) Occupied Periods: Reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 1000-ppm concentration.
 - 2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- m. VVT Relays:
 - 1) Provide heating- and cooling-mode changeover relays compatible with VVT terminal control system required in Division 23 Section(s) "Air Terminal Units" AND "Instrumentation And Control For Hvac".
4. Interface Requirements for HVAC Instrumentation and Control System:
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
 - c. Provide BACnet **OR** LonWorks, **as directed**, compatible interface for central HVAC control workstation for the following:
 - 1) Adjusting set points.



- 2) Monitoring supply fan start, stop, and operation.
- 3) Inquiring data to include outdoor-air damper position, **as directed**, supply- and room-air temperature and humidity, **as directed**.
- 4) Monitoring occupied and unoccupied operations.
- 5) Monitoring constant and variable motor loads.
- 6) Monitoring variable-frequency drive operation.
- 7) Monitoring cooling load.
- 8) Monitoring economizer cycles.
- 9) Monitoring air-distribution static pressure and ventilation air volume.

J. Accessories

1. Electric heater with integral thermostat maintains minimum 50 deg F (10 deg C) temperature in gas burner compartment.
2. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open, **as directed**.
3. Low-ambient kit using staged **OR** damper on **OR** variable-speed, **as directed**, condenser fans for operation down to 35 deg F (1.7 deg C).
4. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
5. Coil guards of painted, galvanized-steel wire.
6. Hail guards of galvanized steel, painted to match casing.
7. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

K. Roof Curbs

1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
OR
Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C 1071, Type I or II.
 - 2) Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C 916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - 3) Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - 4) Liner Adhesive: Comply with ASTM C 916, Type I.
2. Curb Height: 14 inches (355 mm) **OR** 24 inches (610 mm) **OR** 36 inches (910 mm), **as directed**.
3. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for wind-load requirements.

1.3 EXECUTION

A. Installation



1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger than supported equipment and minimum 6 inches (150 mm) above finished ground elevation.
 - b. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - c. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - d. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - e. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
 2. Equipment Mounting: Install RTUs on concrete base using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
OR
Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Accessories". Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
 3. Unit Support: Install unit level on structural curbs **OR** pilings, **as directed**. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
 4. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- B. Connections
1. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
 2. Install piping adjacent to RTUs to allow service and maintenance.
 - a. Gas Piping: Comply with applicable requirements in Division 23 Section(s) "Facility Natural-gas Piping" **OR** "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
 3. Duct installation requirements are specified in other Division 21. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - a. Install ducts to termination at top of roof curb.
 - b. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 - c. Connect supply ducts to RTUs with flexible duct connectors specified in Division 23 Section "Air Duct Accessories".
 - d. Install return-air duct continuously through roof structure.
 - e. Install normal-weight, 3000-psi (20.7-MPa), compressive strength (28-day) concrete mix inside roof curb, 4 inches (100 mm) thick. Concrete, formwork, and reinforcement are specified in Division 31.
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 2. Tests and Inspections:
 - a. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - b. Inspect for and remove shipping bolts, blocks, and tie-down straps.



- c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning units and retest as specified above.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
2. Complete installation and startup checks according to manufacturer's written instructions and do the following:
 - a. Inspect for visible damage to unit casing.
 - b. Inspect for visible damage to furnace combustion chamber.
 - c. Inspect for visible damage to compressor, coils, and fans.
 - d. Inspect internal insulation.
 - e. Verify that labels are clearly visible.
 - f. Verify that clearances have been provided for servicing.
 - g. Verify that controls are connected and operable.
 - h. Verify that filters are installed.
 - i. Clean condenser coil and inspect for construction debris.
 - j. Clean furnace flue and inspect for construction debris.
 - k. Connect and purge gas line.
 - l. Remove packing from vibration isolators.
 - m. Inspect operation of barometric relief dampers.
 - n. Verify lubrication on fan and motor bearings.
 - o. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - p. Adjust fan belts to proper alignment and tension.
 - q. Start unit according to manufacturer's written instructions.
 - 1) Start refrigeration system.
 - 2) Do not operate below recommended low-ambient temperature.
 - 3) Complete startup sheets and attach copy with Contractor's startup report.
 - r. Inspect and record performance of interlocks and protective devices; verify sequences.
 - s. Operate unit for an initial period as recommended or required by manufacturer.
 - t. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
 - 1) Measure gas pressure on manifold.
 - 2) Inspect operation of power vents.
 - 3) Measure combustion-air temperature at inlet to combustion chamber.
 - 4) Measure flue-gas temperature at furnace discharge.
 - 5) Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - 6) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 - u. Calibrate thermostats.
 - v. Adjust and inspect high-temperature limits.
 - w. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
 - x. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F (8 deg C) above return-air temperature:
 - 1) Coil leaving-air, dry- and wet-bulb temperatures.
 - 2) Coil entering-air, dry- and wet-bulb temperatures.
 - 3) Outdoor-air, dry-bulb temperature.
 - 4) Outdoor-air-coil, discharge-air, dry-bulb temperature.
 - y. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 - z. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.



- 1) Supply-air volume.
 - 2) Return-air volume.
 - 3) Relief-air volume.
 - 4) Outdoor-air intake volume.
 - aa. Simulate maximum cooling demand and inspect the following:
 - 1) Compressor refrigerant suction and hot-gas pressures.
 - 2) Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
 - bb. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
 - 1) High-temperature limit on gas-fired heat exchanger.
 - 2) Low-temperature safety operation.
 - 3) Filter high-pressure differential alarm.
 - 4) Economizer to minimum outdoor-air changeover.
 - 5) Relief-air fan operation.
 - 6) Smoke and firestat alarms.
 - cc. After startup and performance testing and prior to Final Completion, replace existing filters with new filters.
- E. Cleaning And Adjusting
1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.
 2. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.
- F. Demonstration
- G. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 07 72 13 00



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**SECTION 07 72 13 00a - INTAKE AND RELIEF VENTILATORS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for intake and relief ventilators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Louvered-penthouse ventilators.
 - b. Roof hoods.
 - c. Goosenecks.

C. Performance Requirements

1. Delegated Design: Design ventilators, including comprehensive engineering analysis by a qualified professional engineer, using structural and seismic performance requirements and design criteria indicated.
2. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
 - a. Wind Loads: Determine loads based on pressures as indicated on Drawings.
OR
Wind Loads: Determine loads based on a uniform pressure of 20 lbf/sq. ft. (960 Pa) **OR** 30 lbf/sq. ft. (1440 Pa), **as directed**, acting inward or outward.
OR
Wind Loads: Determine loads based on pressures indicated below:
 - 1) Corner Zone: Within **<Insert distance>** of building corners, uniform pressure of **<Insert design wind pressure>**, acting inward, and **<Insert design wind pressure>**, acting outward.
 - 2) Other Than Corner Zone: Uniform pressure of **<Insert design wind pressure>**, acting inward, and **<Insert design wind pressure>**, acting outward.
3. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
4. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
5. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

D. Submittals

1. Product Data: For each type of product indicated. For louvered-penthouse ventilators specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
2. LEED Submittal:



- a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62., Section 5 - "Systems and Equipment."
3. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
 - a. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
4. Samples: For each exposed product and for each color and texture specified.
5. Delegated-Design Submittal: For shop-fabricated ventilators indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of shop-fabricated ventilators.
6. Coordination Drawings: Roof framing plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - a. Structural members to which roof curbs and ventilators will be attached.
 - b. Sizes and locations of roof openings.
7. Seismic Qualification Certificates: For ventilators, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
8. Welding certificates.

E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - b. AWS D1.3, "Structural Welding Code - Sheet Steel."

F. Coordination

1. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.2 PRODUCTS

A. Materials

1. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or T-52.
2. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
3. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating, mill phosphatized.
4. Stainless-Steel Sheet: ASTM A 666, Type 304, with No. 4 **OR** 6, **as directed**, finish.
5. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.
 - a. Use types and sizes to suit unit installation conditions.
 - b. Use Phillips flat **OR** hex-head or Phillips pan, **as directed**, -head screws for exposed fasteners unless otherwise indicated.
6. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
7. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.



- B. Fabrication, General
1. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
 2. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
 3. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
 4. Fabricate supports, anchorages, and accessories required for complete assembly.
 5. Perform shop welding by AWS-certified procedures and personnel.
- C. Louvered-Penthouse Ventilators
1. Construction: All-welded assembly with 4-inch (100-mm) **OR** 6-inch (150-mm), **as directed**, -deep louvers, mitered corners, and aluminum **OR** galvanized-steel **OR** stainless-steel, **as directed**, sheet roof with mineral-fiber insulation and vapor barrier, **as directed**.
 2. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080 inch (2.0 mm) for frames and 0.080 inch (2.0 mm) **OR** 0.060 inch (1.5 mm), **as directed**, for blades with condensate deflectors, **as directed**.
 - a. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
 - b. Exterior Corners: Prefabricated corner units with mitered and welded blades **OR** mitered blades with concealed close-fitting splices, **as directed**, and with fully recessed **OR** semirecessed, **as directed**, mullions at corners.
 3. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, of thickness required to comply with structural performance requirements, but not less than 0.052 inch (1.3 mm) for frames and 0.040 inch (1.0 mm) **OR** 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm), **as directed**, for blades with condensate deflectors, **as directed**.
 - a. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
 - b. Exterior Corners: Prefabricated corner units with mitered and welded blades **OR** mitered blades with concealed close-fitting splices, **as directed**, and with fully recessed **OR** semirecessed, **as directed**, mullions at corners.
 4. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, of thickness required to comply with structural performance requirements, but not less than 0.050 inch (1.27 mm) **OR** 0.062 inch (1.57 mm), **as directed**, with grain running parallel **OR** perpendicular, **as directed**, to length of blades and frame members with condensate deflectors, **as directed**.
 - a. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
 - b. Exterior Corners: Prefabricated corner units with mitered and welded blades **OR** mitered blades with concealed close-fitting splices, **as directed**, and with fully recessed **OR** semirecessed, **as directed**, mullions at corners.
 5. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.
 - a. Configuration: Self-flashing without a cant strip, with **OR** Built-in cant and **OR** Built-in raised cant and, **as directed**, mounting flange.
 - b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
 6. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire **OR** Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire **OR** Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick **OR** Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire, **as directed**.
OR
Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) **OR** Stainless-steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm), **as directed**, wire.
 7. Galvanized-Steel Sheet Finish:
 - a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to



ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.

- b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
- c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).
 - 1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

8. Accessories:

a. Dampers:

- 1) Location: Penthouse neck **OR** Inside louver face, **as directed**.
- 2) Control: Manual **OR** Motorized, **as directed**.

D. Roof Hoods

- 1. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 5-6 and 5-7.
- 2. Materials: Galvanized-steel sheet, minimum 0.064-inch- (1.62-mm-) thick base and 0.040-inch- (1.0-mm-) thick hood **OR** Aluminum sheet, minimum 0.063-inch- (1.6-mm-) thick base and 0.050-inch- (1.27-mm-) thick hood, **as directed**; suitably reinforced.
- 3. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.
 - a. Configuration: Self-flashing without a cant strip, with **OR** Built-in cant and **OR** Built-in raised cant and, **as directed**, mounting flange.
 - b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
- 4. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire **OR** Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire **OR** Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick **OR** Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire, **as directed**.
OR
Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) **OR** Stainless-steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm), **as directed**, wire.
- 5. Galvanized-Steel Sheet Finish:
 - a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
 - b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
 - c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).
 - 1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

E. Goosenecks

- 1. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 5-5; with a minimum of 0.052-inch- (1.3-mm-) thick, galvanized-steel sheet.
- 2. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.



- a. Configuration: Self-flashing without a cant strip, with **OR** Built-in cant and **OR** Built-in raised cant and, **as directed**, mounting flange.
- b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
3. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire **OR** Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire **OR** Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick **OR** Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire, **as directed**.
OR
Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) **OR** Stainless-steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm), **as directed**, wire.
4. Galvanized-Steel Sheet Finish:
 - a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
 - b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
 - c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).
 - 1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

1.3 EXECUTION

A. Installation

1. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
2. Install goosenecks on curb base where throat size exceeds 9 by 9 inches (230 by 230 mm).
3. Install gravity ventilators with clearances for service and maintenance.
4. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
5. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 Section "Joint Sealants" for sealants applied during installation.
6. Label gravity ventilators according to requirements specified in Division 23 Section "Identification For Hvac Piping And Equipment".
7. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
8. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

B. Connections

1. Duct installation and connection requirements are specified in other Division 21. Drawings indicate general arrangement of ducts and duct accessories.

C. Adjusting

1. Adjust damper linkages for proper damper operation.

END OF SECTION 07 72 13 00a



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**SECTION 07 72 23 00 - ROOF ACCESSORIES**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for roof accessories. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Roof curbs.
 - b. Equipment supports.
 - c. Roof hatches.
 - d. Dropout-type heat and smoke vents.
 - e. Hatch-type heat and smoke vents.
 - f. Gravity ventilators.
 - g. Roof supports.
 - h. Roof walkways.
 - i. Preformed flashings.

C. Submittals

1. Product Data: For each type of roof accessory indicated.
2. Shop Drawings: Show fabrication and installation details for roof accessories.
3. Samples: For each type of exposed factory-applied color finish required and for each type of roof accessory indicated, prepared on Samples of size to adequately show color.

D. Quality Assurance

1. Sheet Metal Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" details for fabrication of units, including flanges and cap flashing to coordinate with type of roofing indicated.

E. Delivery, Storage, And Handling

1. Pack, handle, and ship roof accessories properly labeled in heavy-duty packaging to prevent damage.

F. Warranty

1. Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace roof accessories that show evidence of deterioration of factory-applied finishes within 20 years from date of Final Completion.

1.2 PRODUCTS

A. Metal Materials

1. Galvanized Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coated and mill phosphatized for field painting.
2. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, AZ50 (AZM150) coated.
3. Prepainted, Metallic-Coated Steel Sheet: Steel sheet metallic coated by hot-dip process and prepainted by coil-coating process to comply with ASTM A 755/A 755M.
 - a. Galvanized Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coated.
 - b. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 (Class AZM150) coated.



- c. Exposed Finishes: Manufacturer's standard 2-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight.
 4. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy and temper recommended by manufacturer for type of use and mill finish. Coil-coat finish as follows:
 - a. Factory-Prime Coating: Where painting after installation is indicated, provide pretreatment and white or light-colored, factory-applied, baked-on epoxy primer coat; with a minimum dry film thickness of 0.2 mil (0.005 mm).
 - b. Clear **OR** Color, **as directed**, Anodic Finish: Architectural Class II, complying with AAMA 611.
 - 1) Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** Champagne, **as directed**.
 - c. Baked-Enamel Finish: Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm), medium gloss.
 - 1) Color and Gloss: As selected from manufacturer's full range.
 - d. High-Performance Organic Finish: Manufacturer's standard 2-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight.
 - 1) Color and Gloss: As selected from manufacturer's full range.
 - e. Powder-Coat Finish: Immediately after cleaning and pretreating, electrostatically apply manufacturer's standard baked-polymer thermosetting powder finish.
 - 1) Color and Gloss: As selected from manufacturer's full range.
 5. Stainless-Steel Shapes or Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304 or Type 316, No. 2D finish.
 6. Aluminum Extrusions and Tubes: ASTM B 221 (ASTM B 221M), alloy and temper recommended by manufacturer for type of use, mill finished.
 7. Steel Shapes: ASTM A 36/A 36M, hot-dip galvanized to comply with ASTM A 123/A 123M, unless otherwise indicated.
 8. Steel Tube: ASTM A 500, round tube, baked-enamel finished.
 9. Galvanized Steel Tube: ASTM A 500, round tube, hot-dip galvanized to comply with ASTM A 123/A 123M.
 10. Galvanized Steel Pipe: ASTM A 53/A 53M.
- B. Miscellaneous Materials
1. Acrylic Glazing: ASTM D 4802, thermoformable, monolithic sheet, category as standard with manufacturer, Type UVA (formulated with UV absorber), Finish 1 (smooth or polished).
 2. Polycarbonate Glazing: Thermoformable, monolithic polycarbonate sheets manufactured by extrusion process, burglar-resistance rated per UL 972 with an average impact strength of 12 to 16 ft-lbf/in. (640 to 854 J/m) of width when tested according to ASTM D 256, Method A (Izod).
 3. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 1, 1 inch (25 mm) thick.
 4. Glass-Fiber Board Insulation: ASTM C 726, 1 inch (25 mm) thick.
 5. Polyisocyanurate Board Insulation: ASTM C 1289, 1 inch (25 mm) thick.
 6. Wood Nailers: Softwood lumber, pressure treated with waterborne preservatives for aboveground use, complying with AWPA C2; not less than 1-1/2 inches (38 mm) thick.
 7. Security Grilles: 3/4-inch- (19-mm-) diameter, ASTM A 1011/A 1011M steel bars spaced 6 inches (150 mm) o.c. in 1 direction and 12 inches (300 mm) o.c. in the other; factory primed.
 - a. Factory Finish:
 - 1) Surface Preparation: Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
 - 2) Factory Priming for Field-Painted Finish: Apply shop primer specified below immediately after surface preparation and pretreatment.
 - 3) Shop Primer: Manufacturer's or fabricator's standard, fast-curing, lead- and chromate-free, universal primer; selected for resistance to normal atmospheric



corrosion, for compatibility with substrate and field-applied finish paint system indicated, and for capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.

8. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil (0.4-mm) dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.
9. Polyethylene Sheet: 6-mil- (0.15-mm-) thick, polyethylene sheet complying with ASTM D 4397.
10. Felt: ASTM D 226, Type II (No. 30), asphalt-saturated organic felt, nonperforated.
 - a. Slip Sheet: Rosin-sized paper, minimum 3 lb/100 sq. ft. (0.16 kg/sq. m).
11. Fasteners: Same metal as metals being fastened, or nonmagnetic stainless steel or other noncorrosive metal as recommended by roof accessory manufacturer. Match finish of exposed fasteners with finish of material being fastened. Provide nonremovable fastener heads to exterior exposed fasteners.
12. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, or PVC; or flat design of foam rubber, sponge neoprene, or cork.
13. Elastomeric Sealant: ASTM C 920, polyurethane **OR** polysulfide **OR** silicone, **as directed**, sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.
14. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant, polyisobutylene plasticized, and heavy bodied for hooked-type expansion joints with limited movement.
15. Roofing Cement: ASTM D 4586, nonasbestos, fibrated asphalt cement designed for trowel application or other adhesive compatible with roofing system.

C. Roof Curbs

1. Roof Curbs: Provide metal roof curbs, internally reinforced and capable of supporting superimposed live and dead loads, including equipment loads and other construction to be supported on roof curbs. Fabricate with welded or sealed mechanical corner joints, with integral metal cant, **OR** stepped integral metal cant raised the thickness of roof insulation, **as directed**, and integral formed mounting flange at perimeter bottom. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.
 - a. Load Requirements: As required to satisfy local code requirements.
 - b. Material:
 - 1) Galvanized **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.052 inch (1.32 mm) **OR** 0.079 inch (2.0 mm), **as directed**, thick.
 - 2) Aluminum sheet, 0.090 inch (2.28 mm) thick.
 - 3) Stainless-steel sheet, 0.078 inch (1.98 mm) thick.
 - c. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - d. Liner: Same material as curb, of manufacturer's standard thickness and finish.
 - e. Factory install wood nailers at tops of curbs.
 - f. On ribbed or fluted metal roofs, form flange at perimeter bottom to conform to roof profile.
 - g. Factory insulate curbs with 1-1/2-inch- (38-mm-) thick, cellulosic-fiber **OR** glass-fiber, **as directed**, board insulation.
 - h. Curb height may be determined by adding thickness of roof insulation and minimum base flashing height recommended by roofing membrane manufacturer. Fabricate units to minimum height of 12 inches (300 mm), unless otherwise indicated.
 - i. Sloping Roofs: Where slope of roof deck exceeds 1:48, fabricate curb units with water diverter or cricket and with height tapered to match slope to level tops of units.

D. Equipment Supports

1. Equipment Supports: Provide metal equipment supports, internally reinforced and capable of supporting superimposed live and dead loads, including equipment loads and other construction to be supported. Fabricate with welded or sealed mechanical corner joints, with integral metal



cant **OR** stepped integral metal cant raised the thickness of roof insulation, **as directed**, and integral formed mounting flange at perimeter bottom. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

- a. Load Requirements: As required to satisfy local code requirements.
- b. Material:
 - 1) Galvanized **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.052 inch (1.32 mm) **OR** 0.079 inch (2.0 mm), **as directed**, thick.
 - 2) Aluminum sheet, 0.090 inch (2.28 mm) thick.
 - 3) Stainless-steel sheet, 0.078 inch (1.98 mm) thick.
- c. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
- d. Factory-install continuous wood nailers 3-1/2 inches (90 mm) **OR** 5-1/2 inches (140 mm), **as directed**, wide at tops of equipment supports.
- e. Metal Counterflashing: Manufacturer's standard removable counterflashing, fabricated of same metal and finish as equipment support.
- f. On ribbed or fluted metal roofs, form flange at perimeter bottom to conform to roof profile.
- g. Fabricate units to minimum height of 12 inches (300 mm), unless otherwise indicated.
- h. Sloping Roofs: Where slope of roof deck exceeds 1:48, fabricate curb units with water diverter or cricket and with height tapered to match slope to level tops of units.

E. Roof Hatches

1. Roof Hatches: Fabricate roof hatches with insulated double-wall lids and insulated single-wall **OR** double-wall, **as directed**, curb frame with integral deck mounting flange and lid frame counterflashing. Fabricate with welded or mechanically fastened and sealed corner joints. Provide continuous weathertight perimeter gasketing and equip with corrosion-resistant or hot-dip galvanized hardware.
 - a. Loads: Fabricate roof hatches to withstand 40-lbf/sq. ft. (1.9-kPa) external and 20-lbf/sq. ft. (0.95-kPa) internal loads.
 - b. Type and Size: Single-leaf lid, 30 by 36 inches (750 by 900 mm) **OR** 30 by 54 inches (750 by 1370 mm) **OR** 30 by 96 inches (750 by 2440 mm), **as directed**.
 - c. Type and Size: Double-leaf lid, 72 by 96 inches (1830 by 2440 mm).
 - d. Curb and Lid Material:
 - 1) Galvanized **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.079 inch (2.0 mm) thick.
 - 2) Aluminum sheet, 0.090 inch (2.28 mm) thick.
 - 3) Stainless-steel sheet, 0.078 inch (1.98 mm) thick.
 - e. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - f. Insulation: Cellulosic-fiber **OR** Glass-fiber **OR** Polyisocyanurate, **as directed**, board.
 - g. Interior Lid Liner: Manufacturer's standard metal liner of same material and finish as outer metal lid.
 - h. Exterior Curb Liner: Manufacturer's standard metal liner of same material and finish as metal curb.
 - i. On ribbed or fluted metal roofs, form flange at perimeter bottom to conform to roof profile.
 - j. Fabricate units to minimum height of 12 inches (300 mm), unless otherwise indicated.
 - k. Sloping Roofs: Where slope or roof deck exceeds 1:48, fabricate hatch curbs with height constant **OR** tapered to match slope to level tops of units, **as directed**.
 - l. Hardware: Galvanized steel **OR** Stainless-steel, **as directed**, spring latch with turn handles, butt- or pintle-type hinge system, and padlock hasps inside and outside.
 - 1) Provide 2-point latch on covers larger than 84 inches (2130 mm).
 - 2) Provide remote-control operation.



- m. Ladder Safety Post: Manufacturer's standard ladder safety post. Post to lock in place on full extension. Provide release mechanism to return post to closed position.
 - n. Safety Railing System: Manufacturer's standard complete system including rails, clamps, fasteners, safety barrier at railing opening, and all accessories required for a complete installation.
- F. Heat And Smoke Vents
- 1. Dropout-Type Heat and Smoke Vents: Manufacturer's standard gravity-operated, automatic smoke and heat vents with integral double-wall insulated curbs and frame with welded or sealed mechanical corner joints, integral condensation gutter, cap flashing, and heat-sensitive dome glazing that will deform and drop out of vent opening within 5 minutes of exposure to a simulated fire represented by a time-temperature gradient that reaches an air temperature of 500 deg F (260 deg C) within 5 minutes.
 - a. Loads: Fabricate heat and smoke vents to withstand a minimum 40-lbf/sq. ft. (1.9-kPa) external live load and 30-lbf/sq. ft. (1.4-kPa) uplift.
 - 1) Dome glazing shall have a thickness capable of resisting 40-lbf/sq. ft. (1.9-kPa) external and 20-lbf/sq. ft. (0.95-kPa) internal loads.
 - b. Regulatory Requirements: Comply with UL 793 and NFPA 204.
 - c. Heat and Smoke Vent Compliance: Provide units that have been tested and UL listed **OR** FMG approved, **as directed**.
 - d. Integral Curb and Framing Material:
 - 1) Galvanized **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.079 inch (2.0 mm) thick.
 - 2) Aluminum sheet, 0.090 inch (2.28 mm) thick.
 - 3) Stainless-steel sheet, 0.078 inch (1.98 mm) thick.
 - e. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Finish: Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
 - f. Insulation: Cellulosic-fiber **OR** Glass-fiber **OR** Polyisocyanurate, **as directed**, board.
 - g. Exterior Curb Liner: Manufacturer's standard metal liner of same material and finish as metal curb.
 - h. Fabricate integral curbs to minimum height of 12 inches (300 mm), unless otherwise indicated.
 - i. Sloping Roofs: Where slope of roof deck exceeds 1:48, fabricate curbs with height constant **OR** tapered to match slope to level tops of units, **as directed**.
 - j. Dome Glazing: Single **OR** Double, **as directed**, acrylic **OR** polycarbonate, **as directed**, glazing.
 - 1) Single-Dome Color: Colorless, transparent **OR** White, translucent **OR** Gray tinted, transparent **OR** Bronze tinted, transparent, **as directed**.
 - 2) Outer Double-Dome Color: Colorless, transparent **OR** White, translucent **OR** Gray tinted, transparent **OR** Bronze tinted, transparent, **as directed**.
 - 3) Inner Double-Dome Color: Colorless, transparent **OR** White, translucent **OR** Gray tinted, transparent **OR** Bronze tinted, transparent, **as directed**.
 - 2. Hatch-Type Heat and Smoke Vents: Manufacturer's standard single-leaf **OR** double-leaf, **as directed**, hatch-type heat and smoke vents with integral double-wall insulated curbs and frame, with welded or sealed mechanical corner joints, integral condensation gutter, and cap flashing. Fabricate with insulated double-wall lid, continuous weathertight perimeter lid gaskets, and equip with automatic self-lifting mechanisms, UL-listed fusible links rated at 165 deg F (74 deg C) **OR** fire-suppression system **OR** smoke-detection system, **as directed**, and corrosion-resistant or hot-dip galvanized hardware including hinges, hold-open devices, and independent manual-release devices for inside and outside operation of lids.
 - a. Loads: Fabricate heat and smoke vent to withstand a minimum 40-lbf/sq. ft. (1.9-kPa) external live load and 30-lbf/sq. ft. (1.4-kPa) uplift.
 - 1) When release is actuated, lid shall open against 10-lbf/sq. ft. (0.5-kPa) snow or wind load and lock in position.



- b. Regulatory Requirements: UL 793 and NFPA 204.
- c. Heat and Smoke Vent Compliance: Provide units that have been tested and UL listed **OR** FMG approved, **as directed**.
- d. Fire Resistance of Lids: UL Class A rating.
- e. Integral Curb, Framing, and Lid Material:
 - 1) Galvanized **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.079 inch (2.0 mm) thick.
 - 2) Aluminum sheet, 0.090 inch (2.28 mm) thick.
 - 3) Stainless-steel sheet, 0.078 inch (1.98 mm) thick.
- f. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
- g. Insulation: Cellulosic-fiber **OR** Glass-fiber **OR** Polyisocyanurate, **as directed**, board.
- h. Fabricate integral curbs to minimum height of 12 inches (300 mm), unless otherwise indicated.
- i. Sloping Roofs: Where slope of roof deck exceeds 1:48, fabricate curbs with height constant **OR** tapered to match slope to level tops of units, **as directed**.

G. Gravity Ventilators

1. Low-Profile, Cylindrical-Style Gravity Ventilators: Manufacturer's standard unit fabricated from the following materials, with manufacturer's standard welded or sealed mechanical joints:
 - a. Provide integral base flange, vent cylinder, cylinder bird screen, and rain cap **OR** hood, **as directed**.
 - b. Dimensions: As indicated.
 - c. Style: As indicated.
 - d. Bird Screens: Manufacturer's standard mesh with rewireable frame.
 - e. Insect Screens: Manufacturer's standard mesh with rewireable frame.
 - f. Vent Cylinder, Base Flange, and Rain-Cap **OR** Hood, **as directed** Material: Galvanized steel **OR** Aluminum **OR** Stainless-steel, **as directed**, sheet, of manufacturer's standard thickness.
 - g. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
2. Low-Profile, Louvered Penthouse-Style Gravity Ventilators: Manufacturer's standard unit fabricated from the following materials, with manufacturer's standard welded or sealed mechanical joints:
 - a. Provide integral frame with base flange, weathertight cap, louver bird screen, and weatherproof sidewall louvers.
 - b. Dimensions: As indicated.
 - c. Style: As indicated.
 - d. Bird Screens: Manufacturer's standard mesh with rewireable frame.
 - e. Insect Screens: Manufacturer's standard mesh with rewireable frame.
 - f. Integral Frame, Base Flange, Weathertight Cap, and Louver Material: Galvanized steel **OR** Aluminum **OR** Stainless-steel, **as directed**, sheet, of manufacturer's standard thickness.
 - g. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
3. Directional Louvered Pedestal-Style Gravity Ventilators: Manufacturer's standard unit fabricated from the following materials, with manufacturer's standard welded or sealed mechanical joints:
 - a. Provide integral weathertight base cap, integral outlet duct, weathertight sidewalls, bird screen, and weatherproof sidewall louver.



- b. Dimensions: As indicated.
 - c. Style: As indicated.
 - d. Bird Screens: Manufacturer's standard mesh with rewireable frame.
 - e. Insect Screens: Manufacturer's standard mesh with rewireable frame.
 - f. Weathertight Base Cap, Outlet Duct, Sidewall, and Louver Material: Galvanized steel **OR** Aluminum **OR** Stainless-steel, **as directed**, sheet, of manufacturer's standard thickness.
 - g. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Mill **OR** Clear anodic **OR** Color anodic, **as directed**.
4. Turbine-Style Gravity Ventilators: Manufacturer's standard unit fabricated from the following materials, with manufacturer's standard welded or sealed mechanical joints:
- a. Provide integral weathertight base cap, outlet duct, and rotating louvered turbine.
 - b. Dimensions: As indicated.
 - c. Style: As indicated.
 - d. Bird Screens: Manufacturer's standard mesh with rewireable frame.
 - e. Insect Screens: Manufacturer's standard mesh with rewireable frame.
 - f. Weathertight Base Cap, Outlet Duct, and Turbine Material: Galvanized steel **OR** Aluminum, **as directed**, sheet, of manufacturer's standard thickness.
 - g. Finish:
 - 1) Prime painted **OR** Baked enamel **OR** High-performance organic coating **OR** Powder coat, **as directed**.
 - 2) Mill **OR** Clear anodic **OR** Color anodic, **as directed**.

H. Roof Supports

- 1. Pipe Roof Supports: Adjustable height, extruded-aluminum tube, urethane insulation filled, 2 inches (50 mm) in diameter, with aluminum base plates and manufacturer's recommended hardware for mounting to structure **OR** structural roof deck, **as directed**, and extruded-aluminum carrier assemblies, suitable for quantity of pipe runs and sizes, with EPDM end caps. Include manufacturer's standard hardware for mounting to structure or structural roof deck.
 - a. Pipe Support Height: As indicated.
 - b. Pipe Roller Assembly: Stainless-steel roller assembly sized for supported pipes with extruded aluminum.
 - c. Pipe Support Flashing: Insulated **OR** Uninsulated, **as directed**, sleeve flashings with integral base flange, and EPDM grommetted top seal and base seals.
 - 1) Metal: Aluminum sheet, 0.064 inch (1.6 mm) thick **OR** Copper sheet, 16 oz. (0.55 mm) thick, **as directed**.
- 2. Terrace Lighting Roof Supports: Epoxy-coated hollow structural section steel pipe support, urethane insulation filled, with epoxy-coated steel base plates and manufacturer's recommended hardware for mounting to structure **OR** structural roof deck, **as directed**, 14 inches (356 mm) **OR** 18 inches (457 mm), **as directed**, high, with galvanized threaded cap.
 - a. Lighting Pole Mounting: Stainless-steel lighting pole adapter **OR** Epoxy-coated steel plate with stainless-steel studs, **as directed**.
 - b. Pipe Support Flashing: Insulated **OR** Uninsulated, , metal sleeve flashings with integral base flange, and EPDM grommetted top seal and base seals.
 - 1) Metal: Aluminum sheet, 0.064 inch (1.6 mm) thick **OR** Copper sheet, 16 oz. (0.55 mm) thick, **as directed**.
- 3. Light-Duty Pipe Roof Supports: Extruded-aluminum base assembly and Type 304 stainless-steel roller assembly for pipe sizes indicated, including manufacturer's standard hardware for mounting to structure or structural roof deck.
- 4. Duct Roof Supports: 2-inch- (50-mm-) diameter, extruded-aluminum, urethane-insulated supports, including manufacturer's standard hardware for mounting to structure or structural roof deck.

I. Roof Walkways



1. Roof Walkway: Multiple C-shaped-channel formed-metal planks, as follows, with upper surface punched in serrated diamond or rectangular shapes to produce raised slip-resistant surface and drainage holes. Provide support framing, brackets, connectors, nosings, and other accessories and components needed for complete installation. Include step units for changes in elevation.
 - a. Plank Width: 4-3/4 inches (121 mm) **OR** 7 inches (178 mm) **OR** 9-1/2 inches (241 mm) **OR** 11-3/4 inches (298 mm) **OR** 18-3/4 inches (476 mm) **OR** 24 inches (610 mm) **OR** As indicated, **as directed**.
 - b. Walkway Width: As indicated.
 - c. Channel Depth: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 2-1/2 inches (64 mm) **OR** 3 inches (76 mm) **OR** As indicated., **as directed**
 - d. Metal Material: -0.079-inch- (2.0-mm-) thick, hot-dip galvanized steel sheet **OR** 0.108-inch- (2.8-mm-) thick, hot-dip galvanized steel sheet **OR** 0.062-inch- (1.6-mm-) thick, stainless-steel sheet **OR** 0.078-inch- (1.98-mm-) thick, stainless-steel sheet **OR** 0.080-inch- (2.03-mm-) thick, mill-finished aluminum sheet **OR** 0.100-inch- (2.5-mm-) thick, mill-finished aluminum sheet, **as directed**.
 - e. Provide isolation pads attached to supports so supports are completely isolated from roof membrane surface.

J. Preformed Flashings

1. Exhaust Vent Flashings: Double-wall metal flashing sleeve, urethane insulation filled, with integral deck flange, 12 inches (300 mm) high, with removable metal hood and slotted **OR** perforated, **as directed**, metal collar, and as follows:
 - a. Metal: Aluminum sheet, 0.064 inch (1.6 mm) thick, mill finished **OR** Copper sheet, 16 oz. (0.55 mm thick), **as directed**.
 - b. Diameter: As indicated.
2. Vent Stack Flashing: Metal flashing sleeve, with integral deck flange, uninsulated, and as follows:
 - a. Metal: Aluminum sheet, 0.064 inch (1.6 mm) thick, mill finished **OR** Copper sheet, 16 oz. (0.55 mm thick), **as directed**.
 - b. Height: As indicated..
 - c. Diameter: As indicated.

1.3 EXECUTION

A. Installation

1. General: Install roof accessories according to manufacturer's written instructions. Anchor roof accessories securely in place and capable of resisting forces specified. Use fasteners, separators, sealants, and other miscellaneous items as required for completing roof accessory installation. Install roof accessories to resist exposure to weather without failing, rattling, leaking, and fastener disengagement.
2. Install roof accessories to fit substrates and to result in watertight performance.
3. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
 - a. Coat concealed side of uncoated aluminum **OR** stainless-steel, **as directed**, roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
 - b. Underlayment: Where installing exposed-to-view components of roof accessories directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet, or install a course of polyethylene underlayment.
 - c. Bed flanges in thick coat of asphalt roofing cement where required by roof accessory manufacturers for waterproof performance.
4. Install roof accessories level, plumb, true to line and elevation, and without warping, jogs in alignment, excessive oil canning, buckling, or tool marks.



5. Seal joints with elastomeric **OR** butyl, **as directed**, sealant as required by manufacturer of roof accessories.

END OF SECTION 07 72 23 00



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Task	Specification	Specification Description
07 72 23 00	07 72 13 00a	Intake and Relief Ventilators
07 72 26 00	07 72 23 00	Roof Accessories
07 72 33 00	07 72 23 00	Roof Accessories
07 72 36 00	07 72 23 00	Roof Accessories



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**SECTION 07 72 53 00 - ASPHALT SHINGLES**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for asphalt shingles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Asphalt shingles.
 - b. Underlayment.

C. Definition

1. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definitions of terms related to roofing work in this Section.

D. Submittals

1. Product Data: For each type of product indicated.
2. Samples: For each exposed product and for each color and blend specified.
3. Product test reports.
4. Research/evaluation reports.
5. Maintenance data.
6. Warranties: Sample of special warranties.

E. Quality Assurance

1. Fire-Resistance Characteristics: Where indicated, provide asphalt shingles and related roofing materials identical to those of assemblies tested for fire resistance per test method below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify products with appropriate markings of applicable testing agency.
 - a. Exterior Fire-Test Exposure: Class A **OR** Class C, **as directed**; ASTM E 108 or UL 790, for application and roof slopes indicated.
2. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Store roofing materials in a dry, well-ventilated, weathertight location according to asphalt shingle manufacturer's written instructions. Store underlayment rolls on end on pallets or other raised surfaces. Do not double stack rolls.
 - a. Handle, store, and place roofing materials in a manner to avoid significant or permanent damage to roof deck or structural supporting members.
2. Protect unused underlayment from weather, sunlight, and moisture when left overnight or when roofing work is not in progress.

G. Warranty

1. Special Warranty: Standard form in which manufacturer agrees to repair or replace asphalt shingles that fail in materials or workmanship within specified warranty period.
 - a. Material Warranty Period: 25 **OR** 30 **OR** 35 **OR** 40, **as directed**, years from date of Final Completion, prorated, with first three **OR** five **OR** 12, **as directed**, years nonprorated.
 - b. Wind-Speed Warranty Period: Asphalt shingles will resist blow-off or damage caused by wind speeds up to 60 mph (27 m/s) **OR** 75 mph (33 m/s) **OR** 80 mph (36 m/s) **OR** 100 mph (45 m/s), **as directed**, for five **OR** 10, **as directed**, years from date of Final Completion.



- c. Algae-Discoloration Warranty Period: Asphalt shingles will not discolor five **OR** 10, **as directed**, years from date of Final Completion.
- d. Workmanship Warranty Period: 10 **OR** 12, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Glass-Fiber-Reinforced Asphalt Shingles

1. Laminated-Strip Asphalt Shingles: ASTM D 3462, laminated, multi-ply overlay construction, glass-fiber reinforced, mineral-granule surfaced, and self-sealing.
 - a. Butt Edge: Straight **OR** Notched **OR** Crenelated, **as directed**, cut.
 - b. Strip Size: Manufacturer's standard.
 - c. Algae Resistance: Granules treated to resist algae discoloration.
 - d. Color and Blends: As selected by the Owner from manufacturer's full range.
2. Laminated-Strip, SBS-Modified Asphalt Shingles: ASTM D 3462, laminated, multi-ply overlay construction, glass-fiber reinforced, mineral-granule surfaced, and self-sealing; complying with UL 2218, Class IV.
 - a. Butt Edge: Straight **OR** Notched **OR** Crenelated, **as directed**, cut.
 - b. Strip Size: Manufacturer's standard.
 - c. Algae Resistance: Granules treated to resist algae discoloration.
 - d. Color and Blends: As selected by the Owner from manufacturer's full range.
3. Multitab-Strip Asphalt Shingles: ASTM D 3462, glass-fiber reinforced, mineral-granule surfaced, and self-sealing.
 - a. Tab Arrangement: Three tabs, regularly spaced **OR** Four tabs, regularly spaced **OR** Five tabs, randomly spaced, **as directed**.
 - b. Cutout Shape: Square **OR** Tapered, **as directed**.
 - c. Butt Edge: Straight **OR** Stagger, **as directed**, cut.
 - d. Strip Size: Manufacturer's standard.
 - e. Algae Resistance: Granules treated to resist algae discoloration.
 - f. Color and Blends: As selected by the Owner from manufacturer's full range.
4. Three-Tab-Strip, SBS-Modified Asphalt Shingles: ASTM D 3462, glass-fiber reinforced, mineral-granule surfaced, and self-sealing; complying with UL 2218, Class IV.
 - a. Strip Size: Manufacturer's standard.
 - b. Algae Resistance: Granules treated to resist algae discoloration.
 - c. Color and Blends: As selected by the Owner from manufacturer's full range.
5. No-Cutout-Strip Asphalt Shingles: ASTM D 3462, glass-fiber reinforced, mineral-granule surfaced, self-sealing, square, and single tab.
 - a. Butt Edge: Stagger **OR** Straight, **as directed**, cut.
 - b. Strip Size: Manufacturer's standard.
 - c. Algae Resistance: Granules treated to resist algae discoloration.
 - d. Color and Blends: As selected by the Owner from manufacturer's full range.
6. Hip and Ridge Shingles: Manufacturer's standard units to match asphalt shingles **OR** Site-fabricated units cut from asphalt shingle strips. Trim each side of lapped portion of unit to taper approximately 1 inch (25 mm), **as directed**.

B. Organic-Felt-Reinforced Asphalt Shingles

1. Laminated-Strip Asphalt Shingles: ASTM D 225, laminated, multi-ply overlay construction, organic-felt reinforced, mineral-granule surfaced, and self-sealing; complying with requirements in ASTM D 3161 for wind resistance.
 - a. Butt Edge: Straight **OR** Notched **OR** Crenelated, **as directed**, cut.
 - b. Strip Size: Manufacturer's standard.
 - c. Algae Resistance: Granules treated to resist algae discoloration.
 - d. Color and Blends: As selected by the Owner from manufacturer's full range.



2. Multitab-Strip Asphalt Shingles: ASTM D 225, organic-felt reinforced, mineral-granule surfaced, and self-sealing; complying with requirements in ASTM D 3161 for wind resistance.
 - a. Tab Arrangement: Three tabs, regularly spaced **OR** Four tabs, regularly spaced **OR** Six tabs, regularly spaced, scalloped edge, **as directed**.
 - b. Strip Size: Manufacturer's standard.
 - c. Algae Resistance: Granules treated to resist algae discoloration.
 - d. Color and Blends: As selected by the Owner from manufacturer's full range.
 3. No-Cutout-Strip Asphalt Shingles: ASTM D 225, organic-felt reinforced, mineral-granule surfaced, self-sealing, square, and single tab; complying with requirements in ASTM D 3161 for wind resistance.
 - a. Butt Edge: Stagger **OR** Straight, **as directed**, cut.
 - b. Strip Size: Manufacturer's standard.
 - c. Color and Blends: As selected by the Owner from manufacturer's full range.
 4. Hip and Ridge Shingles: Manufacturer's standard units to match asphalt shingles **OR** Site-fabricated units cut from asphalt shingle strips. Trim each side of lapped portion of unit to taper approximately 1 inch (25 mm), **as directed**.
- C. Underlayment Materials
1. Felt: ASTM D 226 **OR** ASTM D 4869, **as directed**, Type I **OR** Type II, **as directed**, asphalt-saturated organic felts, nonperforated.
 2. Self-Adhering Sheet Underlayment, Granular Surfaced: ASTM D 1970, minimum of 55-mil- (1.4-mm-) thick sheet; glass-fiber-mat-reinforced, SBS-modified asphalt; mineral-granule surfaced; with release paper backing; cold applied. Provide primer for adjoining concrete or masonry surfaces to receive underlayment.
 3. Self-Adhering Sheet Underlayment, Polyethylene Faced: ASTM D 1970, minimum of 40-mil- (1.0-mm-) thick, slip-resisting, polyethylene-film-reinforced top surface laminated to SBS-modified asphalt adhesive, with release paper backing; cold applied. Provide primer for adjoining concrete or masonry surfaces to receive underlayment.
 4. Self-Adhering Sheet Underlayment, High Temperature: Minimum of 30- to 40-mil- (0.76- to 1.0-mm-) thick, slip-resisting, polyethylene-film-reinforced top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release paper backing; cold applied. Provide primer for adjoining concrete or masonry surfaces to receive underlayment.
 - a. Thermal Stability: Stable after testing at 240 deg F (116 deg C); ASTM D 1970.
 - b. Low-Temperature Flexibility: Passes after testing at minus 20 deg F (29 deg C); ASTM D 1970.
 5. Granular-Surfaced Valley Lining: ASTM D 6380, Class M, organic-felt-based **OR** ASTM D 3909, mineral-granular-surfaced, glass-felt-based, **as directed**, asphalt roll roofing; 36 inches (914 mm) wide.
- D. Ridge Vents
1. Rigid Ridge Vent: Manufacturer's standard, rigid section high-density polypropylene or other UV-stabilized plastic ridge vent with nonwoven geotextile filter strips and external deflector baffles; for use under ridge shingles.
 2. Flexible Ridge Vent: Manufacturer's standard, compression-resisting, three-dimensional, open-nylon or polyester-mat filter bonded to a nonwoven, nonwicking, geotextile fabric cover.
- E. Accessories
1. Asphalt Roofing Cement: ASTM D 4586, Type II, asbestos free.
 2. Roofing Nails: ASTM F 1667; aluminum, stainless-steel, copper, or hot-dip galvanized-steel wire shingle nails, minimum 0.120-inch- (3-mm-) diameter, barbed **OR** smooth, **as directed**, shank, sharp-pointed, with a minimum 3/8-inch- (9.5-mm-) diameter flat head and of sufficient length to penetrate 3/4 inch (19 mm) into solid wood decking or extend at least 1/8 inch (3 mm) through OSB or plywood sheathing.
 - a. Where nails are in contact with metal flashing, use nails made from same metal as flashing.



3. Felt Underlayment Nails: Aluminum, stainless-steel, or hot-dip galvanized-steel wire with low-profile capped heads or disc caps, 1-inch (25-mm) minimum diameter.

F. Metal Flashing And Trim

1. General: Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim".
 - a. Sheet Metal: Copper **OR** Stainless steel **OR** Zinc-tin alloy-coated stainless steel **OR** Zinc-tin alloy-coated steel **OR** Zinc-tin alloy-coated copper **OR** Anodized aluminum **OR** Aluminum, mill finished, **as directed**.
2. Fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of the item.
 - a. Apron Flashings: Fabricate with lower flange a minimum of 4 inches (100 mm) **OR** 5 inches (125 mm), **as directed**, over and 4 inches (100 mm) beyond each side of downslope asphalt shingles and 6 inches (150 mm) up the vertical surface.
 - b. Step Flashings: Fabricate with a headlap of 2 inches (50 mm) and a minimum extension of 4 inches (100 mm) **OR** 5 inches (125 mm), **as directed**, over the underlying asphalt shingle and up the vertical surface.
 - c. Cricket **OR** Backer, **as directed**, Flashings: Fabricate with concealed flange extending a minimum of 18 inches (450 mm) **OR** 24 inches (600 mm), **as directed**, beneath upslope asphalt shingles and 6 inches (150 mm) beyond each side of chimney **OR** skylight, **as directed**, and 6 inches (150 mm) above the roof plane.
 - d. Open-Valley Flashings: Fabricate in lengths not exceeding 10 feet (3 m) with 1-inch- (25-mm-) high, inverted-V profile at center of valley and equal flange widths of 10 inches (250 mm) **OR** 12 inches (300 mm), **as directed**.
 - e. Drip Edges: Fabricate in lengths not exceeding 10 feet (3 m) with 2-inch (50-mm) roof-deck flange and 1-1/2-inch (38-mm) fascia flange with 3/8-inch (9.6-mm) drip at lower edge.
3. Vent Pipe Flashings: ASTM B 749, Type L51121, at least 1/16 inch (1.6 mm) thick. Provide lead sleeve sized to slip over and turn down into pipe, soldered to skirt at slope of roof, and extending at least 4 inches (100 mm) from pipe onto roof.

1.3 EXECUTION

A. Underlayment Installation

1. General: Comply with underlayment manufacturer's written installation instructions applicable to products and applications indicated unless more stringent requirements apply.
2. Single-Layer Felt Underlayment: Install on roof deck parallel with and starting at the eaves. Lap sides a minimum of 2 inches (50 mm) over underlying course. Lap ends a minimum of 4 inches (100 mm). Stagger end laps between succeeding courses at least 72 inches (1830 mm). Fasten with felt underlayment **OR** roofing, **as directed**, nails.
 - a. Install felt underlayment on roof deck not covered by self-adhering sheet underlayment. Lap sides of felt over self-adhering sheet underlayment not less than 3 inches (75 mm) in direction to shed water. Lap ends of felt not less than 6 inches (150 mm) over self-adhering sheet underlayment.
 - b. Install fasteners at no more than 36 inch (900 mm) o.c. where the basic wind speed is equal to or greater than 110 mph (176 km/h).
3. Double-Layer Felt Underlayment: Install on roof deck parallel with and starting at the eaves. Install a 19-inch- (485-mm-) wide starter course at eaves and completely cover with full-width second course. Install succeeding courses lapping previous courses 19 inches (485 mm) in shingle fashion. Lap ends a minimum of 6 inches (150 mm). Stagger end laps between succeeding courses at least 72 inches (1830 mm). Fasten with felt underlayment **OR** roofing, **as directed**, nails.



- a. Apply a continuous layer of asphalt roofing cement over starter course and on felt underlayment surface to be concealed by succeeding courses as each felt course is installed. Apply over entire roof **OR** at locations indicated on Drawings, **as directed**.
 - b. Install felt underlayment on roof sheathing not covered by self-adhering sheet underlayment. Lap edges over self-adhering sheet underlayment not less than 3 inches (75 mm) in direction to shed water.
 - c. Terminate felt underlayment flush **OR** extended up not less than 4 inches (100 mm), **as directed**, against sidewalls, curbs, chimneys, and other roof projections.
 - d. Install fasteners at no more than 36 inch (900 mm) o.c. where the basic wind speed is equal to or greater than 110 mph (176 km/h).
4. Self-Adhering Sheet Underlayment: Install, wrinkle free, on roof deck. Comply with low-temperature installation restrictions of underlayment manufacturer if applicable. Install at locations indicated below **OR** on Drawings, **as directed**, lapped in direction to shed water. Lap sides not less than 3-1/2 inches (89 mm). Lap ends not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses. Roll laps with roller. Cover underlayment within seven days.
- a. Prime concrete and masonry surfaces to receive self-adhering sheet underlayment.
 - b. Eaves: Extend from edges of eaves 24 inches (600 mm) **OR** 36 inches (914 mm), **as directed**, beyond interior face of exterior wall.
 - c. Rakes: Extend from edges of rake 24 inches (600 mm) **OR** 36 inches (914 mm), **as directed**, beyond interior face of exterior wall.
 - d. Valleys: Extend from lowest to highest point 18 inches (450 mm) on each side.
 - e. Hips: Extend 18 inches (450 mm) on each side.
 - f. Ridges: Extend 36 inches (914 mm) on each side without obstructing continuous ridge vent slot.
 - g. Sidewalls: Extend beyond sidewall 18 inches (450 mm), and return vertically against sidewall not less than 4 inches (100 mm).
 - h. Dormers, Chimneys, Skylights, and Other Roof-Penetrating Elements: Extend beyond penetrating element 18 inches (450 mm), and return vertically against penetrating element not less than 4 inches (100 mm).
 - i. Roof Slope Transitions: Extend 18 inches (450 mm) on each roof slope.
5. Concealed, Woven **OR** Closed-Cut, **as directed**, Valley Lining: Comply with NRCA's recommendations. Install a 36-inch- (914-mm-) wide felt underlayment centered in valley. Fasten to roof deck with felt underlayment **OR** roofing, **as directed**, nails.
- a. Lap roof-deck felt underlayment over valley felt underlayment at least 6 inches (150 mm).
 - b. Install a 36-inch- (914-mm-) wide strip of granular-surfaced valley lining centered in valley, with granular-surface face up. Lap ends of strips at least 12 inches (300 mm) in direction to shed water, and seal with asphalt roofing cement. Fasten to roof deck with roofing nails.
6. Metal-Flushed, Open-Valley Underlayment: Install two layers of 36-inch- (914-mm-) wide felt underlayment centered in valley. Stagger end laps between layers at least 72 inches (1830 mm). Lap ends of each layer at least 12 inches (300 mm) in direction to shed water, and seal with asphalt roofing cement. Fasten each layer to roof deck with felt underlayment **OR** roofing, **as directed**, nails.
- a. Lap roof-deck felt underlayment over first layer of valley felt underlayment at least 6 inches (150 mm).
7. Granular-Surfaced, Open-Valley Lining: Comply with NRCA's recommendations. Install a 36-inch- (914-mm-) wide felt underlayment centered in valley. Fasten to roof deck with felt underlayment **OR** roofing, **as directed**, nails.
- a. Lap roof-deck felt underlayment over valley felt underlayment at least 6 inches (150 mm).
 - b. Install an 18-inch- (450-mm-) wide strip of valley lining centered in valley, with granular-surface face down. Install a second 36-inch- (914-mm-) wide strip of valley lining centered in valley, with granular-surface face up. Lap ends of each strip at least 12 inches (300 mm) in direction to shed water, and seal with asphalt roofing cement. Stagger end laps between succeeding strips at least 72 inches (1830 mm). Fasten each strip to roof deck with roofing nails.



B. Metal Flashing Installation

1. General: Install metal flashings and other sheet metal to comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim".
 - a. Install metal flashings according to recommendations in ARMA's "Residential Asphalt Roofing Manual" and asphalt shingle recommendations in NRCA's "The NRCA Roofing and Waterproofing Manual."
2. Apron Flashings: Extend lower flange over and beyond each side of downslope asphalt shingles and up the vertical surface.
3. Step Flashings: Install with a headlap of 2 inches (50 mm) and extend over the underlying asphalt shingle and up the vertical surface. Fasten to roof deck only.
4. Cricket **OR** Backer, **as directed**, Flashings: Install against the roof-penetrating element extending concealed flange beneath upslope asphalt shingles and beyond each side.
5. Open-Valley Flashings: Install centered in valleys, lapping ends at least 8 inches (200 mm) in direction to shed water. Fasten upper end of each length to roof deck beneath overlap.
 - a. Secure hemmed flange edges into metal cleats spaced 12 inches (300 mm) apart and fastened to roof deck.
 - b. Adhere 9-inch- (225-mm-) wide strip of self-adhering sheet to metal flanges and to self-adhering sheet underlayment.
6. Rake Drip Edges: Install rake drip edge flashings over underlayment and fasten to roof deck.
7. Eave Drip Edges: Install eave drip edge flashings below underlayment and fasten to roof sheathing.
8. Pipe Flashings: Form flashing around pipe penetrations and asphalt shingles. Fasten and seal to asphalt shingles as recommended by manufacturer.

C. Asphalt Shingle Installation

1. General: Install asphalt shingles according to manufacturer's written instructions, recommendations in ARMA's "Residential Asphalt Roofing Manual," and asphalt shingle recommendations in NRCA's "The NRCA Roofing and Waterproofing Manual."
2. Install starter strip along lowest roof edge, consisting of an asphalt shingle strip with tabs removed **OR** at least 7 inches (175 mm) wide, **as directed**, with self-sealing strip face up at roof edge.
 - a. Extend asphalt shingles 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, over fasciae at eaves and rakes.
 - b. Install starter strip along rake edge.
3. For Three-Tab- And Other Multitab-Strip Asphalt Shingles: Install first and remaining courses of asphalt shingles stair-stepping diagonally across roof deck with 4-inch (100-mm) **OR** 5-inch (125-mm) **OR** 6-inch (150-mm) **OR** 1/2-tab **OR** 1/3-tab **OR** manufacturer's recommended, **as directed**, offset pattern at succeeding courses, maintaining uniform exposure.
4. For Laminated-Strip And No-Cutout-Strip Asphalt Shingles: Install first and remaining courses of asphalt shingles stair-stepping diagonally across roof deck with manufacturer's recommended offset pattern at succeeding courses, maintaining uniform exposure.
5. Install asphalt shingles by single-strip column or racking method, maintaining uniform exposure. Install full-length first course followed by cut second course, repeating alternating pattern in succeeding courses.
6. Fasten asphalt shingle strips with a minimum of four **OR** five **OR** six, **as directed**, roofing nails located according to manufacturer's written instructions.
 - a. Where roof slope exceeds 20:12, seal asphalt shingles with asphalt roofing cement spots after fastening with additional roofing nails.
 - b. Where roof slope is less than 4:12, seal asphalt shingles with asphalt roofing cement spots.
 - c. When ambient temperature during installation is below 50 deg F (10 deg C), seal asphalt shingles with asphalt roofing cement spots.
7. Woven Valleys: Extend succeeding asphalt shingle courses from both sides of valley 12 inches (300 mm) beyond center of valley, weaving intersecting shingle-strip courses over each other. Use one-piece shingle strips without joints in valley.



- a. Do not nail asphalt shingles within 6 inches (150 mm) of valley center.
8. Closed-Cut Valleys: Extend asphalt shingle strips from one side of valley 12 inches (300 mm) beyond center of valley. Use one-piece shingle strips without joints in valley. Fasten with extra nail in upper end of shingle. Install asphalt shingle courses from other side of valley and cut back to a straight line 2 inches (50 mm) short of valley centerline. Trim upper concealed corners of cut-back shingle strips.
 - a. Do not nail asphalt shingles within 6 inches (150 mm) of valley center.
 - b. Set trimmed, concealed-corner asphalt shingles in a 3-inch- (75-mm-) wide bed of asphalt roofing cement.
9. Open Valleys: Cut and fit asphalt shingles at open valleys, trimming upper concealed corners of shingle strips. Maintain uniform width of exposed open valley **OR** Widen exposed portion of open valley 1/8 inch in 12 inches (1:96), **as directed**, from highest to lowest point.
 - a. Set valley edge of asphalt shingles in a 3-inch- (75-mm-) wide bed of asphalt roofing cement.
 - b. Do not nail asphalt shingles to metal open-valley flashings.
10. Ridge Vents: Install continuous ridge vents over asphalt shingles according to manufacturer's written instructions. Fasten with roofing nails of sufficient length to penetrate sheathing.
11. Ridge and Hip Cap Shingles: Maintain same exposure of cap shingles as roofing shingle exposure. Lap cap shingles at ridges to shed water away from direction of prevailing winds. Fasten with roofing nails of sufficient length to penetrate sheathing.
 - a. Fasten ridge cap asphalt shingles to cover ridge vent without obstructing airflow.

END OF SECTION 07 72 53 00



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Task	Specification	Specification Description
07 72 53 00	07 72 23 00	Roof Accessories



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**SECTION 07 72 56 00 - RADIANT-HEATING ELECTRIC CABLES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for radiant-heating electric cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes electric heating cables for ceiling or floor radiant heating, snow and ice melting on pavement, and freezer-floor frost-heave prevention with the following electric heating cables:
 - a. Mineral insulated, series resistance.
 - b. Plastic insulated, series resistance.
 - c. Self-regulating, parallel resistance.

C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
 - a. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
2. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and Maintenance Data.
5. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within 10 **OR** 15, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Mineral-Insulated, Series-Resistance Heating Cables

1. Heating Element: Single- or dual-conductor resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.
2. Electrical Insulating Mineral: Magnesium oxide.
3. Cable Cover: Copper/nickel alloy and high-density polyethylene outer jacket, **as directed**.
4. Maximum Operating Temperature: 300 deg F (150 deg C).

B. Plastic-Insulated, Series-Resistance Heating Cables

1. Comply with UL 1673.
2. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.



3. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone jacket or Tefzel.
4. Cable Cover: Aluminum braid and silicone or Hylar outer jacket, **as directed**.
5. Maximum Operating Temperature: 300 deg F (150 deg C).
6. Heating Cable Mats: Factory-fabricated cable and fiberglass or plastic mesh with uniform 1-1/2-inch (38-mm) **OR** 3-inch (76-mm), **as directed**, cable spacing, in 18-inch (457-mm) **OR** 36-inch (914-mm), **as directed**, widths.

C. Self-Regulating, Parallel-Resistance Heating Cables

1. Comply with UL 1673.
2. Heating Element: Pair of parallel No. 16 **OR** 18, **as directed**, AWG, tinned **OR** nickel-coated, **as directed**, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.
3. Electrical Insulating Jacket: Flame-retardant polyolefin.
4. Cable Cover: Tinned-copper **OR** Stainless-steel, **as directed**, braid, and polyolefin outer jacket with UV inhibitor, **as directed**.
5. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).
6. Heating Cable Mats: Factory-fabricated cable and fiberglass or plastic mesh with uniform 1-1/2-inch (38-mm) **OR** 3-inch (76-mm), **as directed**, cable spacing, in 18-inch (457-mm) **OR** 36-inch (914-mm), **as directed**, widths.
7. Maximum Operating Temperature: 300 deg F (150 deg C).

D. Controls

1. Refer to Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
2. Wall-Mounting Thermostats for Ceiling and Floor Heating Cables:
 - a. Minimum temperature range from 50 to 90 deg F (10 to 32 deg C).
 - b. Manually operated with on-off switch.
3. Precipitation and Temperature Sensor for Snow Melting on Pavement:
 - a. Microprocessor-based **OR** Automatic, **as directed**, control with manual on, automatic, and standby/reset switch.
 - b. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to energize the cable as follows:
 - 1) Temperature Span: 34 to 44 deg F (1 to 7 deg C).
 - 2) Adjustable Delay Off Span: 30 to 90 minutes.
 - 3) Energize Cables: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
 - 4) De-Energize Cables: On detection of a dry surface plus time delay.
 - c. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
 - d. Minimum 30-A contactor to energize cable or close other contactors.
 - e. Precipitation sensor shall be mounted in pavement.
 - f. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.

E. Accessories

1. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

1.3 EXECUTION

A. Applications



1. Install the following types of electric heating cable for the applications described:
 - a. Ceiling Radiant Heating: Plastic-insulated, series-resistance **OR** Self-regulating, parallel-resistance, **as directed**, heating cable.
 - b. Floor Radiant Heating: Plastic-insulated, series-resistance **OR** Self-regulating, parallel-resistance, **as directed**, heating cable.
 - c. Snow and Ice Melting on Pavement: Mineral-insulated, series-resistance **OR** Plastic-insulated, series-resistance **OR** Self-regulating, parallel-resistance, **as directed**, heating cable.
 - d. Freezer-Floor Frost-Heave Prevention: Plastic-insulated, series-resistance **OR** Self-regulating, parallel-resistance, **as directed**, heating cable.

- B. Installation
 1. Install electric heating cable or mats across expansion, construction, and control joints according to manufacturer's written recommendations using cable protection conduit and slack cable to allow movement without damage to cable.
 2. Do not energize cables embedded in concrete or plaster until those assemblies are cured.
 3. Electric Heating Cable Installation for Ceiling Radiant Heating: Install heating cable with heat-conductive fill materials such as plaster, to ensure direct contact with finished radiant surfaces.
 4. Electric Heating Cable Installation for Floor Radiant Heating: Install heating cable with heat-conductive fill materials such as concrete, to ensure direct contact with finished radiant surfaces.
 5. Electric Heating Cable Installation for Snow and Ice Melting on Pavement:
 - a. Install heating cable with heat-conductive fill materials such as asphalt or concrete, to ensure direct contact with finished radiant surfaces.
 - b. Install cables or mats after applying bituminous binder course to lower base; ensure that second bituminous binder course is applied to cables before pouring finish topping.
 6. Electric Heating Cable Installation for Freezer-Floor Frost-Heave Prevention: Install electric heating cable below insulation in subsoil.
 7. Set field-adjustable switches and circuit-breaker trip ranges.
 8. Protect installed heating cables, including nonheating leads, from damage.

- C. Connections
 1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

- D. Field Quality Control
 1. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
 - a. Test cables for electrical continuity and insulation integrity before energizing.
 - b. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
 2. Repeat tests for continuity, insulation resistance, and input power after applying finished surface on heating cables.
 3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 07 72 56 00



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**SECTION 07 72 56 00a - HEAT TRACING FOR FIRE-SUPPRESSION PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for heat tracing for fire suppression piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes heat tracing with the following electric heating cables:
 - a. Plastic insulated, series resistance.
 - b. Self-regulating, parallel resistance.

C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
 - a. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
2. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and Maintenance Data.
5. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within 10 **OR** 15, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Plastic-Insulated, Series-Resistance Heating Cables

1. Comply with IEEE 515.1.
2. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.
3. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone jacket or Tefzel.
4. Cable Cover: Aluminum braid and silicone or Hylar outer jacket, **as directed**.
5. Maximum Operating Temperature: 300 deg F (150 deg C).

B. Self-Regulating, Parallel-Resistance Heating Cables

1. Heating Element: Pair of parallel No. 16 **OR** 18, **as directed**, AWG, tinned **OR** nickel-coated, **as directed**, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.



2. Electrical Insulating Jacket: Flame-retardant polyolefin.
3. Cable Cover: Tinned-copper **OR** Stainless-steel, **as directed**, braid, and polyolefin outer jacket with UV inhibitor, **as directed**.
4. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).
5. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).
6. Maximum Operating Temperature: 300 deg F (150 deg C).

C. Controls

1. Remote bulb unit with adjustable temperature range from 30 to 50 deg F (minus 1 to plus 10 deg C).
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
4. Corrosion-resistant, waterproof control enclosure.

D. Accessories

1. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
2. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
 - a. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
 - b. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

1.3 EXECUTION

A. Installation

1. Install electric heating cable across expansion joints according to manufacturer's written recommendations using slack cable to allow movement without damage to cable.
2. Install electric heating cables after piping has been tested and before insulation is installed.
3. Install electric heating cables according to IEEE 515.1.
4. Install insulation over piping with electric cables according to Division 21 Section "Fire-suppression Systems Insulation".
5. Install warning tape on piping insulation where piping is equipped with electric heating cables.
6. Set field-adjustable switches and circuit-breaker trip ranges.
7. Protect installed heating cables, including nonheating leads, from damage.

B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
 - a. Test cables for electrical continuity and insulation integrity before energizing.
 - b. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
2. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.



3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 07 72 56 00a



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**SECTION 07 72 56 00b - HEAT TRACING FOR PLUMBING PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for heat tracing for plumbing piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes plumbing piping heat tracing for freeze prevention, domestic hot-water-temperature maintenance, and snow and ice melting on roofs and in gutters and downspouts with the following electric heating cables:
 - a. Plastic insulated, series resistance.
 - b. Self-regulating, parallel resistance.
 - c. Constant wattage.

C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
 - a. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
2. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
5. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within 10 **OR** 15, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Plastic-Insulated, Series-Resistance Heating Cables

1. Comply with IEEE 515.1.
2. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.
3. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone jacket or Tefzel.
4. Cable Cover: Aluminum braid and silicone or Hylar outer jacket, **as directed**.
5. Maximum Operating Temperature: 300 deg F (150 deg C).

B. Self-Regulating, Parallel-Resistance Heating Cables



1. Heating Element: Pair of parallel No. 16 **OR** 18, **as directed**, AWG, tinned **OR** nickel-coated, **as directed**, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.
 2. Electrical Insulating Jacket: Flame-retardant polyolefin.
 3. Cable Cover: Tinned-copper **OR** Stainless-steel, **as directed**, braid, and polyolefin outer jacket with UV inhibitor, **as directed**.
 4. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).
 5. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).
 6. Maximum Operating Temperature: 300 deg F (150 deg C).
- C. Constant-Wattage Heating Cables
1. Heating Element: Pair of parallel No. 12 AWG, tinned **OR** nickel-coated, **as directed**, stranded copper bus wires with single-stranded resistor wire connected between bus wires. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight.
 2. Electrical Insulating Jacket: Flame-retardant fluoropolymer.
 3. Cable Cover: Tinned-copper **OR** Stainless-steel, **as directed**, braid, and polyolefin outer jacket with UV inhibitor, **as directed**.
 4. Maximum Operating Temperature (Power On): 392 deg F (200 deg C).
- D. Controls
1. Pipe-Mounting Thermostats for Freeze Protection:
 - a. Remote bulb unit with adjustable temperature range from 30 to 50 deg F (minus 1 to plus 10 deg C).
 - b. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
 - c. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
 - d. Corrosion-resistant, waterproof control enclosure.
 2. Precipitation and Temperature Sensor for Snow Melting on Roofs and in Gutters:
 - a. Microprocessor-based **OR** Automatic, **as directed**, control with manual on, automatic, and standby/reset switch.
 - b. Precipitation and temperature sensors shall sense the surface conditions of roof and gutters and shall be programmed to energize the cable as follows:
 - 1) Temperature Span: 34 to 44 deg F (1 to 7 deg C).
 - 2) Adjustable Delay Off Span: 30 to 90 minutes.
 - 3) Energize Cables: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
 - 4) De-Energize Cables: On detection of a dry surface plus time delay.
 - c. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
 - d. Minimum 30-A contactor to energize cable or close other contactors.
 - e. Precipitation sensor shall be freestanding.
 - f. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.
 3. Programmable Timer for Domestic Hot-Water-Temperature Maintenance:
 - a. Microprocessor based.
 - b. Minimum of four separate schedules.
 - c. Minimum 24-hour battery carryover.
 - d. On-off-auto switch.
 - e. 365-day calendar with 20 programmable holidays.
 - f. Relays with contacts to indicate operational status, on or off, and for interface with central HVAC control system workstation.



E. Accessories

1. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
2. Warning Labels: Refer to Division 22 Section "Identification For Plumbing Piping And Equipment".
3. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
 - a. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
 - b. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

1.3 EXECUTION

A. Applications

1. Install the following types of electric heating cable for the applications described:
 - a. Snow and Ice Melting on Roofs and in Gutters and Downspouts: Plastic-insulated, series-resistance **OR** Self-regulating, parallel-resistance **OR** Constant-wattage, **as directed**, heating cable.
 - b. Temperature Maintenance for Domestic Hot Water: Self-regulating, parallel-resistance heating cable.

B. Installation

1. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written recommendations using cable protection conduit and slack cable to allow movement without damage to cable.
2. Electric Heating Cable Installation for Snow and Ice Melting on Roofs and in Gutters and Downspouts: Install on roof and in gutters and downspouts with clips furnished by manufacturer that are compatible with roof, gutters, and downspouts.
3. Electric Heating Cable Installation for Freeze Protection for Piping:
 - a. Install electric heating cables after piping has been tested and before insulation is installed.
 - b. Install electric heating cables according to IEEE 515.1.
 - c. Install insulation over piping with electric cables according to Division 22 Section "Plumbing Insulation".
 - d. Install warning tape on piping insulation where piping is equipped with electric heating cables.
4. Electric Heating Cable Installation for Temperature Maintenance for Domestic Hot Water:
 - a. Install electric heating cables after piping has been tested and before insulation is installed.
 - b. Install insulation over piping with electric heating cables according to Division 22 Section "Plumbing Insulation".
 - c. Install warning tape on piping insulation where piping is equipped with electric heating cables.
5. Set field-adjustable switches and circuit-breaker trip ranges.
6. Protect installed heating cables, including nonheating leads, from damage.

C. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

D. Field Quality Control

1. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.



-
- a. Test cables for electrical continuity and insulation integrity before energizing.
 - b. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
2. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.
 3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 07 72 56 00b

**SECTION 07 72 56 00c - HEAT TRACING FOR HVAC PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for heat tracing for HVAC piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes heat tracing with the following electric heating cables:
 - a. Plastic insulated, series resistance.
 - b. Self-regulating, parallel resistance.

C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
 - a. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
2. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
5. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within 10 **OR** 15, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Plastic-Insulated, Series-Resistance Heating Cables

1. Comply with IEEE 515.1.
2. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.
3. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone jacket or Tefzel.
4. Cable Cover: Aluminum braid and silicone or Hylar outer jacket, **as directed**.
5. Maximum Operating Temperature: 300 deg F (150 deg C).

B. Self-Regulating, Parallel-Resistance Heating Cables

1. Heating Element: Pair of parallel No. 16 **OR** 18 **as directed**, AWG, tinned **OR** nickel-coated **as directed**, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof,



factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

2. Electrical Insulating Jacket: Flame-retardant polyolefin.
3. Cable Cover: Tinned-copper **OR** Stainless-steel **as directed**, braid, and polyolefin outer jacket with UV inhibitor **as directed**.
4. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).
5. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).
6. Maximum Operating Temperature: 300 deg F (150 deg C).

C. Controls

1. Remote bulb unit with adjustable temperature range from 30 to 50 deg F (minus 1 to plus 10 deg C).
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
4. Corrosion-resistant, waterproof control enclosure.

D. Accessories

1. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
2. Warning Labels: Refer to Division 23 Section "Identification For Hvac Piping And Equipment".
3. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
 - a. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
 - b. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

1.3 EXECUTION

A. Installation

1. Install electric heating cable across expansion joints according to manufacturer's written recommendations using slack cable to allow movement without damage to cable.
2. Install electric heating cables after piping has been tested and before insulation is installed.
3. Install electric heating cables according to IEEE 515.1.
4. Install insulation over piping with electric cables according to Division 23 Section "Hvac Insulation".
5. Install warning tape on piping insulation where piping is equipped with electric heating cables.
6. Set field-adjustable switches and circuit-breaker trip ranges.
7. Protect installed heating cables, including nonheating leads, from damage.

B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
 - a. Test cables for electrical continuity and insulation integrity before energizing.



- b. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
2. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.
3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 07 72 56 00c



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Task	Specification	Specification Description
07 72 63 00	01 22 16 00	No Specification Required
07 73 00 00	07 51 13 00	Built-Up Asphalt Roofing
07 73 00 00	07 05 13 00	Built-Up Coal-Tar Roofing
07 73 00 00	07 53 16 00	EPDM Membrane Roofing
07 73 00 00	07 05 13 00a	CSPE Membrane Roofing
07 73 00 00	07 05 13 00b	APP-Modified Bituminous Membrane Roofing
07 73 00 00	07 05 13 00c	SBS-Modified Bituminous Membrane Roofing
07 73 00 00	07 22 16 00	Fluid-Applied Protected Membrane Roofing
07 76 16 00	01 22 16 00	No Specification Required



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**SECTION 07 81 16 00 - SPRAYED FIRE-RESISTIVE MATERIALS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for sprayed fire-resistive materials. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Concealed SFRM.
 - b. Exposed SFRM.
 - c. Exposed intumescent mastic fire-resistive coatings.

C. Definitions

1. SFRM: Sprayed fire-resistive material.
2. Concealed: Fire-resistive materials applied to surfaces that are concealed from view behind other construction when the Work is completed and have not been defined as exposed, **as directed**.
3. Exposed: Fire-resistive materials applied to surfaces that are exposed to view when the Work is completed, that are accessible through suspended ceilings **OR** that are in elevator shafts and machine rooms **OR** that are in mechanical rooms **OR** that are in air-handling plenums **OR** and that are identified as exposed on Drawings, **as directed**.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show extent of sprayed fire-resistive material for each construction and fire-resistance rating, applicable fire-resistive design designations of a qualified testing and inspecting agency acceptable to authorities having jurisdiction, and minimum thicknesses.
3. Product certificates **OR** test reports, **as directed**.
4. Compatibility and adhesion test reports.
5. Research/evaluation reports.
6. Field quality-control test and special inspection, **as directed**, reports.

E. Quality Assurance

1. Installer Qualifications: A qualified installer approved by SFRM manufacturer to install manufacturer's products. A manufacturer's willingness to sell its SFRM to Contractor or to an installer engaged by Contractor does not in itself confer qualification on the buyer.
2. SFRM Testing: By a qualified testing and inspecting agency engaged by Contractor or manufacturer to test for compliance with specified requirements for performance and test methods.
 - a. SFRMs are randomly selected for testing from bags bearing the applicable classification marking of UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
 - b. Testing is performed on specimens of SFRMs that comply with laboratory testing requirements specified in Part 2 and are otherwise identical to installed fire-resistive materials, including application of accelerant, sealers, topcoats, tamping, troweling, rolling, and water overspray, if any of these are used in final application.
 - c. Testing is performed on specimens whose application the independent testing and inspecting agency witnessed during preparation and conditioning. Include in test reports a full description of preparation and conditioning of laboratory test specimens.



3. Compatibility and Adhesion Testing: Engage a qualified testing and inspecting agency to test for compliance with requirements for specified performance and test methods.
 - a. Test for bond per ASTM E 736 and requirements in UL's "Fire Resistance Directory" for coating materials. Provide bond strength indicated in referenced fire-resistance design, but not less than minimum specified in Part 2.
 - b. Verify that manufacturer, through its own laboratory testing or field experience, has not found primers or coatings to be incompatible with SFRM.
4. Fire-Test-Response Characteristics: Where indicated, provide products identical to those tested for fire resistance per ASTM E 119 by a testing agency acceptable to authorities having jurisdiction.
 - a. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another testing and inspecting agency.
 - b. Identify products with appropriate markings of applicable testing and inspecting agency.
5. Provide products containing no detectable asbestos as determined according to the method specified in 40 CFR 763, Subpart E, Appendix E, Section 1, "Polarized Light Microscopy."
6. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Deliver products to Project site in original, unopened packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, shelf life if applicable, and fire-resistance ratings applicable to Project.
2. Use materials with limited shelf life within period indicated. Remove from Project site and discard materials whose shelf life has expired.
3. Store materials inside, under cover, and aboveground; keep dry until ready for use. Remove from Project site and discard wet or deteriorated materials.

G. Project Conditions

1. Environmental Limitations: Do not apply SFRM when ambient or substrate temperature is 40 deg F (4 deg C) or lower unless temporary protection and heat are provided to maintain temperature at or above this level for 24 hours before, during, and for 24 hours after product application.
2. Ventilation: Ventilate building spaces during and after application of SFRM. Use natural means or, if they are inadequate, forced-air circulation until fire-resistive material dries thoroughly.

H. Warranty

1. Special Warranty: Manufacturer's standard form, signed by Contractor and by Installer, in which manufacturer agrees to repair or replace SFRMs that fail in materials or workmanship within two years from date of Final Completion.

1.2 PRODUCTS

A. Concealed SFRM

1. Material Composition: Manufacturer's standard product, as follows **OR** either of the following, **as directed**:
 - a. Concealed Cementitious SFRM: Factory-mixed, dry formulation of gypsum or portland cement binders, additives, and lightweight mineral or synthetic aggregates mixed with water at Project site to form a slurry or mortar for conveyance and application.
 - b. Concealed Sprayed-Fiber Fire-Resistive Material: Factory-mixed, dry formulation of inorganic binders, mineral fibers, fillers, and additives conveyed in a dry state by pneumatic equipment and mixed with water at spray nozzle to form a damp, as-applied product.
2. Physical Properties: Minimum values, unless otherwise indicated, or higher values required to attain designated fire-resistance ratings, measured per standard test methods referenced with each property as follows:



- a. Dry Density: 15 lb/cu. ft. (240 kg/cu. m) for average and individual densities, or greater if required to attain fire-resistance ratings indicated, per ASTM E 605 or AWCI Technical Manual 12-A, Section 5.4.5, "Displacement Method."
 - b. Thickness: Minimum average thickness required for fire-resistance design indicated according to the following criteria, but not less than 0.375 inch (9 mm), per ASTM E 605:
 - 1) Where the referenced fire-resistance design lists a thickness of 1 inch (25 mm) or more, the minimum allowable individual thickness of SFRM is the design thickness minus 0.25 inch (6 mm).
 - 2) Where the referenced fire-resistance design lists a thickness of less than 1 inch (25 mm) but more than 0.375 inch (9 mm), the minimum allowable individual thickness of SFRM is the greater of 0.375 inch (9 mm) or 75 percent of the design thickness.
 - 3) No reduction in average thickness is permitted for those fire-resistance designs whose fire-resistance ratings were established at densities of less than 15 lb/cu. ft. (240 kg/cu. m).
 - c. Bond Strength: 150 lbf/sq. ft. (7.2 kPa) minimum per ASTM E 736 based on laboratory testing of 0.75-inch (19-mm) minimum thickness of SFRM.
 - d. Compressive Strength: 5.21 lbf/sq. in. (35.9 kPa) minimum per ASTM E 761. Minimum thickness of SFRM tested shall be 0.75 inch (19 mm) and minimum dry density shall be as specified but not less than 15 lb/cu. ft. (240 kg/cu. m).
 - e. Corrosion Resistance: No evidence of corrosion per ASTM E 937.
 - f. Deflection: No cracking, spalling, or delamination per ASTM E 759.
 - g. Effect of Impact on Bonding: No cracking, spalling, or delamination per ASTM E 760.
 - h. Air Erosion: Maximum weight loss of 0.025 g/sq. ft. (0.270 g/sq. m) in 24 hours per ASTM E 859. For laboratory tests, minimum thickness of SFRM is 0.75 inch (19 mm), maximum dry density is 15 lb/cu. ft. (240 kg/cu. m), test specimens are not prepured by mechanically induced air velocities, and tests are terminated after 24 hours.
 - i. Fire-Test-Response Characteristics: Provide SFRM with the following surface-burning characteristics as determined by testing identical products per ASTM E 84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:
 - 1) Flame-Spread Index: 10 or less.
 - 2) Smoke-Developed Index: 0.
 - j. Fungal Resistance: No observed growth on specimens per ASTM G 21.
- B. Exposed SFRM
1. Material Composition: Manufacturer's standard product, as follows:
 - a. Exposed Cementitious SFRM: Factory-mixed, dry, cement aggregate formulation; or chloride-free formulation of gypsum or portland cement binders, additives, and inorganic aggregates mixed with water at Project site to form a slurry or mortar for conveyance and application.
 - b. Exposed Sprayed-Fiber Fire-Resistive Material: Factory-mixed, dry formulation of inorganic binders, mineral fibers, fillers, and additives conveyed in a dry state by pneumatic equipment and mixed with water at spray nozzle to form a damp, as-applied product.
 2. Physical Properties: Minimum values, unless otherwise indicated, or higher values required to attain designated fire-resistance ratings, measured per standard test methods referenced with each property as follows:
 - a. Dry Density: Values for average and individual densities as required for fire-resistance ratings indicated, per ASTM E 605 or AWCI Technical Manual 12-A, Section 5.4.5, "Displacement Method," but with an average density of not less than 22 lb/cu. ft. (352 kg/cu. m).
 - b. Bond Strength: 434 lbf/sq. ft. (21 kPa) minimum per ASTM E 736.
 - c. Compressive Strength: 51 lbf/sq. in. (351 kPa) minimum per ASTM E 761.
 - d. Dry Density: Values for average and individual densities as required for fire-resistance ratings indicated, per ASTM E 605 or AWCI Technical Manual 12-A, Section 5.4.5, "Displacement Method," but with an average density of not less than 39 lb/cu. ft. (625 kg/cu. m).
 - e. Bond Strength: 1000 lbf/sq. ft. (48 kPa) minimum per ASTM E 736.



- f. Compressive Strength: 300 lbf/sq. in. (2067 kPa) minimum per ASTM E 761.
 - g. Corrosion Resistance: No evidence of corrosion per ASTM E 937.
 - h. Deflection: No cracking, spalling, or delamination per ASTM E 759.
 - i. Effect of Impact on Bonding: No cracking, spalling, or delamination per ASTM E 760.
 - j. Air Erosion: Maximum weight loss of 0.025 g/sq. ft. (0.270 g/sq. m) per ASTM E 859.
 - k. Combustion Characteristics: Passes ASTM E 136.
 - l. Fire-Test-Response Characteristics: Provide SFRM with the following surface-burning characteristics as determined by testing identical products per ASTM E 84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:
 - 1) Flame-Spread Index: 10 or less.
 - 2) Smoke-Developed Index: 0.
 - m. Fungal Resistance: No observed growth on specimens per ASTM G 21.
 - n. For exterior applications of SFRM, provide formulation listed and labeled by testing and inspecting agency acceptable to authorities having jurisdiction for surfaces exposed to exterior.
- C. Exposed Intumescent Mastic Fire-Resistive Coatings
- 1. Fire-Resistive, Intumescent Mastic Coating: Factory-mixed formulation.
 - a. Water-Based Formulation: Approved by manufacturer and authorities having jurisdiction and investigated for Interior General **OR** Conditioned Interior Space, **as directed**, Purpose by UL.
 - b. Non-Water-Based Formulation: Approved by manufacturer and UL or another testing and inspecting agency acceptable to authorities having jurisdiction and investigated for Interior General Purpose by UL **OR** investigated for Interior General Purpose and Exterior Use by UL **OR** tested per ASTM E 1529 **OR** tested per UL 1709, **as directed**.
 - c. Multicomponent system consisting of intumescent base coat and topcoat.
 - 2. Color and Gloss: As selected from manufacturer's full range.
- D. Auxiliary Fire-Resistive Materials
- 1. General: Provide auxiliary fire-resistive materials that are compatible with SFRM and substrates and are approved by UL or another testing and inspecting agency acceptable to authorities having jurisdiction for use in fire-resistance designs indicated.
 - 2. Substrate Primers: For use on each substrate and with each sprayed fire-resistive product, provide primer that complies with one or more of the following requirements:
 - a. Primer's bond strength complies with requirements specified in UL's "Fire Resistance Directory" for coating materials based on a series of bond tests per ASTM E 736.
 - b. Primer is identical to those used in assemblies tested for fire-test-response characteristics of SFRM per ASTM E 119 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
 - 3. Adhesive for Bonding Fire-Resistive Material: Product approved by manufacturer of SFRM.
 - 4. Metal Lath: Expanded metal lath fabricated from material of weight, configuration, and finish required to comply with fire-resistance designs indicated and fire-resistive material manufacturer's written recommendations. Include clips, lathing accessories, corner beads, and other anchorage devices required to attach lath to substrates and to receive SFRM.
 - 5. Reinforcing Fabric: Glass- or carbon-fiber fabric of type, weight, and form required to comply with fire-resistance designs indicated; approved and provided by manufacturer of SFRM.
 - 6. Reinforcing Mesh: Metallic mesh reinforcement of type, weight, and form required to comply with fire-resistance designs indicated; approved and provided by manufacturer of intumescent mastic coating fire-resistive material. Include pins and attachment.
 - 7. Sealer for Sprayed-Fiber Fire-Resistive Material: Transparent-drying, water-dispersible, tinted protective coating recommended in writing by manufacturer of sprayed-fiber fire-resistive material.
 - 8. Topcoat: Type recommended in writing by manufacturer of each SFRM for application over concealed **OR** exposed, **as directed**, SFRM.



9. Cement-Based Topcoat: Factory-mixed, cementitious hardcoat formulation recommended in writing by manufacturer of SFRM for trowel or spray application over concealed **OR** exposed, **as directed**, SFRM.
10. Veneer-Plaster Topcoat: Factory-mixed formulation of a latex-modified, portland cement-based veneer plaster recommended in writing by manufacturer of SFRM for trowel or spray application over concealed **OR** exposed, **as directed**, SFRM.
11. Water-Based Permeable Topcoat: Factory-mixed formulation recommended in writing by manufacturer of SFRM for brush, roller, or spray application over concealed **OR** exposed, **as directed**, SFRM. Provide application at a rate of 120 sq. ft./gal. (3 sq. m/L) **OR** 60 sq. ft./gal. (1.5 sq. m/L) **OR** 30 sq. ft./gal. (0.75 sq. m/L), **as directed**.

1.3 EXECUTION

A. Preparation

1. Cover other work subject to damage from fallout or overspray of fire-resistive materials during application.
2. Clean substrates of substances that could impair bond of fire-resistive material, including dirt, oil, grease, release agents, rolling compounds, mill scale, loose scale, and incompatible primers, paints, and encapsulants.
3. Prime substrates where recommended in writing by SFRM manufacturer unless compatible shop primer has been applied and is in satisfactory condition to receive SFRM.
4. For exposed applications, repair substrates to remove surface imperfections that could affect uniformity of texture and thickness in finished surface of SFRM. Remove minor projections and fill voids that would telegraph through fire-resistive products after application.

B. Application, General

1. Comply with fire-resistive material manufacturer's written instructions for mixing materials, application procedures, and types of equipment used to mix, convey, and spray on fire-resistive material, as applicable to particular conditions of installation and as required to achieve fire-resistance ratings indicated.
2. Apply SFRM that is identical to products tested as specified in Part 1.1 "Quality Assurance" Article and substantiated by test reports, with respect to rate of application, accelerator use, sealers, topcoats, tamping, troweling, water overspray, or other materials and procedures affecting test results.
3. Install metal lath and reinforcing fabric, as required, to comply with fire-resistance ratings and fire-resistive material manufacturer's written recommendations for conditions of exposure and intended use. Securely attach lath and fabric, as required, to substrate in position required for support and reinforcement of fire-resistive material. Use anchorage devices of type recommended in writing by SFRM manufacturer. Attach accessories where indicated or required for secure attachment of lath and fabric, as required, to substrate.
4. Coat substrates with bonding adhesive before applying fire-resistive material where required to achieve fire-resistance rating or as recommended in writing by SFRM manufacturer for material and application indicated.
5. Extend fire-resistive material in full thickness over entire area of each substrate to be protected. Unless otherwise recommended in writing by SFRM manufacturer, install body of fire-resistive covering in a single course.
6. Spray apply fire-resistive materials to maximum extent possible. Following the spraying operation in each area, complete the coverage by trowel application or other placement method recommended in writing by SFRM manufacturer.
7. For applications over encapsulant materials, including lockdown (post-removal) encapsulants, apply SFRM that differs in color from that of encapsulant over which it is applied.
8. Where sealers are used, apply products that are tinted to differentiate them from SFRM over which they are applied.

C. Application, Concealed SFRM



1. Apply concealed SFRM in thicknesses and densities not less than those required to achieve fire-resistance ratings designated for each condition, but apply in greater thicknesses and densities if specified in Part 1.2 "Concealed SFRM" Article.
2. Apply water overspray to concealed sprayed-fiber fire-resistive material as required to obtain designated fire-resistance rating and where indicated.
3. Cure concealed SFRM according to product manufacturer's written recommendations.
4. Apply sealer to concealed SFRM where indicated.
5. Apply topcoat to concealed SFRM where indicated.

D. Application, Exposed SFRM

1. Apply exposed SFRM in thicknesses and densities not less than those required to achieve fire-resistance ratings designated for each condition, but apply in greater thicknesses and densities if indicated.
 - a. For steel beams and bracing, provide a thickness of not less than 1 inch (25 mm).
 - b. For metal floor or roof decks, provide a thickness of not less than 1/2 inch (13 mm).
2. Provide a uniform finish complying with description indicated for each type of material and matching the Owner's sample or, if none, finish approved for field-erected mockup.
3. Apply exposed cementitious SFRM to produce the following finish:
 - a. Spray-textured finish with no further treatment.
 - b. Even, spray-textured finish, produced by rolling flat surfaces of fire-protected members with a damp paint roller to remove drippings and excessive roughness.
 - c. Skip-troweled finish with leveled surface, smoothed-out texture, and neat edges.
 - d. Smooth, troweled finish with surface markings eliminated and edges squared.
4. Apply exposed sprayed-fiber fire-resistive material to produce the following finish:
 - a. Spray-textured finish.
 - b. Sealer where indicated.
 - c. Topcoat where indicated.
5. Cure exposed SFRM according to product manufacturer's written recommendations.

E. Application, Exposed Intumescent Mastic Fire-Resistive Coatings

1. Apply exposed intumescent mastic fire-resistive coatings in thicknesses and densities not less than those required to achieve fire-resistance ratings designated for each condition.
2. Apply intumescent mastic fire-resistive coating as follows:
 - a. Install reinforcing fabric as required to obtain designated fire-resistance rating and where indicated.
 - b. Finish: Spray-textured finish with no further treatment.
 - c. Finish: Even, spray-textured finish produced by lightly rolling flat surfaces of fire-protected members before fire-resistive material dries, to smooth out surface irregularities and to seal in surface fibers.

F. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
 - a. Testing and inspecting agency will interpret tests and state in each report whether tested work complies with or deviates from requirements.
2. Tests and Inspections: Testing and inspecting of completed applications of SFRM shall take place in successive stages, in areas of extent and using methods as follows. Do not proceed with application of SFRM for the next area until test results for previously completed applications of SFRM show compliance with requirements. Tested values must equal or exceed values indicated and required for approved fire-resistance design.
 - a. Thickness for Floor, Roof, and Wall Assemblies: For each 1000-sq. ft. (93-sq. m) area, or partial area, on each floor, from the average of 4 measurements from a 144-sq. in. (0.093-sq. m) sample area, with sample width of not less than 6 inches (152 mm) per ASTM E 605.



- b. Thickness for Structural Frame Members: From a sample of 25 percent of structural members per floor, taking 9 measurements at a single cross section for structural frame beams or girders, 7 measurements of a single cross section for joists and trusses, and 12 measurements of a single cross section for columns per ASTM E 605.
 - c. Density for Floors, Roofs, Walls, and Structural Frame Members: At frequency and from sample size indicated for determining thickness of each type of construction and structural framing member, per ASTM E 605 or AWC Technical Manual 12-A, Section 5.4.5, "Displacement Method."
 - d. Bond Strength for Floors, Roofs, Walls, and Structural Framing Members: For each 10,000-sq. ft. (929 sq. m) area, or partial area, on each floor, cohesion and adhesion from one sample of size indicated for determining thickness of each type of construction and structural framing member, per ASTM E 736.
 - 1) Field test SFRM that is applied to flanges of wide-flange, structural-steel members on surfaces matching those that will exist for remainder of steel receiving fire-resistive material.
 - 2) If surfaces of structural steel receiving SFRM are primed or otherwise painted for coating materials, perform series of bond tests specified in UL's "Fire Resistance Directory." Provide bond strength indicated in referenced UL fire-resistance criteria, but not less than 150 lbf/sq. ft. (7.2 kPa) minimum per ASTM E 736.
 - e. If testing finds applications of SFRM are not in compliance with requirements, testing and inspecting agency will perform additional random testing to determine extent of noncompliance.
3. Remove and replace applications of SFRM that do not pass tests and inspections for cohesion and adhesion, for density, or for both and retest as specified above.
 4. Apply additional SFRM, per manufacturer's written instructions, where test results indicate that thickness does not comply with specified requirements, and retest as specified above.
- G. Cleaning, Protecting, And Repair
1. Cleaning: Immediately after completing spraying operations in each containable area of Project, remove material overspray and fallout from surfaces of other construction and clean exposed surfaces to remove evidence of soiling.
 2. Protect SFRM, according to advice of product manufacturer and Installer, from damage resulting from construction operations or other causes so fire protection will be without damage or deterioration at time of Final Completion.
 3. Coordinate application of SFRM with other construction to minimize need to cut or remove fire protection. As installation of other construction proceeds, inspect SFRM and patch any damaged or removed areas.
 4. Repair or replace work that has not successfully protected steel.

END OF SECTION 07 81 16 00



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Task	Specification	Specification Description
07 81 23 00	07 81 16 00	Sprayed Fire-Resistive Materials
07 81 33 00	07 81 16 00	Sprayed Fire-Resistive Materials



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**SECTION 07 82 00 00 - BOARD FIRE PROTECTION**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for board fire protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Calcium silicate board fire protection.
 - b. Mineral-fiber board fire protection.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Structural framing plans indicating the following:
 - a. Locations and types of surface preparations required before applying board fire protection.
 - b. Extent of board fire protection for each construction and fire-resistance rating, including the following:
 - 1) Applicable fire-resistance design designations of a qualified testing and inspecting agency acceptable to authorities having jurisdiction.
 - a) For steel joist assemblies, include applicable fire-resistance design designations, with each steel joist tested with same maximum tensile stress as each steel joist indicated on Drawings **OR** in a schedule, **as directed**. Design designations with steel joists tested at lower maximum tensile stress than those indicated are not permitted.
 - 2) Minimum thicknesses needed to achieve required fire-resistance ratings of structural components and assemblies.
 - 3) Treatment of sprayed fire-resistive material after application.
3. Product Certificates: For each type of board fire protection, from manufacturer.
4. Research/Evaluation Reports: For board fire protection.

D. Quality Assurance

1. Source Limitations: Obtain board fire-protection materials from single source from single manufacturer.
2. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" **OR** UL's "Fire Resistance Directory" or from the listings of another testing and inspecting agency, **as directed**, acceptable to authorities having jurisdiction, for board fireproofing serving as direct-applied protection tested per ASTM E 119.

E. Coordination

1. Coordinate installation of board fire protection with other construction specified in other Sections.
 - a. Do not install board fire protection on structural members until piping and other construction behind fire-resistive materials have been completed, uninterrupted coverage of fire-resistive materials can be provided, and the need for subsequent cutting and patching of fire-resistive materials has been eliminated.
 - b. Do not install enclosing or concealing construction until after board fire protection has been applied and inspected by authorities having jurisdiction.



1.2 PRODUCTS

A. Board Fire Protection

1. Calcium Silicate Board: Rigid board containing no asbestos and consisting primarily of lime, silica, inert fillers, and cellulosic reinforcing fibers; of thickness required to produce fire-resistance rating indicated; with flame-spread and smoke-developed indexes of zero per ASTM E 84; passing ASTM E 136 for combustion characteristics.
 - a. Finish: Sanded finish on both sides **OR** one side, **as directed**.
2. Mineral-Fiber Board: Unfaced **OR** Foil-faced **OR** Fiberglass mat-faced, **as directed**, rigid board produced by combining slag-wool/rock-wool fibers with thermosetting resin binders passing ASTM E 136 for combustion characteristics; of thickness required to produce fire-resistance rating indicated.
 - a. Maximum Density: 8 lb/cu. ft. (128 kg/cu. m) **OR** 10 lb/cu. ft. (160 kg/cu. m) **OR** 12 lb/cu. ft. (192 kg/cu. m), **as directed**, per ASTM C 612.
 - b. Surface-Burning Characteristics: Flame-spread and smoke-developed indexes of 15 **OR** zero, **as directed**, and 5 **OR** zero, **as directed**, respectively, per ASTM E 84.

B. Accessories

1. Anchorage Accessories: Provide manufacturer's standard board-anchorage components complying with related design of UL or of another testing and inspecting agency acceptable to authorities having jurisdiction.
2. Joint Treatment and Finishing Materials: For exposed calcium silicate board applications, provide joint treatment tape and joint compounds recommended in writing by board manufacturer for finishing surfaces.

1.3 EXECUTION

A. Preparation

1. Remove rust and scale from steel substrates at welded steel stud anchorage locations.

B. Installation

1. Install board fire protection according to manufacturer's written instructions.
2. Install board fire protection to comply with requirements for layer thicknesses and number, construction of joints and corners, and anchorage methods applicable to fire-resistance-rated assemblies indicated.
3. Finish exposed calcium silicate board to comply with board manufacturer's written instructions and as follows:
 - a. At joints in calcium silicate board, embed tape in joint compound and apply first, fill, and finish coats of joint compounds over tape, fastener heads, and accessories.
 - b. Apply a thin, uniform skim coat of joint compound over entire surface.
 - c. Touch up and sand between coats and after last coat as needed to produce a surface free of visual defects, tool marks, and ridges.

C. Protection

1. Replace or repair board fire protection that has been cut away to facilitate other construction. Maintain complete coverage of full thickness on members and substrates protected by board fire protection.
 - a. Provide final protection and maintain conditions in a manner acceptable to Installer, manufacturer, and authorities having jurisdiction to ensure that board fire protection is without damage or deterioration at time of Final Completion.

END OF SECTION 07 82 00 00



Task	Specification	Specification Description
07 82 00 00	07 81 16 00	Sprayed Fire-Resistive Materials



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**SECTION 07 84 13 16 - THROUGH-PENETRATION FIRESTOP SYSTEMS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for through-penetration firestop systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes through-penetration firestop systems for penetrations through fire-resistance-rated constructions, including both empty openings and openings containing penetrating items.

C. Performance Requirements

1. General: For penetrations through fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.
2. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per ASTM E 814 or UL 1479:
 - a. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.
 - b. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:
 - 1) Penetrations located outside wall cavities.
 - 2) Penetrations located outside fire-resistance-rated shaft enclosures.
 - c. L-Rated Systems: Where through-penetration firestop systems are indicated in smoke barriers, provide **OR** Provide, **as directed**, through-penetration firestop systems with L-ratings indicated **OR** of not more than, **as directed**, 3.0 cfm/sq. ft (0.01524cu. m/s x sq. m) at both ambient temperatures and 400 deg F (204 deg C).
3. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.
 - a. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.
 - b. For floor penetrations with annular spaces exceeding 4 inches (100 mm) in width and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads involved, either by installing floor plates or by other means.
 - c. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.
4. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For each through-penetration firestop system, submit documentation, including illustrations, from a qualified testing and inspecting agency, showing each type of construction condition penetrated, relationships to adjoining construction, and type of penetrating item.



- a. Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular through-penetration firestop condition, submit illustration, with modifications marked, approved by through-penetration firestop system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

E. Quality Assurance

1. Installation Responsibility: Assign installation of through-penetration firestop systems and fire-resistive joint systems in Project to a single qualified installer.
2. Fire-Test-Response Characteristics: Provide through-penetration firestop systems that comply with the following requirements and those specified in Part 1.1 "Performance Requirements" Article:
 - a. Firestopping tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is UL **OR** OPL **OR** ITS, **as directed**, or another agency performing testing and follow-up inspection services for firestop systems acceptable to authorities having jurisdiction.
 - b. Through-penetration firestop systems are identical to those tested per testing standard referenced in "Part 1.1 Performance Requirements" Article. Provide rated systems bearing classification marking of qualified testing and inspecting agency.
3. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.
4. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by the Owner's inspecting agency and building inspector, if required by authorities having jurisdiction.

F. Delivery, Storage, And Handling

1. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, lot number, shelf life if applicable, qualified testing and inspecting agency's classification marking applicable to Project, curing time, and mixing instructions for multicomponent materials.
2. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.2 PRODUCTS

A. Firestopping

1. Compatibility: Provide through-penetration firestop systems that are compatible with one another; with the substrates forming openings; and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.
2. Accessories: Provide components for each through-penetration firestop system that are needed to install fill materials and to comply with Part 1.1 "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by qualified testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:
 - a. Permanent forming/damming/backing materials, including the following:
 - 1) Slag-/rock-wool-fiber insulation.
 - 2) Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
 - 3) Fire-rated form board.
 - 4) Fillers for sealants.
 - b. Temporary forming materials.
 - c. Substrate primers.



- d. Collars.
- e. Steel sleeves.

B. Fill Materials

1. General: Provide through-penetration firestop systems containing the types of fill materials indicated in the Through-Penetration Firestop System Schedule at the end of Part 1.3 by referencing the types of materials described in this Article. Fill materials are those referred to in directories of referenced testing and inspecting agencies as "fill," "void," or "cavity" materials.
2. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.
3. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture.
4. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.
5. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.
6. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.
7. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.
8. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.
9. Pillows/Bags: Reusable heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents, and fire-retardant additives.
10. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
11. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:
 - a. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces, and nonsag formulation for openings in vertical and other surfaces requiring a nonslumping, gunnable sealant, unless indicated firestop system limits use to nonsag grade for both opening conditions.
 - b. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.
 - c. Grade for Vertical Surfaces: Nonsag formulation for openings in vertical and other surfaces.

- C. Mixing: For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

1.3 EXECUTION

A. Through-Penetration Firestop System Installation

1. General: Install through-penetration firestop systems to comply with Part 1.1 "Performance Requirements" Article and with firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.



2. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
 - a. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.
 3. Install fill materials for firestop systems by proven techniques to produce the following results:
 - a. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
 - b. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
 - c. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.
 4. Identification: Identify through-penetration firestop systems with preprinted metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches (150 mm) of edge of the firestop systems so that labels will be visible to anyone seeking to remove penetrating items or firestop systems. Use mechanical fasteners for metal labels. Include the following information on labels:
 - a. The words "Warning - Through-Penetration Firestop System - Do Not Disturb. Notify Building Management of Any Damage."
 - b. Contractor's name, address, and phone number.
 - c. Through-penetration firestop system designation of applicable testing and inspecting agency.
 - d. Date of installation.
 - e. Through-penetration firestop system manufacturer's name.
 - f. Installer's name.
- B. Field Quality Control
1. Inspecting Agency: Engage an independent inspecting agency to inspect through-penetration firestops. Independent inspecting agency shall comply with ASTM E 2174 requirements including those related to qualifications, conducting inspections, and preparing test reports.
 2. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with requirements.
 3. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued and firestop installations comply with requirements.
- C. Cleaning And Protecting
1. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.
 2. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Final Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.
- D. Through-Penetration Firestop System Schedule
1. Choices in the following paragraphs which are contained within brackets shall be as required to satisfy building and local code requirements.
 2. Where UL-classified systems are indicated, they refer to alpha-alpha-numeric designations listed in UL's "Fire Resistance Directory" under product Category XHEZ.
 3. Where OPL-classified systems are indicated, they refer to alpha-numeric design numbers in OPL's "Directory of Listed Building Products, Materials, & Assemblies."
 4. Where ITS-listed systems are indicated, they refer to design numbers listed in ITS's "Directory of Listed Products," "Firestop Systems" Section.



5. Firestop Systems with No Penetrating Items:
 - a. UL-Classified Systems: [C-AJ-] [C-BJ-] [F-A-] [W-J-] [W-L-] <Insert one or more four-digit numbers> [0001-0999].
 - b. OPL-Classified Systems: FS <Insert one or more OPL design numbers> [F] [W], Penetrating Item Type G.
 - c. ITS-Listed Systems: <Insert ITS design number(s).>
 - d. Type of Fill Materials: One or more of the following:
 - 1) Latex sealant.
 - 2) Silicone sealant.
 - 3) Intumescent putty.
 - 4) Mortar.
6. Firestop Systems for Metallic Pipes, Conduit, or Tubing:
 - a. UL-Classified Systems: [C-AJ-] [C-BJ-] [C-BK-] [F-A-] [F-B-] [F-C-] [W-J-] [W-K-] [W-L-] <Insert one or more four-digit numbers> [1001-1999].
 - b. OPL-Classified Systems: FS <Insert one or more OPL design numbers> [F] [W], Penetrating Item Type A.
 - c. ITS-Listed Systems: <Insert ITS design number(s).>
 - d. Type of Fill Materials: One or more of the following:
 - 1) Latex sealant.
 - 2) Silicone sealant.
 - 3) Intumescent putty.
 - 4) Mortar.
7. Firestop Systems for Nonmetallic Pipe, Conduit, or Tubing:
 - a. UL-Classified Systems: [C-AJ-] [C-BJ-] [F-A-] [F-B-] [F-C-] [W-J-] [W-L-] <Insert one or more four-digit numbers> [2001-2999].
 - b. OPL-Classified Systems: FS <Insert one or more OPL design numbers> [F] [W], Penetrating Item Type B.
 - c. ITS-Listed Systems: <Insert ITS design number(s).>
 - d. Type of Fill Materials: One or more of the following:
 - 1) Latex sealant.
 - 2) Silicone sealant.
 - 3) Intumescent putty.
 - 4) Intumescent wrap strips.
 - 5) Firestop device.
8. Firestop Systems for Electrical Cables:
 - a. UL-Classified Systems: [C-AJ-] [C-BJ-] [F-A-] [F-B-] [F-C-] [W-J-] [W-L-] <Insert one or more four-digit numbers> [3001-3999].
 - b. OPL-Classified Systems: FS <Insert one or more OPL design numbers> [F] [W], Penetrating Item Type D.
 - c. ITS-Listed Systems: <Insert ITS design number(s).>
 - d. Type of Fill Materials: One or more of the following:
 - 1) Latex sealant.
 - 2) Silicone sealant.
 - 3) Intumescent putty.
 - 4) Silicone foam.
 - 5) Pillows/bags.
9. Firestop Systems for Cable Trays:
 - a. UL-Classified Systems: [C-AJ-] [C-BJ-] [F-A-] [F-B-] [F-C-] [W-J-] [W-K-] [W-L-] <Insert one or more four-digit numbers> [4001-4999].
 - b. OPL-Classified Systems: FS <Insert one or more OPL design numbers> [F] [W], Penetrating Item Type D.
 - c. ITS-Listed Systems: <Insert ITS design number(s).>
 - d. Type of Fill Materials: One or more of the following:
 - 1) Latex sealant.
 - 2) Intumescent putty.
 - 3) Silicone foam.



- 4) Pillows/bags.
 - 5) Mortar.
10. Firestop Systems for Insulated Pipes:
- a. UL-Classified Systems: [C-AJ-] [C-BJ-] [F-A-] [F-C-] [W-J-] [W-L-] <Insert one or more four-digit numbers> [5001-5999].
 - b. OPL-Classified Systems: FS <Insert one or more OPL design numbers> [F] [W], Penetrating Item Type C.
 - c. ITS-Listed Systems: <Insert ITS design number(s).>
 - d. Type of Fill Materials: One or more of the following:
 - 1) Latex sealant.
 - 2) Intumescent putty.
 - 3) Silicone foam.
 - 4) Intumescent wrap strips.
11. Firestop Systems for Miscellaneous Electrical Penetrants:
- a. UL-Classified Systems: [C-AJ-] [F-A-] [W-L-] <Insert one or more four-digit numbers> [6001-6999].
 - b. OPL-Classified Systems: FS <Insert one or more OPL design numbers> [F] [W], Penetrating Item Type E.
 - c. ITS-Listed Systems: <Insert ITS design number(s).>
 - d. Type of Fill Materials: One or more of the following:
 - 1) Latex sealant.
 - 2) Intumescent putty.
 - 3) Mortar.
12. Firestop Systems for Miscellaneous Mechanical Penetrants:
- a. UL-Classified Systems: [C-AJ-] [F-C-] [W-J-] [W-L-] <Insert one or more four-digit numbers> [7001-7999].
 - b. ITS-Listed Systems: <Insert ITS design number(s).>
 - c. Type of Fill Materials: One or both of the following:
 - 1) Latex sealant.
 - 2) Mortar.
13. Firestop Systems for Groupings of Penetrants:
- a. UL-Classified Systems: [C-AJ-] [C-BJ-] [F-A-] [F-C-] [W-J-] [W-L-] <Insert one or more four-digit numbers> [8001-8999].
 - b. ITS-Listed Systems: <Insert ITS design number(s).>
 - c. Type of Fill Materials: One or more of the following:
 - 1) Latex sealant.
 - 2) Mortar.
 - 3) Intumescent wrap strips.
 - 4) Firestop device.
 - 5) Intumescent composite sheet.

END OF SECTION 07 84 13 16

**SECTION 07 84 13 16a - FIRE-RESISTIVE JOINT SYSTEMS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for fire-resistive joint systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes fire-resistive joint systems for the following:
 - a. Floor-to-floor joints.
 - b. Floor-to-wall joints.
 - c. Head-of-wall joints.
 - d. Wall-to-wall joints.
 - e. Perimeter fire-resistive joint systems consisting of floor-to-wall joints between perimeter edge of fire-resistance-rated floor assemblies and exterior curtain walls.

C. Performance Requirements

1. General: Provide fire-resistive joint systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly in which fire-resistive joint systems are installed.
2. Joint Systems in and between Fire-Resistance-Rated Constructions: Provide systems with assembly ratings equaling or exceeding the fire-resistance ratings of construction that they join, and with movement capabilities and L-ratings indicated as determined by UL 2079.
 - a. Load-bearing capabilities as determined by evaluation during the time of test.
3. Perimeter Fire-Resistive Joint Systems: For joints between edges of fire-resistance-rated floor assemblies and exterior curtain walls, provide systems of type and with ratings indicated below and those indicated in the Fire-Resistive Joint System Schedule at the end of Part 1.3, as determined by IBC Standard **OR** NFPA 285, **as directed**, and UL 2079.
 - a. UL-Listed, Perimeter Fire-Containment Systems: Integrity ratings equaling or exceeding fire-resistance ratings of floor or floor/ceiling assembly forming one side of joint.
 - b. OPL-Listed, Perimeter Fire-Barrier Systems: F-ratings equaling or exceeding fire-resistance ratings of floor or floor/ceiling assembly forming one side of joint.
4. For fire-resistive systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

D. Submittals

1. Product Data: For each product indicated.
2. Shop Drawings: For each fire-resistive joint system.
3. Qualification Data: For Installer.
4. Field quality-control test reports.
5. Evaluation Reports: Evidence of fire-resistive joint systems' compliance with ICBO ES AC30, from the ICBO Evaluation Service.
6. Research/Evaluation Reports: For each type of fire-resistive joint system.

E. Quality Assurance

1. Installer Qualifications: A firm that has been approved by FMG according to FMG 4991, "Approval of Firestop Contractors."
2. Installation Responsibility: Assign installation of through-penetration firestop systems and fire-resistive joint systems in Project to a single qualified installer.
3. Fire-Test-Response Characteristics: Provide fire-resistive joint systems that comply with the following requirements and those specified in Part 1 "Performance Requirements" Article:



- a. Fire-resistance tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is UL **OR** OPL, **as directed**, or another agency performing testing and follow-up inspection services for fire-resistive joint systems acceptable to authorities having jurisdiction.
- b. Fire-resistive joint systems are identical to those tested per methods indicated in Part 1 "Performance Requirements" Article and comply with the following:
 - 1) Fire-resistive joint system products bear classification marking of qualified testing and inspecting agency.
 - 2) Fire-resistive joint systems correspond to those indicated by referencing system designations of the qualified testing and inspecting agency.
4. Coordinate construction of joints to ensure that fire-resistive joint systems are installed according to specified requirements.
5. Do not cover up fire-resistive joint system installations that will become concealed behind other construction until inspecting agency and building inspector of authorities having jurisdiction have examined each installation.

F. Delivery, Storage, And Handling

1. Deliver fire-resistive joint system products to Project site in original, unopened containers or packages with qualified testing and inspecting agency's classification marking applicable to Project and with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, lot number, shelf life, curing time, and mixing instructions for multicomponent materials.
2. Store and handle materials for fire-resistive joint systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.2 PRODUCTS

A. Fire-Resistive Joint Systems

1. Compatibility: Provide fire-resistive joint systems that are compatible with joint substrates, under conditions of service and application, as demonstrated by fire-resistive joint system manufacturer based on testing and field experience.
2. Accessories: Provide components of fire-resistive joint systems, including primers and forming materials, that are needed to install fill materials and to comply with Part 1 "Performance Requirements" Article. Use only components specified by fire-resistive joint system manufacturer and approved by the qualified testing and inspecting agency for systems indicated.

1.3 EXECUTION

A. Installation

1. Install fire-resistive joint systems to comply with Part 1.1 "Performance Requirements" Article and fire-resistive joint system manufacturer's written installation instructions for products and applications indicated.
2. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

B. Field Quality Control

1. Inspecting Agency: Engage a qualified independent inspecting agency to inspect fire-resistive joint systems and prepare inspection reports.
2. Testing Services: Inspecting of completed installations of fire-resistive joint systems shall take place in successive stages as installation of fire-resistive joint systems proceeds. Do not proceed with installation of joint systems for the next area until inspecting agency determines completed work shows compliance with requirements.



- a. Inspecting agency shall state in each report whether inspected fire-resistive joint systems comply with or deviate from requirements.
 3. Remove and replace fire-resistive joint systems where inspections indicate that they do not comply with specified requirements.
 4. Proceed with enclosing fire-resistive joint systems with other construction only after inspection reports are issued and fire-resistive joint systems comply with requirements.
- C. Fire-Resistive Joint System Schedule
1. Designation System for Joints in or between Fire-Resistance-Rated Constructions: Alphanumeric systems listed in UL's "Fire Resistance Directory" under Product Category XHBN.
 2. Designation System for Joints at the Intersection of Fire-Resistance-Rated Floor or Floor/Ceiling Assembly and an Exterior Curtain-Wall Assembly: Alphanumeric systems listed in UL's "Fire Resistance Directory" under Product Category XHDG **OR** OPL's "Directory of Listed Building Products, Materials, & Assemblies" as perimeter fire-barrier systems, **as directed**.

END OF SECTION 07 84 13 16a



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**SECTION 07 84 13 16b - FIRESTOPPING**

1.1 DESCRIPTION OF WORK

- A. This specification covers the furnishing and installation of materials for firestopping. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 GENERAL

- A. System Description
1. Performance Requirements: Comply with following:
 - a. Firestopping: Consist of material or combination of materials to form effective barrier against spread of flame, smoke, and gases, and maintain integrity of fire-resistance rated walls, partitions, floors, and ceiling-floor assemblies at penetrations.
 - 1) Penetrations: Include annular space around pipes, ducts, chimneys, tubes, conduit, wires, cables, and vents.
- B. Submittals
1. Product Data:
 - a. Composition and performance characteristics.
 - b. List of FM, UL, or WH classification number of systems installed.
 2. Quality Assurance/Control Submittals:
 - a. Test Reports: If not FM, UL, or WH listed, submit certified test results for ASTM E 814 tests by UL, FM, WH, or other accredited independent laboratory demonstrating compliance of firestopping with specified requirements.
 - b. Manufacturers installation instructions.
- C. Quality Assurance
1. Regulatory Requirements: Comply with applicable building-code requirements for firestopping.
- D. Delivery, Storage, And Handling
1. Packing, Shipping, Handling, and Unloading: Deliver in original, unopened containers with manufacturer's labels.
 - a. Products: FM, UL, or WH labeled and FM, UL, or WHI listed.
 2. Storage and Protection: Store firestopping materials in accordance with manufacturer's recommendations.

1.3 PRODUCTS

- A. Fire-Rated Penetration Sealant Systems
1. Firestopping Materials: Commercially manufactured asbestos-free products complying with following minimum requirements:
 - a. Material:
 - 1) Flame Spread: ASTM E 84 or UL 723, 25 or less.
 - 2) Smoke Developed Rating: ASTM E 84 or UL 723, 50 or less.
 - 3) Material: Approved firestopping material as listed in UL 05, FM P7825, or WH Certified Listing.
 - b. Material Properties:
 - 1) Contain no flammable or toxic solvents and have no dangerous or flammable outgassing during the drying or curing of products.



- 2) Non-toxic to human beings at all stages of application and during fire conditions.
- 3) Water-resistant after drying or curing and unaffected by high humidity, condensation, or transient water exposure.
- c. Devices and systems requiring heat activation to seal opening created by burning or melting of penetrant shall exhibit demonstrated ability to function as required for floors and walls of construction and thickness similar to those to be firestopped.
2. Firestopping System Requirements: Materials from single manufacturer capable of maintaining effective barrier against flame, smoke, and gases in accordance with ASTM E 814 and UL 1479.
 - a. Fire-Resistance Rating: Equal or greater than fire-resistance rating of assembly in which it is being placed.
 - b. F Ratings: Equal to or greater than fire-resistance rating of assembly penetrated.
 - c. T Ratings: Equal to or greater than fire-resistance rating of assembly penetrated at following locations:
 - 1) Penetrations located outside of wall cavities.
 - 2) Penetrations located outside of fire-resistive shaft enclosures.
 - 3) Penetrations located in enclosures with doors required to have temperature-rise rating.
 - 4) Penetrations with penetrating hems larger than 100 mm (4 inch) diameter nominal pipe or 10 320 sq. mm (16 square inches) in cross-sectional area.
 - d. System: Listed in UL 05, FM 7825, or WH Certified Listing, or tested by approved laboratory in accordance with ASTM E 814.
 - e. System: Suitable for firestopping of penetrations made by steel, glass, plastic, and insulated pipe.
 - f. Penetration by Insulated Pipe: Does not require removal of insulation.

1.4 EXECUTION

A. Examination

1. Verification of Conditions:
 - a. Existing Conditions: Examine penetrations before beginning installation.
 - b. Do not proceed with installation until conditions are satisfactory.

B. Installation

1. Fire-Rated Penetration Sealant Systems: Install in accordance with UL 05, FM P7825, or WH systems and manufacturers recommendations to maintain required fire-separation rating.
 - a. Preparation: Clean surfaces in contact with firestopping materials that may affect proper fitting or required fire rating. Prime if required. Dam void if required.
 - b. Penetrations: Completely fill void with sealant materials to smooth surface, flush with adjacent surfaces and in contact with surfaces formed by openings and penetrating items ensuring adhesion. Provide sealant in thickness to achieve required fire rating and smoke barrier.
 - c. Firestopping at Voids 100 mm (4 inches) or More in Any Direction: Capable of supporting same load as floor is designed to support or protected by permanent barrier.
 - d. Remove any excess sealant from adjacent surfaces.
2. Firestopping: Provide at following locations:
 - a. Penetrations of duct, chimney, conduit, tubing, cable, and pipe through floors and through fire-resistance rated walls, partitions, and ceiling-floor assemblies.
 - b. Penetrations of vertical shafts such as pipe chases, elevator shafts, and utility chutes.
 - c. Gaps at intersection of fire-rated floor slabs and walls.
 - d. Gaps at perimeter of fire-rated walls and partitions, such as between top of walls and bottom of floor or roof decks.
 - e. Construction joints in fire-rated floors, walls, and partitions.
 - f. Other locations where required to maintain fire-resistance rating of the construction.
 - g. Other locations as indicated on Drawings (if any).



- C. Field Quality Control
 - 1. Inspection: Examine areas to be firestopped prior to concealing or enclosing to ensure proper installation.
 - a. Keep areas of firestopping work accessible until inspection by authorities having jurisdiction over work.

END OF SECTION 07 84 13 16b



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Task	Specification	Specification Description
07 84 13 19	07 84 13 16	Through-Penetration Firestop Systems
07 84 13 19	07 84 13 16a	Fire-Resistive Joint Systems
07 84 13 19	07 84 13 16b	Firestopping



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SECTION 07 84 16 00 - CAST-IN-PLACE CONCRETE**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for cast-in-place concrete. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section specifies cast-in place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:
 - a. Footings.
 - b. Foundation walls.
 - c. Slabs-on-grade.
 - d. Suspended slabs.
 - e. Concrete toppings.
 - f. Building frame members.
 - g. Building walls.

C. Definitions

1. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
 - b. Design Mixtures for Credit ID 1.1: For each concrete mixture containing fly ash as a replacement for portland cement or other portland cement replacements and for equivalent concrete mixtures that do not contain portland cement replacements.
3. Design Mixtures: For each concrete mixture.
4. Shop Drawings: For steel reinforcement and formwork. Material test reports **OR** certificates, **as directed**.

E. Quality Assurance

1. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
 - a. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
2. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, **as directed**, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
3. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
 - a. ACI 301, "Specification for Structural Concrete," Sections 1 through 5 **OR** Sections 1 through 5 and Section 7, "Lightweight Concrete", **as directed**.
 - b. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
4. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.



5. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement, **as directed**.
2. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

1.2 PRODUCTS

A. Form-Facing Materials

1. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
2. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
3. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
4. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.
5. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
6. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.
7. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.
8. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
 - a. Formulate form-release agent with rust inhibitor for steel form-facing materials.
9. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
 - a. Furnish units that will leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.
 - b. Furnish ties that, when removed, will leave holes no larger than 1 inch (25 mm) in diameter in concrete surface.
 - c. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

B. Steel Reinforcement

1. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 **OR** 60, **as directed**, percent.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
3. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
4. Galvanized Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**, deformed bars, ASTM A 767/A 767M, Class I **OR** II, **as directed**, zinc coated after fabrication and bending.
5. Epoxy-Coated Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**, deformed bars, ASTM A 775/A 775M **OR** ASTM A 934/A 934M, **as directed**, epoxy coated, with less than 2 percent damaged coating in each 12-inch (300-mm) bar length.
6. Stainless-Steel Reinforcing Bars: ASTM A 955/A 955M, Grade 60 (Grade 420), Type 304 **OR** 316L, **as directed**, deformed.



7. Steel Bar Mats: ASTM A 184/A 184M, fabricated from ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**, deformed bars, assembled with clips.
 8. Plain-Steel Wire: ASTM A 82, as drawn **OR** galvanized, **as directed**.
 9. Deformed-Steel Wire: ASTM A 496.
 10. Epoxy-Coated Wire: ASTM A 884/A 884M, Class A, Type 1 coated, as-drawn, plain-steel-wire **OR** deformed-steel wire, **as directed**, with less than 2 percent damaged coating in each 12-inch (300-mm) wire length.
 11. Plain-Steel Welded Wire Reinforcement: ASTM A 185, plain, fabricated from as-drawn steel wire into flat sheets.
 12. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.
 13. Galvanized-Steel Welded Wire Reinforcement: ASTM A 185, plain, fabricated from galvanized steel wire into flat sheets.
 14. Epoxy-Coated Welded Wire Reinforcement: ASTM A 884/A 884M, Class A coated, Type 1, plain **OR** deformed, **as directed**, steel.
- C. Reinforcement Accessories
1. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars, cut bars true to length with ends square and free of burrs.
 2. Epoxy-Coated Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars, ASTM A 775/A 775M epoxy coated.
 3. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating; compatible with epoxy coating on reinforcement and complying with ASTM A 775/A 775M.
 4. Zinc Repair Material: ASTM A 780, zinc-based solder, paint containing zinc dust, or sprayed zinc.
 5. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
 - a. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
 - b. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
 - c. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.
- D. Concrete Materials
1. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
 - a. Portland Cement: ASTM C 150, Type I **OR** II **OR** I/II **OR** III **OR** V, **as directed**, gray **OR** white, **as directed**. Supplement with the following:
 - 1) Fly Ash: ASTM C 618, Class C **OR** F, **as directed**.
 - 2) Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
 - b. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag **OR** IP, portland-pozzolan **OR** I (PM), pozzolan-modified portland **OR** I (SM), slag-modified Portland, **as directed**, cement.
 2. Silica Fume: ASTM C 1240, amorphous silica.
 3. Normal-Weight Aggregates: ASTM C 33, graded, 1-1/2-inch (38-mm) **OR** 1-inch (25-mm) **OR** 3/4-inch (19-mm), **as directed**, nominal maximum coarse-aggregate size.
 - a. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
 4. Lightweight Aggregate: ASTM C 330, 1-inch (25-mm) **OR** 3/4-inch (19-mm) **OR** 1/2-inch (13-mm) **OR** 3/8-inch (10-mm), **as directed**, nominal maximum aggregate size.
 5. Water: ASTM C 94/C 94M and potable, **as directed**.
- E. Admixtures
1. Air-Entraining Admixture: ASTM C 260.



2. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 - a. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 - b. Retarding Admixture: ASTM C 494/C 494M, Type B.
 - c. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 - d. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 - e. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 - f. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
 3. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C 494/C 494M, Type C.
 4. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.
 5. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, **as directed**, nonfading, and resistant to lime and other alkalis.
 - a. Color: As indicated by manufacturer's designation **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.
- F. Fiber Reinforcement
1. Carbon-Steel Fiber: ASTM A 820, deformed, minimum of 1.5 inches (38 mm) **OR** 2 inches (50 mm) **OR** 2.4 inches (60 mm), **as directed**, long, and aspect ratio of 35 to 40 **OR** 45 to 50 **OR** 60 to 65, **as directed**.
 - a. Fiber: Type 1, cold-drawn wire **OR** 2, cut sheet, **as directed**.
 2. Synthetic Micro-Fiber: Monofilament or fibrillated polypropylene micro-fibers engineered and designed for use in concrete, complying with ASTM C 1116/ C 1116M , Type III, 1/2 to 1-1/2 inches (13 to 38 mm) **OR** 1 to 2-1/4 inches (25 to 57 mm)long.
 3. Synthetic Macro-Fiber: Polyolefin macro-fibers engineered and designed for use in concrete, complying with ASTM C 1116/C 1116M, Type III, 1 to 2-1/4 inches (25 to 57 mm) long.
- G. Waterstops
1. Flexible Rubber Waterstops: CE CRD-C 513, with factory-installed metal eyelets, **as directed**, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
 - a. Profile: Flat, dumbbell with center bulb **OR** Flat, dumbbell without center bulb **OR** Ribbed with center bulb **OR** Ribbed without center bulb **OR** As indicated, **as directed**.
 - b. Dimensions: 4 inches by 3/16 inch thick (100 mm by 4.75 mm thick) **OR** 6 inches by 3/8 inch thick (150 mm by 10 mm thick) **OR** 9 inches by 3/8 inch thick (225 mm by 10 mm thick), **as directed**; nontapered.
 2. Chemically Resistant Flexible Waterstops: Thermoplastic elastomer rubber waterstops with factory-installed metal eyelets, **as directed**, for embedding in concrete to prevent passage of fluids through joints; resistant to oils, solvents, and chemicals. Factory fabricate corners, intersections, and directional changes.
 - a. Profile: Flat, dumbbell with center bulb **OR** Flat, dumbbell without center bulb **OR** Ribbed with center bulb **OR** Ribbed without center bulb **OR** As indicated, **as directed**.
 - b. Dimensions: 4 inches by 3/16 inch thick (100 mm by 4.75 mm thick) **OR** 6 inches by 3/16 inch thick (150 mm by 4.75 mm thick) **OR** 6 inches by 3/8 inch thick (150 mm by 10 mm thick) **OR** 9 inches by 3/16 inch thick (225 mm by 4.75 mm thick) **OR** 9 inches by 3/8 inch thick (225 mm by 10 mm thick), **as directed**; nontapered.
 3. Flexible PVC Waterstops: CE CRD-C 572, with factory-installed metal eyelets, **as directed**, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.



- a. Profile: Flat, dumbbell with center bulb **OR** Flat, dumbbell without center bulb **OR** Ribbed with center bulb **OR** Ribbed without center bulb **OR** As indicated, **as directed**.
 - b. Dimensions: 4 inches by 3/16 inch thick (100 mm by 4.75 mm thick) **OR** 6 inches by 3/8 inch thick (150 mm by 10 mm thick) **OR** 9 inches by 3/8 inch thick (225 mm by 10 mm thick), **as directed**; nontapered.
 4. Self-Expanding Butyl Strip Waterstops: Manufactured rectangular or trapezoidal strip, butyl rubber with sodium bentonite or other hydrophilic polymers, for adhesive bonding to concrete, 3/4 by 1 inch (19 by 25 mm).
 5. Self-Expanding Rubber Strip Waterstops: Manufactured rectangular or trapezoidal strip, bentonite-free hydrophilic polymer modified chloroprene rubber, for adhesive bonding to concrete, 3/8 by 3/4 inch (10 by 19 mm).
- H. Vapor Retarders
1. Plastic Vapor Retarder:
 - a. ASTM E 1745, Class A. Include manufacturer's recommended adhesive or pressure-sensitive tape.
 - b. ASTM E 1745, Class B. Include manufacturer's recommended adhesive or pressure-sensitive tape.
 - c. ASTM E 1745, Class C, or polyethylene sheet, ASTM D 4397, not less than 10 mils (0.25 mm) thick, **as directed**. Include manufacturer's recommended adhesive or pressure-sensitive joint tape.
 2. Bituminous Vapor Retarder: 110-mil- (2.8-mm-) thick, semiflexible, 7-ply sheet membrane consisting of reinforced core and carrier sheet with fortified asphalt layers, protective weathercoating, and removable plastic release liner. Furnish manufacturer's accessories including bonding asphalt, pointing mastics, and self-adhering joint tape.
 - a. Water-Vapor Permeance: 0.00 grains/h x sq. ft. x inches Hg (0.00 ng/Pa x s x sq. m); ASTM E 154.
 - b. Tensile Strength: 140 lbf/in. (24.5 kN/m); ASTM E 154.
 - c. Puncture Resistance: 90 lbf (400N); ASTM E 154.
 3. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448, Size 57, with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.
 4. Fine-Graded Granular Material: Clean mixture of crushed stone, crushed gravel, and manufactured or natural sand; ASTM D 448, Size 10, with 100 percent passing a 3/8-inch (9.5-mm) sieve, 10 to 30 percent passing a No. 100 (0.15-mm) sieve, and at least 5 percent passing No. 200 (0.075-mm) sieve; complying with deleterious substance limits of ASTM C 33 for fine aggregates.
- I. Floor And Slab Treatments
1. Slip-Resistive Emery Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive, crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials with 100 percent passing 3/8-inch (9.5-mm) **OR** No. 4 (4.75-mm) **OR** No. 8 (2.36-mm), **as directed**, sieve.
 2. Slip-Resistive Aluminum Granule Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of not less than 95 percent fused aluminum-oxide granules.
 3. Emery Dry-Shake Floor Hardener: Pigmented **OR** Unpigmented, **as directed**, factory-packaged, dry combination of portland cement, graded emery aggregate, and plasticizing admixture; with emery aggregate consisting of no less than 60 percent of total aggregate content.
 - a. Color: As indicated by manufacturer's designation **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.
 4. Metallic Dry-Shake Floor Hardener: Pigmented **OR** Unpigmented, **as directed**, factory-packaged, dry combination of portland cement, graded metallic aggregate, rust inhibitors, and plasticizing admixture; with metallic aggregate consisting of no less than 65 percent of total aggregate content.



- a. Color: As indicated by manufacturer's designation **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.
 5. Unpigmented Mineral Dry-Shake Floor Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, and plasticizing admixture.
 6. Pigmented Mineral Dry-Shake Floor Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.
 - a. Color: As indicated by manufacturer's designation **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.
 7. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; colorless; that penetrates, hardens, and densifies concrete surfaces.
- J. Liquid Floor Treatments
1. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.
 2. Penetrating Liquid Floor Treatments for Polished Concrete Finish: Clear, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and is suitable for polished concrete surfaces.
- K. Curing Materials
1. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
 2. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.
 3. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
 4. Water: Potable.
 5. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.
 6. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering, **as directed**.
 7. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, 18 to 25 percent solids, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering, **as directed**.
 8. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.
 9. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.
- L. Related Materials
1. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber **OR** ASTM D 1752, cork or self-expanding cork, **as directed**.
 2. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 **OR** aromatic polyurea with a Type A shore durometer hardness range of 90 to 95, **as directed**, per ASTM D 2240.
 3. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
 4. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
 - a. Types I and II, non-load bearing **OR** IV and V, load bearing, **as directed**, for bonding hardened or freshly mixed concrete to hardened concrete.
 5. Reglets: Fabricate reglets of not less than 0.0217-inch- (0.55-mm-) thick, galvanized steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.



6. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.0336 inch (0.85 mm) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.
- M. Repair Materials
1. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3.2 mm) and that can be feathered at edges to match adjacent floor elevations.
 - a. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
 - b. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
 - c. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by underlayment manufacturer.
 - d. Compressive Strength: Not less than 4100 psi (29 MPa) at 28 days when tested according to ASTM C 109/C 109M.
 2. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3.2 mm) and that can be feathered at edges to match adjacent floor elevations.
 - a. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
 - b. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
 - c. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by topping manufacturer.
 - d. Compressive Strength: Not less than 5000 psi (34.5 MPa) at 28 days when tested according to ASTM C 109/C 109M.
- N. Concrete Mixtures, General
1. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
 - a. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.
 2. Cementitious Materials: Use fly ash, pozzolan, ground granulated blast-furnace slag, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent **OR** Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows, **as directed**
 - a. Fly Ash: 25 percent.
 - b. Combined Fly Ash and Pozzolan: 25 percent.
 - c. Ground Granulated Blast-Furnace Slag: 50 percent.
 - d. Combined Fly Ash or Pozzolan and Ground Granulated Blast-Furnace Slag: 50 percent portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.
 - e. Silica Fume: 10 percent.
 - f. Combined Fly Ash, Pozzolans, and Silica Fume: 35 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.
 - g. Combined Fly Ash or Pozzolans, Ground Granulated Blast-Furnace Slag, and Silica Fume: 50 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.
 3. Limit water-soluble, chloride-ion content in hardened concrete to 0.06 **OR** 0.15 **OR** 0.30 **OR** 1.00, **as directed**, percent by weight of cement.
 4. Admixtures: Use admixtures according to manufacturer's written instructions.
 - a. Use water-reducing **OR** high-range water-reducing **OR** plasticizing, **as directed**, admixture in concrete, as required, for placement and workability.
 - b. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.



- c. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
 - d. Use corrosion-inhibiting admixture in concrete mixtures where indicated.
5. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

O. Concrete Mixtures For Building Elements

1. Footings: Proportion normal-weight concrete mixture as follows:
 - a. Minimum Compressive Strength: 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**, at 28 days.
 - b. Maximum Water-Cementitious Materials Ratio: 0.50 **OR** 0.45 **OR** 0.40, **as directed**.
 - c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm) **OR** 8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture, **as directed**, plus or minus 1 inch (25 mm).
 - d. Air Content:
 - 1) 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
 - 2) 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) **OR** 3/4-inch (19-mm), **as directed**, nominal maximum aggregate size.
2. Foundation Walls: Proportion normal-weight concrete mixture as follows:
 - a. Minimum Compressive Strength: 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**, at 28 days.
 - b. Maximum Water-Cementitious Materials Ratio: 0.50 **OR** 0.45 **OR** 0.40, **as directed**.
 - c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm) **OR** 8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture, **as directed**, plus or minus 1 inch (25 mm).
 - d. Air Content:
 - 1) 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
 - 2) 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) **OR** 3/4-inch (19-mm), **as directed**, nominal maximum aggregate size.
3. Slabs-on-Grade: Proportion normal-weight concrete mixture as follows:
 - a. Minimum Compressive Strength: 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**, at 28 days.
 - b. Minimum Cementitious Materials Content: 470 lb/cu. yd. (279 kg/cu. m) **OR** 520 lb/cu. yd. (309 kg/cu. m) **OR** 540 lb/cu. yd. (320 kg/cu. m), **as directed**.
 - c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm), **as directed**, plus or minus 1 inch (25 mm).
 - d. Air Content
 - 1) 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
 - 2) 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) **OR** 3/4-inch (19-mm), **as directed**, nominal maximum aggregate size.
 - 3) Do not allow air content of troweled finished floors to exceed 3 percent.
 - e. Steel-Fiber Reinforcement: Add to concrete mixture, according to manufacturer's written instructions, at a rate of 50 lb/cu. yd. (29.7 kg/cu. m).
 - f. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m) **OR** 1.5 lb/cu. yd. (0.90 kg/cu. m), **as directed**.
4. Suspended Slabs: Proportion normal-weight concrete mixture as follows:
 - a. Minimum Compressive Strength: 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**, at 28 days.



- b. Minimum Cementitious Materials Content: 470 lb/cu. yd. (279 kg/cu. m) **OR** 520 lb/cu. yd. (309 kg/cu. m) **OR** 540 lb/cu. yd. (320 kg/cu. m), **as directed**.
 - c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm), **as directed**, plus or minus 1 inch (25 mm).
 - d. Air Content:
 - 1) 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
 - 2) 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) **OR** 3/4-inch (19-mm), **as directed**, nominal maximum aggregate size.
 - 3) Do not allow air content of troweled finished floors to exceed 3 percent.
 - e. Steel-Fiber Reinforcement: Add to concrete mixture, according to manufacturer's written instructions, at a rate of 50 lb/cu. yd. (29.7 kg/cu. m).
 - f. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m) **OR** 1.5 lb/cu. yd. (0.90 kg/cu. m), **as directed**.
5. Suspended Slabs: Proportion structural lightweight concrete mixture as follows:
- a. Minimum Compressive Strength: 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**, at 28 days.
 - b. Calculated Equilibrium Unit Weight: 115 lb/cu. ft. (1842 kg/cu. m) **OR** 110 lb/cu. ft. (1762 kg/cu. m) **OR** 105 lb/cu. ft. (1682 kg/cu. m), **as directed**, plus or minus 3 lb/cu. ft. (48.1 kg/cu. m) as determined by ASTM C 567.
 - c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm), **as directed**, plus or minus 1 inch (25 mm).
 - d. Air Content:
 - 1) 6 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size greater than 3/8 inch (10 mm).
 - 2) 7 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size 3/8 inch (10 mm) or less.
 - 3) Do not allow air content of troweled finished floors to exceed 3 percent.
 - e. Steel-Fiber Reinforcement: Add to concrete mixture, according to manufacturer's written instructions, at a rate of 50 lb/cu. yd. (29.7 kg/cu. m).
 - f. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m) **OR** 1.5 lb/cu. yd. (0.90 kg/cu. m), **as directed**.
6. Concrete Toppings: Proportion normal-weight concrete mixture as follows:
- a. Minimum Compressive Strength: 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**, at 28 days.
 - b. Minimum Cementitious Materials Content: 470 lb/cu. yd. (279 kg/cu. m) **OR** 520 lb/cu. yd. (309 kg/cu. m) **OR** 540 lb/cu. yd. (320 kg/cu. m), **as directed**.
 - c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm), **as directed**, plus or minus 1 inch (25 mm).
 - d. Air Content:
 - 1) 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
 - 2) 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) **OR** 3/4-inch (19-mm), **as directed**, nominal maximum aggregate size.
 - 3) Do not allow air content of troweled finished toppings to exceed 3 percent.
 - e. Steel-Fiber Reinforcement: Add to concrete mixture, according to manufacturer's written instructions, at a rate of 50 lb/cu. yd. (29.7 kg/cu. m).
 - f. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m) **OR** 1.5 lb/cu. yd. (0.90 kg/cu. m), **as directed**.
7. Building Frame Members: Proportion normal-weight concrete mixture as follows:
- a. Minimum Compressive Strength: 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**, at 28 days.
 - b. Maximum Water-Cementitious Materials Ratio: 0.50 **OR** 0.45 **OR** 0.40, **as directed**.



- c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm) **OR** 8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture, **as directed**, plus or minus 1 inch (25 mm).
 - d. Air Content:
 - 1) 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
 - 2) 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) **OR** 3/4-inch (19-mm), **as directed**, nominal maximum aggregate size.
8. Building Walls: Proportion normal-weight concrete mixture as follows:
- a. Minimum Compressive Strength: 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**, at 28 days.
 - b. Maximum Water-Cementitious Materials Ratio: 0.50 **OR** 0.45 **OR** 0.40, **as directed**.
 - c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm) **OR** 8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture, **as directed**, plus or minus 1 inch (25 mm).
 - d. Air Content:
 - 1) 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
 - 2) 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) **OR** 3/4-inch (19-mm), **as directed**, nominal maximum aggregate size.

P. Fabricating Reinforcement

- 1. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

Q. Concrete Mixing

- 1. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116, **as directed**, and furnish batch ticket information.
 - a. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
- 2. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - a. For mixer capacity of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 - b. For mixer capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
 - c. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

1.3 EXECUTION

A. Formwork

- 1. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.
- 2. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- 3. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
 - a. Class A, 1/8 inch (3.2 mm) for smooth-formed finished surfaces.



- b. Class B, 1/4 inch (6 mm) **OR** Class C, 1/2 inch (13 mm) **OR** Class D, 1 inch (25 mm), **as directed**, for rough-formed finished surfaces.
 4. Construct forms tight enough to prevent loss of concrete mortar.
 5. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 - a. Install keyways, reglets, recesses, and the like, for easy removal.
 - b. Do not use rust-stained steel form-facing material.
 6. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
 7. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
 8. Chamfer **OR** Do not chamfer, **as directed**, exterior corners and edges of permanently exposed concrete.
 9. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
 10. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
 11. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
 12. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.
- B. Embedded Items
1. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - a. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
 - b. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
 - c. Install dovetail anchor slots in concrete structures as indicated.
- C. Removing And Reusing Forms
1. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
 - a. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved at least 70 percent of, **as directed**, its 28-day design compressive strength.
 - b. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
 2. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.
 3. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by the Owner.
- D. Shores And Reshores



1. Comply with ACI 318 (ACI 318M) and ACI 301 for design, installation, and removal of shoring and reshoring.
 - a. Do not remove shoring or reshoring until measurement of slab tolerances is complete.
2. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.
3. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

E. Vapor Retarders

1. Plastic Vapor Retarders: Place, protect, and repair vapor retarders according to ASTM E 1643 and manufacturer's written instructions.
 - a. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended tape.
2. Bituminous Vapor Retarders: Place, protect, and repair vapor retarders according to manufacturer's written instructions.
3. Granular Course: Cover vapor retarder with granular fill **OR** fine-graded granular material, **as directed**, moisten, and compact with mechanical equipment to elevation tolerances of plus 0 inch (0 mm) or minus 3/4 inch (19 mm).
 - a. Place and compact a 1/2-inch- (13-mm-) thick layer of fine-graded granular material over granular fill.

F. Steel Reinforcement

1. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
 - a. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.
2. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.
3. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
 - a. Weld reinforcing bars according to AWS D1.4, where indicated.
4. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
5. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.
6. Epoxy-Coated Reinforcement: Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M. Use epoxy-coated steel wire ties to fasten epoxy-coated steel reinforcement.
7. Zinc-Coated Reinforcement: Repair cut and damaged zinc coatings with zinc repair material according to ASTM A 780. Use galvanized steel wire ties to fasten zinc-coated steel reinforcement.

G. Joints

1. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
2. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by the Owner.
 - a. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
 - b. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
 - c. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 - d. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.



- e. Space vertical joints in walls, **as directed**. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
 - f. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - g. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
3. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:
 - a. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch (3.2 mm). Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
 - b. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3.2-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
 4. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
 - a. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.
 - b. Terminate full-width joint-filler strips not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished concrete surface where joint sealants, specified in Division 07 Section "Joint Sealants", are indicated.
 - c. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
 5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.
- H. Waterstops
1. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.
 2. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, adhesive bonding, mechanically fastening, and firmly pressing into place. Install in longest lengths practicable.
- I. Concrete Placement
1. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
 2. Do not add water to concrete during delivery, at Project site, or during placement unless approved by the Owner.
 3. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.
 - a. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.
 4. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
 - a. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
 - b. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
 - c. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6



inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

5. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
 - a. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 - b. Maintain reinforcement in position on chairs during concrete placement.
 - c. Screed slab surfaces with a straightedge and strike off to correct elevations.
 - d. Slope surfaces uniformly to drains where required.
 - e. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.
6. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - a. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
 - b. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 - c. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
7. Hot-Weather Placement: Comply with ACI 301 and as follows:
 - a. Maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 - b. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

J. Finishing Formed Surfaces

1. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
 - a. Apply to concrete surfaces not exposed to public view.
2. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
 - a. Apply to concrete surfaces exposed to public view, **OR** to receive a rubbed finish, **OR** to be covered with a coating or covering material applied directly to concrete, **as directed**.
3. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:
 - a. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
 - b. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.



- c. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.
 4. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.
- K. Finishing Floors And Slabs
1. General: Comply with ACI 302.1R recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
 2. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch (6 mm) in 1 direction.
 - a. Apply scratch finish to surfaces indicated and to receive concrete floor toppings **OR** to receive mortar setting beds for bonded cementitious floor finishes, **as directed**.
 3. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture.
 - a. Apply float finish to surfaces indicated **OR** to receive trowel finish **OR** to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo, **as directed**.
 4. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
 - a. Apply a trowel finish to surfaces indicated **OR** exposed to view **OR** to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system, **as directed**.
 - b. Finish surfaces to the following tolerances, according to ASTM E 1155 (ASTM E 1155M), for a randomly trafficked floor surface:
 - 1) Specified overall values of flatness, F(F) 25; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 17; and of levelness, F(L) 15.
 - 2) Specified overall values of flatness, F(F) 35; and of levelness, F(L) 25; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 17; for slabs-on-grade.
 - 3) Specified overall values of flatness, F(F) 30; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 15; for suspended slabs.
 - 4) Specified overall values of flatness, F(F) 45; and of levelness, F(L) 35; with minimum local values of flatness, F(F) 30; and of levelness, F(L) 24.
 - c. Finish and measure surface so gap at any point between concrete surface and an unleveled, freestanding, 10-foot- (3.05-m-) long straightedge resting on 2 high spots and placed anywhere on the surface does not exceed 1/4 inch (6 mm) **OR** 3/16 inch (4.8 mm) **OR** 1/8 inch (3.2 mm), **as directed**.
 5. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces indicated **OR** where ceramic or quarry tile is to be installed by either thickset or thin-set method, **as directed**. While concrete is still plastic, slightly scarify surface with a fine broom.
 - a. Comply with flatness and levelness tolerances for trowel finished floor surfaces.
 6. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.
 - a. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with the Owner before application.



7. Slip-Resistive Finish: Before final floating, apply slip-resistive aggregate **OR** aluminum granule, **as directed**, finish where indicated and to concrete stair treads, platforms, and ramps. Apply according to manufacturer's written instructions and as follows:
 - a. Uniformly spread 25 lb/100 sq. ft. (12 kg/10 sq. m) of dampened slip-resistive aggregate **OR** aluminum granules, **as directed**, over surface in 1 or 2 applications. Tamp aggregate flush with surface, but do not force below surface.
 - b. After broadcasting and tamping, apply float finish.
 - c. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive aggregate **OR** aluminum granules, **as directed**.
 8. Dry-Shake Floor Hardener Finish: After initial floating, apply dry-shake floor hardener to surfaces according to manufacturer's written instructions and as follows:
 - a. Uniformly apply dry-shake floor hardener at a rate of 100 lb/100 sq. ft. (49 kg/10 sq. m), **as directed**, unless greater amount is recommended by manufacturer.
 - b. Uniformly distribute approximately two-thirds of dry-shake floor hardener over surface by hand or with mechanical spreader, and embed by power floating. Follow power floating with a second dry-shake floor hardener application, uniformly distributing remainder of material, and embed by power floating.
 - c. After final floating, apply a trowel finish. Cure concrete with curing compound recommended by dry-shake floor hardener manufacturer and apply immediately after final finishing.
- L. Miscellaneous Concrete Items
1. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.
 2. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
 3. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.
 4. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel-finish concrete surfaces.
- M. Concrete Protecting And Curing
1. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.
 2. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
 3. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.
 4. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
 5. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
 - a. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - 1) Water.
 - 2) Continuous water-fog spray.



- 3) Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.
 - b. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 - 1) Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
 - 2) Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
 - 3) Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.
 - c. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
 - 1) After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.
 - d. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.
- N. Liquid Floor Treatments
1. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.
 - a. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
 - b. Do not apply to concrete that is less than three **OR** seven **OR** 14 **OR** 28, **as directed**, days' old.
 - c. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.
 2. Polished Concrete Floor Treatment: Apply polished concrete finish system to cured and prepared slabs to match.
 - a. Machine grind floor surfaces to receive polished finishes level and smooth and to depth required to reveal aggregate to match.
 - b. Apply penetrating liquid floor treatment for polished concrete in polishing sequence and according to manufacturer's written instructions, allowing recommended drying time between successive coats.
 - c. Continue polishing with progressively finer grit diamond polishing pads to gloss level to match approved mockup.
 - d. Control and dispose of waste products produced by grinding and polishing operations.
 - e. Neutralize and clean polished floor surfaces.
 3. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.
- O. Joint Filling
1. Prepare, clean, and install joint filler according to manufacturer's written instructions.
 - a. Defer joint filling until concrete has aged at least one **OR** six, **as directed**, month(s). Do not fill joints until construction traffic has permanently ceased.



2. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.
3. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches (50 mm) deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

P. Concrete Surface Repairs

1. Defective Concrete: Repair and patch defective areas when approved by the Owner. Remove and replace concrete that cannot be repaired and patched to the Owner's approval.
2. Patching Mortar: Mix dry-pack patching mortar, consisting of one part portland cement to two and one-half parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.
3. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
 - a. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension in solid concrete, but not less than 1 inch (25 mm) in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
 - b. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
 - c. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by the Owner.
4. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
 - a. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
 - b. After concrete has cured at least 14 days, correct high areas by grinding.
 - c. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
 - d. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
 - e. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 - f. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
 - g. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt,



- and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.
5. Perform structural repairs of concrete, subject to the Owner's approval, using epoxy adhesive and patching mortar.
 6. Repair materials and installation not specified above may be used, subject to the Owner's approval.
- Q. Field Quality Control
1. Testing and Inspecting: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
 2. Inspections:
 - a. Steel reinforcement placement.
 - b. Steel reinforcement welding.
 - c. Headed bolts and studs.
 - d. Verification of use of required design mixture.
 - e. Concrete placement, including conveying and depositing.
 - f. Curing procedures and maintenance of curing temperature.
 - g. Verification of concrete strength before removal of shores and forms from beams and slabs.
 3. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
 - a. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. (76 cu. m) or fraction thereof of each concrete mixture placed each day.
 - 1) When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 - b. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
 - c. Air Content: ASTM C 231, pressure method, for normal-weight concrete; ASTM C 173/C 173M, volumetric method, for structural lightweight concrete, **as directed**; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - d. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each composite sample.
 - e. Unit Weight: ASTM C 567, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - f. Compression Test Specimens: ASTM C 31/C 31M.
 - 1) Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
 - 2) Cast and field cure two sets of two standard cylinder specimens for each composite sample.
 - g. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.
 - 1) Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days.
 - 2) A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
 - h. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
 - i. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength



and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).

- j. Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
 - k. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the Owner but will not be used as sole basis for approval or rejection of concrete.
 - l. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by the Owner. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by the Owner.
 - m. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 - n. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
4. Measure floor and slab flatness and levelness according to ASTM E 1155 (ASTM E 1155M) within 24 **OR** 48, **as directed**, hours of finishing.
- R. Protection Of Liquid Floor Treatments
1. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.

END OF SECTION 07 84 16 00



Task	Specification	Specification Description
07 84 43 00	07 84 13 16	Through-Penetration Firestop Systems
07 84 43 00	07 84 13 16a	Fire-Resistive Joint Systems
07 84 43 00	07 84 13 16b	Firestopping
07 84 56 13	07 81 16 00	Sprayed Fire-Resistive Materials
07 84 56 13	07 82 00 00	Board Fire Protection



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**SECTION 07 91 23 00 - JOINT SEALANTS**

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for joint sealants. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Silicone joint sealants.
 - b. Urethane joint sealants.
 - c. Polysulfide joint sealants.
 - d. Latex joint sealants.
 - e. Solvent-release-curing joint sealants.
 - f. Preformed joint sealants.
 - g. Acoustical joint sealants.

C. Preconstruction Testing

1. Preconstruction Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for testing indicated below, samples of materials that will contact or affect joint sealants.
 - a. Use ASTM C 1087 **OR** manufacturer's standard test method, **as directed**, to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
 - b. Submit not fewer than eight pieces of each kind of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
 - c. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
 - d. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures including use of specially formulated primers.
 - e. Testing will not be required if joint-sealant manufacturers submit joint preparation data that are based on previous testing, not older than 24 months, of sealant products for adhesion to, and compatibility with, joint substrates and other materials matching those submitted.
2. Preconstruction Field-Adhesion Testing: Before installing sealants, field test their adhesion to Project joint substrates as follows:
 - a. Locate test joints where indicated on Project or, if not indicated, as directed by the Owner.
 - b. Conduct field tests for each application indicated below:
 - 1) Each kind of sealant and joint substrate indicated.
 - c. Notify the Owner seven days in advance of dates and times when test joints will be erected.
 - d. Arrange for tests to take place with joint-sealant manufacturer's technical representative present.
 - 1) Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
 - a) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
 - e. Report whether sealant failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. For sealants that fail adhesively, retest until satisfactory adhesion is obtained.
 - f. Evaluation of Preconstruction Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with



requirements, will be considered satisfactory. Do not use sealants that fail to adhere to joint substrates during testing.

D. Submittals

1. Product Data: For each joint-sealant product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For sealants and sealant primers used inside the weatherproofing system, including printed statement of VOC content.
3. Samples: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.
4. Joint-Sealant Schedule: Include the following information:
 - a. Joint-sealant application, joint location, and designation.
 - b. Joint-sealant manufacturer and product name.
 - c. Joint-sealant formulation.
 - d. Joint-sealant color.
5. Qualification Data: For qualified Installer and testing agency.
6. Product Certificates: For each kind of joint sealant and accessory, from manufacturer.
7. Sealant, Waterproofing, and Restoration Institute (SWRI) Validation Certificate: For each sealant specified to be validated by SWRI's Sealant Validation Program.
8. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating that sealants comply with requirements.
9. Preconstruction Compatibility and Adhesion Test Reports: From sealant manufacturer, indicating the following:
 - a. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
 - b. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.
10. Preconstruction Field-Adhesion Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.
11. Field-Adhesion Test Reports: For each sealant application tested.
12. Warranties: Sample of special warranties.

E. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Source Limitations: Obtain each kind of joint sealant from single source from single manufacturer.
3. Product Testing: Test joint sealants using a qualified testing agency.
 - a. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.
 - b. Test according to SWRI's Sealant Validation Program for compliance with requirements specified by reference to ASTM C 920 for adhesion and cohesion under cyclic movement, adhesion-in-peel, and indentation hardness.
4. Preinstallation Conference: Conduct conference at Project site.

F. Project Conditions

1. Do not proceed with installation of joint sealants under the following conditions:
 - a. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C, **as directed**).
 - b. When joint substrates are wet.
 - c. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.



- d. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

G. Warranty

- 1. Special Installer's Warranty: Manufacturer's standard form in which Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - a. Warranty Period: Two years from date of Final Completion.
- 2. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:
 - a. Movement of the structure caused by structural settlement or errors attributable to design or construction resulting in stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
 - b. Disintegration of joint substrates from natural causes exceeding design specifications.
 - c. Mechanical damage caused by individuals, tools, or other outside agents.
 - d. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

1.2 PRODUCTS

A. Materials, General

- 1. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
- 2. VOC Content of Interior Sealants: Provide sealants and sealant primers for use inside the weatherproofing system that comply with the following limits for VOC content when calculated according to 40 CFR 59, Part 59, Subpart D (EPA Method 24):
 - a. Architectural Sealants: 250 g/L.
 - b. Sealant Primers for Nonporous Substrates: 250 g/L.
 - c. Sealant Primers for Porous Substrates: 775 g/L.
- 3. Liquid-Applied Joint Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied joint sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
 - a. Suitability for Immersion in Liquids. Where sealants are indicated for Use I for joints that will be continuously immersed in liquids, provide products that have undergone testing according to ASTM C 1247. Liquid used for testing sealants is deionized water, unless otherwise indicated.
- 4. Stain-Test-Response Characteristics: Where sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.
- 5. Suitability for Contact with Food: Where sealants are indicated for joints that will come in repeated contact with food, provide products that comply with 21 CFR 177.2600.
- 6. Colors of Exposed Joint Sealants: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

B. Silicone Joint Sealants

- 1. Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 100/50, for Use NT.
- 2. Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 50, for Use NT.
- 3. Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.
- 4. Single-Component, Nonsag, Acid-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.



5. Single-Component, Nonsag, Traffic-Grade, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 100/50, for Use T.
6. Single-Component, Pourable, Traffic-Grade, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade P, Class 100/50, for Use T.
7. Multicomponent, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type M, Grade NS, Class 50, for Use NT.
8. Multicomponent, Pourable, Traffic-Grade, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type M, Grade P, Class 100/50, for Use T.
9. Mildew-Resistant, Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.
10. Mildew-Resistant, Single-Component, Acid-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.

C. Urethane Joint Sealants

1. Single-Component, Nonsag, Urethane Joint Sealant: ASTM C 920, Type S, Grade NS, Class 100/50, for Use NT.
2. Single-Component, Nonsag, Urethane Joint Sealant: ASTM C 920, Type S, Grade NS, Class 50, for Use NT.
3. Single-Component, Nonsag, Urethane Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.
4. Single-Component, Nonsag, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use T.
5. Single-Component, Pourable, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Use T.
6. Multicomponent, Nonsag, Urethane Joint Sealant: ASTM C 920, Type M, Grade NS, Class 50, for Use NT.
7. Multicomponent, Nonsag, Urethane Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use NT.
8. Multicomponent, Nonsag, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type M, Grade NS, Class 50, for Use T.
9. Multicomponent, Nonsag, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.
10. Immersible, Single-Component, Nonsag, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Uses T and I.
11. Immersible, Single-Component, Pourable, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Uses T and I.
12. Immersible Multicomponent, Nonsag, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Uses T and I.
13. Immersible Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type M, Grade P, Class 25, for Use T and I.

D. Polysulfide Joint Sealants

1. Single-Component, Nonsag, Polysulfide Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.
2. Multicomponent, Nonsag, Polysulfide Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use NT.
3. Multicomponent, Nonsag, Traffic-Grade, Polysulfide Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.
4. Multicomponent, Pourable, Traffic-Grade, Polysulfide Joint Sealant: ASTM C 920, Type M, Grade P, Class 25, for Use T.
5. Immersible, Multicomponent Nonsag, Traffic-Grade, Polysulfide Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T and Use I.

E. Latex Joint Sealants

1. Latex Joint Sealant: Acrylic latex or siliconized acrylic latex, ASTM C 834, Type OP, Grade NF.



- F. Solvent-Release-Curing Joint Sealants
1. Acrylic-Based Joint Sealant: ASTM C 1311.
 2. Butyl-Rubber-Based Joint Sealant: ASTM C 1311.
- G. Preformed Joint Sealants
1. Preformed Silicone Joint Sealants: Manufacturer's standard sealant consisting of precured low-modulus silicone extrusion, in sizes to fit joint widths indicated, combined with a neutral-curing silicone sealant for bonding extrusions to substrates.
 2. Preformed Foam Joint Sealant: Manufacturer's standard preformed, precompressed, open-cell foam sealant manufactured from urethane foam with minimum density of 10 lb/cu. ft. (160 kg/cu. m) and impregnated with a nondrying, water-repellent agent. Factory produce in precompressed sizes in roll or stick form to fit joint widths indicated; coated on one side with a pressure-sensitive adhesive and covered with protective wrapping.
- H. Acoustical Joint Sealants
1. Acoustical Joint Sealant: Manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C 834. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.
- I. Joint Sealant Backing
1. General: Provide sealant backings of material that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
 2. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin) **OR** Type O (open-cell material) **OR** Type B (bicellular material with a surface skin) **OR** any of the preceding types, as approved in writing by joint-sealant manufacturer for joint application indicated, **as directed**, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
 3. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.
- J. Miscellaneous Materials
1. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
 2. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
 3. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

1.3 EXECUTION

A. Examination

1. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:



- a. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 - b. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
 - 1) Concrete.
 - 2) Masonry.
 - 3) Unglazed surfaces of ceramic tile.
 - 4) Exterior insulation and finish systems.
 - c. Remove laitance and form-release agents from concrete.
 - d. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
 - 1) Metal.
 - 2) Glass.
 - 3) Porcelain enamel.
 - 4) Glazed surfaces of ceramic tile.
2. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
 3. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

C. Installation Of Joint Sealants

1. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
2. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
3. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - a. Do not leave gaps between ends of sealant backings.
 - b. Do not stretch, twist, puncture, or tear sealant backings.
 - c. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.
4. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
5. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - a. Place sealants so they directly contact and fully wet joint substrates.
 - b. Completely fill recesses in each joint configuration.
 - c. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
6. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - a. Remove excess sealant from surfaces adjacent to joints.



- b. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
 - c. Provide concave joint profile per Figure 8A in ASTM C 1193, unless otherwise indicated.
 - d. Provide flush joint profile where indicated per Figure 8B in ASTM C 1193.
 - e. Provide recessed joint configuration of recess depth and at locations indicated per Figure 8C in ASTM C 1193.
 - 1) Use masking tape to protect surfaces adjacent to recessed tooled joints.
7. Installation of Preformed Silicone-Sealant System: Comply with the following requirements:
- a. Apply masking tape to each side of joint, outside of area to be covered by sealant system.
 - b. Apply silicone sealant to each side of joint to produce a bead of size complying with preformed silicone-sealant system manufacturer's written instructions and covering a bonding area of not less than 3/8 inch (10 mm). Hold edge of sealant bead 1/4 inch (6 mm) inside masking tape.
 - c. Within 10 minutes of sealant application, press silicone extrusion into sealant to wet extrusion and substrate. Use a roller to apply consistent pressure and ensure uniform contact between sealant and both extrusion and substrate.
 - d. Complete installation of sealant system in horizontal joints before installing in vertical joints. Lap vertical joints over horizontal joints. At ends of joints, cut silicone extrusion with a razor knife.
8. Installation of Preformed Foam Sealants: Install each length of sealant immediately after removing protective wrapping. Do not pull or stretch material. Produce seal continuity at ends, turns, and intersections of joints. For applications at low ambient temperatures, apply heat to sealant in compliance with sealant manufacturer's written instructions.
9. Acoustical Sealant Installation: At sound-rated assemblies and elsewhere as indicated, seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and with manufacturer's written recommendations.
- D. Field Quality Control
1. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
 - a. Extent of Testing: Test completed and cured sealant joints as follows:
 - 1) Perform 10 tests for the first 1000 feet (300 m) of joint length for each kind of sealant and joint substrate.
 - 2) Perform 1 test for each 1000 feet (300 m) of joint length thereafter or 1 test per each floor per elevation.
 - b. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
 - 1) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
 - c. Inspect tested joints and report on the following:
 - 1) Whether sealants filled joint cavities and are free of voids.
 - 2) Whether sealant dimensions and configurations comply with specified requirements.
 - 3) Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion passes sealant manufacturer's field-adhesion hand-pull test criteria.
 - d. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant fill, sealant configuration, and sealant dimensions.
 - e. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.



2. Evaluation of Field-Adhesion Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.
- E. Cleaning
1. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.
- F. Protection
1. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Final Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.
- G. Joint-Sealant Schedule
1. Joint-Sealant Application: Exterior joints in horizontal traffic surfaces.
 - a. Joint Locations:
 - 1) Control and expansion joints in brick pavers.
 - 2) Isolation and contraction joints in cast-in-place concrete slabs.
 - 3) Joints between plant-precast architectural concrete paving units.
 - 4) Joints in stone paving units, including steps.
 - 5) Tile control and expansion joints.
 - 6) Joints between different materials listed above.
 - 7) Other joints as indicated.
 - b. Silicone Joint Sealant: Single component, nonsag, traffic grade, neutral curing **OR** Single component, pourable, traffic grade, neutral curing **OR** Multicomponent, pourable, traffic grade, neutral curing, **as directed**.
 - c. Urethane Joint Sealant: Single component, nonsag, traffic grade **OR** Single component, pourable, traffic grade **OR** Multicomponent, nonsag, traffic grade, Class 50 **OR** Multicomponent, nonsag, traffic grade, Class 25, **as directed**.
 - d. Polysulfide Joint Sealant: Multicomponent, nonsag, traffic grade **OR** Multicomponent, pourable, traffic grade, **as directed**.
 - e. Preformed Joint Sealant: Preformed foam sealant.
 - f. Joint-Sealant Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range of colors, **as directed**.
 2. Joint-Sealant Application: Exterior joints in horizontal traffic surfaces subject to water immersion.
 - a. Joint Locations:
 - 1) Joints in pedestrian plazas.
 - 2) Joints in swimming pool decks.
 - 3) Other joints as indicated.
 - b. Urethane Joint Sealant: Immersible, single component, nonsag, traffic grade **OR** Immersible, single component, pourable, traffic grade **OR** Immersible, multicomponent, nonsag, traffic grade **OR** Immersible, multicomponent, pourable, traffic grade, **as directed**.
 - c. Polysulfide Joint Sealant: Immersible, multicomponent, nonsag, traffic grade.
 - d. Joint-Sealant Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range of colors, **as directed**.
 3. Joint-Sealant Application: Exterior joints in vertical surfaces and horizontal nontraffic surfaces.
 - a. Joint Locations:
 - 1) Construction joints in cast-in-place concrete.
 - 2) Joints between plant-precast architectural concrete units.
 - 3) Control and expansion joints in unit masonry.
 - 4) Joints in dimension stone cladding.



- 5) Joints in glass unit masonry assemblies.
- 6) Joints in exterior insulation and finish systems.
- 7) Joints between metal panels.
- 8) Joints between different materials listed above.
- 9) Perimeter joints between materials listed above and frames of doors, windows and louvers.
- 10) Control and expansion joints in ceilings and other overhead surfaces.
- 11) Other joints as indicated.
- b. Silicone Joint Sealant: Single component, nonsag, neutral curing, Class 100/50 **OR** Single component, nonsag, neutral curing, Class 50 **OR** Single component, nonsag, neutral curing, Class 25 **OR** Single component, nonsag, acid curing **OR** Multicomponent, nonsag, neutral curing, **as directed**.
- c. Urethane Joint Sealant: Single component, nonsag, Class 100/50 **OR** Single component, nonsag, Class 50 **OR** Single component, nonsag, Class 25 **OR** Multicomponent, nonsag,, Class 50 **OR** Multicomponent, nonsag,, Class 25, **as directed**.
- d. Polysulfide Joint Sealant: Single component, nonsag **OR** Multicomponent, nonsag, **as directed**.
- e. Preformed Joint Sealant: Preformed silicone **OR** Preformed foam, **as directed**.
- f. Joint-Sealant Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range of colors, **as directed**.
4. Joint-Sealant Application: Interior joints in horizontal traffic surfaces.
 - a. Joint Locations:
 - 1) Isolation joints in cast-in-place concrete slabs.
 - 2) Control and expansion joints in stone flooring.
 - 3) Control and expansion joints in brick flooring.
 - 4) Control and expansion joints in tile flooring.
 - 5) Other joints as indicated.
 - b. Silicone Joint Sealant: Single component, nonsag, traffic grade, neutral curing **OR** Single component, pourable, traffic grade, neutral curing **OR** Multicomponent, pourable, traffic grade, neutral curing, **as directed**.
 - c. Urethane Joint Sealant: Single component, nonsag, traffic grade **OR** Single component, pourable, traffic grade **OR** Multicomponent, nonsag, traffic grade, Class 50 **OR** Multicomponent, nonsag, traffic grade, Class 25, **as directed**.
 - d. Polysulfide Joint Sealant: Multicomponent, nonsag, traffic grade **OR** Multicomponent, pourable, traffic grade, **as directed**.
 - e. Preformed Joint Sealant: Preformed foam.
 - f. Joint-Sealant Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range of colors, **as directed**.
5. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces.
 - a. Joint Locations:
 - 1) Control and expansion joints on exposed interior surfaces of exterior walls.
 - 2) Perimeter joints of exterior openings where indicated.
 - 3) Tile control and expansion joints.
 - 4) Vertical joints on exposed surfaces of interior unit masonry and concrete walls and partitions.
 - 5) Joints on underside of plant-precast structural concrete beams and planks.
 - 6) Perimeter joints between interior wall surfaces and frames of interior doors, windows and elevator entrances.
 - 7) Other joints as indicated.
 - b. Joint Sealant: Latex **OR** Acrylic based **OR** Butyl rubber based, **as directed**.
 - c. Joint-Sealant Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range of colors, **as directed**.
6. Joint-Sealant Application: Mildew-resistant interior joints in vertical surfaces and horizontal nontraffic surfaces.
 - a. Joint Sealant Location:
 - 1) Joints between plumbing fixtures and adjoining walls, floors, and counters.



-
- 2) Tile control and expansion joints where indicated.
 - 3) Other joints as indicated.
 - b. Joint Sealant: Mildew resistant, single component, nonsag, neutral curing, Silicone **OR** Single component, nonsag, mildew resistant, acid curing, **as directed**.
 - c. Joint-Sealant Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range of colors, **as directed**.
7. Joint-Sealant Application: Interior acoustical joints in vertical surfaces and horizontal nontraffic surfaces.
- a. Joint Location:
 - 1) Acoustical joints where indicated.
 - 2) Other joints as indicated.
 - b. Joint Sealant: Acoustical.
 - c. Joint-Sealant Color: As selected from manufacturer's full range.

END OF SECTION 07 91 23 00



Task	Specification	Specification Description
07 91 26 00	07 91 23 00	Joint Sealants
07 92 13 00	07 91 23 00	Joint Sealants
07 92 19 00	07 91 23 00	Joint Sealants



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**SECTION 07 95 13 13 - ARCHITECTURAL JOINT SYSTEMS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for architectural joint systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.
2. See Division 03 Section "Cast-in-place Concrete" for cast-in architectural-joint-system frames furnished, but not installed, in this Section.

B. Definitions

1. Maximum Joint Width: Widest linear gap a joint system tolerates and in which it performs its designed function without damaging its functional capabilities.
2. Minimum Joint Width: Narrowest linear gap a joint system tolerates and in which it performs its designed function without damaging its functional capabilities.
3. Movement Capability: Value obtained from the difference between widest and narrowest widths of a joint opening typically expressed in numerical values (mm or inches) or a percentage (plus or minus) of nominal value of joint width.
4. Nominal Joint Width: The width of the linear opening specified in practice and in which the joint system is installed.

C. Submittals

1. Shop Drawings: Provide placement drawings, including line diagrams and details, and a tabular schedule of architectural joint systems.

D. Quality Assurance

1. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines (ADAAG)" and ICC A117.1.
2. Fire-Test-Response Characteristics: Where indicated, provide architectural joint system and fire-barrier assemblies identical to those of assemblies tested for fire resistance per UL 2079 or ASTM E 1966 by a testing and inspecting agency acceptable to authorities having jurisdiction.
 - a. Hose Stream Test: Wall-to-wall and wall-to-ceiling assemblies shall be subjected to hose stream testing.

1.2 PRODUCTS

A. Materials

1. Aluminum: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 for extrusions; ASTM B 209 (ASTM B 209M), Alloy 6061-T6 for sheet and plate.
 - a. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious materials.
 - b. Mill Finish.
 - c. Clear Anodic Finish: Class II, clear anodic coating **OR** Class I, clear anodic coating, **as directed**, complying with AAMA 611.
 - d. Color Anodic Finish: Class II, color anodic coating **OR** Class I, color anodic coating, **as directed**, complying with AAMA 611.
 - e. High-Performance Organic Finish (Two-Coat Fluoropolymer): Comply with AAMA 2604 and with coating and resin manufacturers' written instructions.
2. Stainless Steel: ASTM A 666, Type 304 for plates, sheet, and strips.
3. Brass: ASTM B 36/B 36M, UNS Alloy C26000 for half hard sheet and coil.



4. Bronze: ASTM B 455, Alloy C38500 for extrusions; Alloy C23000 red brass for plates.
5. Moisture Barrier: PVC , minimum 30 mils thick **OR** EPDM, minimum 45 mils thick **OR** Santoprene, **as directed**.
6. Elastomeric Seals: Preformed elastomeric membranes or extrusions to be installed in metal frames.
7. Compression Seals: ASTM E 1612; preformed rectangular elastomeric extrusions having internal baffle system and designed to function under compression.
8. Strip Seals: ASTM E 1783; preformed elastomeric membrane or tubular extrusions having an internal baffle system and secured in or over a joint by a metal locking rail.
9. Cellular Foam Seals: Extruded, compressible foam designed to function under compression.
10. Elastomeric Concrete: Modified epoxy or polyurethane extended into a prepackaged aggregate blend, specifically designed for bonding to concrete substrates.
11. Fire Barriers: Any material or material combination, when fire tested after cycling, designated to resist the passage of flame and hot gases through a movement joint and to meet performance criteria for required rating period.
12. Accessories: Manufacturer's standard anchors, fasteners, and other accessories as required for complete installations.

B. Architectural Joint Systems, General

1. General: Provide joint systems of design indicated.
 - a. Furnish in longest practicable lengths to minimize splicing. Install with hairline mitered corners where joint changes direction.
 - b. Include factory-fabricated closure materials and transition pieces to provide continuous joint systems.
2. Design architectural joint systems for the following size and movement characteristics:
 - a. Nominal Joint Width: As indicated on Drawings **OR** As scheduled, **as directed**.
 - b. Movement Capability: Plus or minus 25 percent **OR** Plus or minus 50 percent **OR** Plus or minus 100 percent **OR** As indicated on Drawings **OR** As scheduled, **as directed**.
 - c. Type of Movement: As indicated on Drawings **OR** As scheduled **OR** Thermal **OR** Seismic **OR** Wind sway, **as directed**.

C. Architectural Joint Systems For Building Interiors

1. Floor-to-Floor and Floor-to-Wall Joint Systems:
 - a. Type: Cover plate **OR** Center plate **OR** Glide plate **OR** Hidden sightline **OR** Pan **OR** Surface mounted, **as directed**.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel **OR** Bronze **OR** Brass, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear anodic **OR** Class II, clear anodic **OR** No. 2B **OR** No. 4, **as directed**.
 - b) Color: As selected from manufacturer's full range.
 - b. Type: Elastomeric **OR** Dual elastomeric, **as directed**, seal.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel **OR** Bronze **OR** Brass, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear anodic **OR** Class II, clear anodic **OR** No. 2B **OR** No. 4, **as directed**.
 - b) Color: As selected from manufacturer's full range.
 - 2) Seal Material: Santoprene.
 - a) Color: As selected from manufacturer's full range.
 - c. Cover-Plate Design:
 - 1) Plain **OR** Serrated **OR** Abrasive filled, **as directed**.
 - 2) Recessed to accept field-applied finish materials.
 - a) Recess Depth: To accommodate adjacent flooring.
 - d. Attachment Method: Mechanical anchors **OR** Cast in, **as directed**.
 - e. Load Capacity: Standard **OR** Heavy **OR** Extra heavy, **as directed**, duty.
 - f. Fire-Resistance Rating: Match adjacent construction.
 - g. Moisture Barrier: Manufacturer's standard.
2. Wall-to-Wall and Wall Corner Joint Systems:



- a. Type: Vertical cover plate **OR** Glide plate **OR** Hidden sightline **OR** Snap-on cover **OR** Clip-in cover, **as directed**.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel **OR** Bronze **OR** Brass, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear anodic **OR** Class II, clear anodic **OR** No. 2B **OR** No, 4, **as directed**.
 - b) Color: As selected from manufacturer's full range.
 - b. Type: Elastomeric seal **OR** Dual elastomeric seal **OR** Accordion, **as directed**.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel **OR** Bronze **OR** Brass, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear anodic **OR** Class II, clear anodic **OR** No. 2B **OR** No, 4, **as directed**.
 - b) Color: As selected from manufacturer's full range.
 - 2) Seal Material: Santoprene **OR** PVC, **as directed**.
 - a) Color: As selected from manufacturer's full range.
 - c. Type: Flat seal.
 - 1) Seal Material: Santoprene.
 - a) Color: As selected from manufacturer's full range.
 - d. Fire-Resistance Rating: Match adjacent construction.
 - e. Moisture Barrier: Manufacturer's standard.
3. Wall-to-Ceiling and Ceiling-to-Ceiling Joint Systems:
- a. Type: Cover plate **OR** Glide plate **OR** Snap-on cover **OR** Clip-in cover, **as directed**.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel **OR** Bronze **OR** Brass, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear anodic **OR** Class II, clear anodic **OR** No. 2B **OR** No, 4, **as directed**.
 - b) Color: As selected from manufacturer's full range.
 - b. Type: Elastomeric seal **OR** Dual elastomeric seal **OR** Accordion, **as directed**.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel **OR** Bronze **OR** Brass, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear Color: As selected from manufacturer's full range.
 - b) Seal Material: Santoprene **OR** PVC, **as directed**.
 - c) Color: As selected from manufacturer's full range.
 - c. Type: Flat seal.
 - 1) Seal Material: Santoprene.
 - a) Color: As selected from manufacturer's full range.
 - d. Fire-Resistance Rating: Match adjacent construction.
 - e. Moisture Barrier: Manufacturer's standard.
- D. Architectural Joint Systems For Building Exteriors
- 1. Architectural Joint Systems for Exterior Walls and Soffits:
 - a. Type: Vertical cover-plate.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear anodic **OR** Class II, clear anodic **OR** Class I, color anodic **OR** Class II, color anodic **OR** High-performance organic **OR** No. 2B **OR** No. 4, **as directed**.
 - b) Color: As selected from full range of industry colors and color densities.
 - 2) Secondary Seal: Manufacturer's standard extruded-elastomeric seal designed to prevent water and moisture infiltration.
 - b. Type: Flat seal.
 - 1) Seal Material: Santoprene.
 - a) Color: As selected from manufacturer's full range.
 - 2) Secondary Seal: Manufacturer's standard extruded-elastomeric seal designed to prevent water and moisture infiltration.
 - 3) Pantograph Mechanism: Manufacturer's standard nylon pantographic wind-load support mechanism with stainless-steel fasteners.
 - c. Type: Preformed cellular foam.



- 1) Foam Material: Manufacturer's standard **OR** Non-extruded, low-density, crosslinked, nitrogen-blown, ethylene-vinyl-acetate copolymer **OR** Polyurethane, **as directed**.
 - a) Color: As selected from manufacturer's full range.
 - d. Fire-Resistance Rating: Match adjacent construction.
- E. Architectural Joint Systems For Open-Air Structures
1. Slab-to-Slab Joint Systems for Parking Structures **OR** Plaza Decks **OR** Stadiums, **as directed**:
 - a. Type: Metal plate.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear anodic **OR** Class II, clear anodic **OR** Class I, color anodic **OR** Class II, color anodic **OR** High-performance organic **OR** No. 2B **OR** No. 4, **as directed**.
 - b) Color: As selected from full range of industry colors and color densities.
 - b. Type: Sealant T-joint **OR** Rubber pad **OR** Compression seal **OR** Strip seal **OR** Winged seal **OR** Epoxy-bonded seal **OR** Split-slab membrane, **as directed**.
 - 1) Seal Material: Santoprene **OR** Neoprene **OR** Silicone **OR** EPDM **OR** PVC **OR** Manufacturer's standard, **as directed**.
 - a) Color: As selected from manufacturer's full range.
 - c. Attachment Method: Mechanical anchors **OR** Cast in **OR** Elastomeric concrete header **OR** Compressed, epoxy adhered **OR** Compressed, lubricant adhesive adhered, **as directed**.
 - d. Load Capacity: Heavy **OR** Extra heavy, **as directed**, duty.
 - e. Fire-Resistance Rating: Match adjacent construction.
 - f. Gutter: Flexible, fabric-reinforced neoprene gutter system with drain tubes.
 2. Slab-to-Wall Joint Systems for Parking Structures **OR** Plaza Decks **OR** Stadiums, **as directed**:
 - a. Type: Metal plate.
 - 1) Exposed Metal: Aluminum **OR** Stainless steel, **as directed**.
 - a) Finish: Manufacturer's standard finish **OR** Mill **OR** Class I, clear anodic **OR** Class II, clear anodic **OR** Class I, color anodic **OR** Class II, color anodic **OR** High-performance organic **OR** No. 2B **OR** No. 4, **as directed**.
 - b) Color: As selected from full range of industry colors and color densities.
 - b. Type: Sealant T-joint **OR** Rubber pad **OR** Compression seal **OR** Strip seal **OR** Winged seal **OR** Epoxy-bonded seal **OR** Split-slab membrane, **as directed**.
 - 1) Seal Material: Santoprene **OR** Neoprene **OR** Silicone **OR** EPDM **OR** PVC **OR** Manufacturer's standard, **as directed**.
 - a) Color: As selected from manufacturer's full range.
 - c. Attachment Method: Mechanical anchors **OR** Cast in **OR** Elastomeric concrete header **OR** Compressed, epoxy adhered **OR** Compressed, lubricant adhesive adhered, **as directed**.
 - d. Fire-Resistance Rating: Match adjacent construction.
 - e. Gutter: Flexible, fabric reinforced neoprene gutter system with drain tubes.
 3. Wall-to-Wall Joint Systems for Parking Structures **OR** Plaza Decks **OR** Stadiums, **as directed**:
 - a. Type: Compression seal.
 - 1) Seal Material: Santoprene **OR** Neoprene **OR** Silicone **OR** EPDM **OR** PVC **OR** Manufacturer's standard, **as directed**.
 - a) Color: As selected from manufacturer's full range.
 - b. Type: Preformed cellular foam.
 - 1) Foam Material: Manufacturer's standard **OR** Non-extruded, low-density, crosslinked, nitrogen-blown, ethylene-vinyl-acetate copolymer **OR** Polyurethane, **as directed**.
 - a) Color: As selected from manufacturer's full range.
 - c. Attachment Method: Mechanical anchors **OR** Cast in **OR** Compressed, epoxy adhered **OR** Compressed, lubricant adhesive adhered, **as directed**.
 - d. Fire-Resistance Rating: Match adjacent construction.
- F. Finishes



1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Appearance of Finished Work: Noticeable variations in same piece are not acceptable.

1.3 EXECUTION

A. Installation

1. Comply with manufacturer's written instructions for storing, handling, and installing architectural joint assemblies and materials unless more stringent requirements are indicated.
2. Metal Frames: Perform cutting, drilling, and fitting required to install joint systems.
 - a. Install in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
 - b. Adjust for differences between actual structural gap and nominal design gap due to ambient temperature at time of installation.
 - c. Cut and fit ends to accommodate thermal expansion and contraction of metal without buckling of frames.
 - d. Locate in continuous contact with adjacent surfaces.
 - e. Support underside of frames continuously to prevent vertical deflection when in service.
 - f. Locate anchors at interval recommended by manufacturer, but not less than 3 inches (75 mm) from each end and not more than 24 inches (600 mm) o.c.
3. Seals in Metal Frames: Install elastomeric seals in frames to comply with manufacturer's written instructions. Install with minimum number of end joints.
 - a. Provide in continuous lengths for straight sections.
 - b. Seal transitions according to manufacturer's written instructions.
4. Compression Seals: Apply adhesive or lubricant adhesive as recommended by manufacturer to both frame interfaces **OR** sides of slabs, **as directed**, before installing compression seals.
5. Foam Seals: Install with adhesive recommended by manufacturer.
6. Epoxy-Bonded Seals: Pressurize seal for time period and to pressure recommended by manufacturer. Do not overpressurize.
7. Terminate exposed ends of joint assemblies with field- or factory-fabricated termination devices.
8. Fire-Resistance-Rated Assemblies: Coordinate so complete assemblies comply with assembly performance requirements.
 - a. Fire Barriers: Install fire barriers to provide continuous, uninterrupted fire resistance throughout length of joint, including transitions and field splices.
9. Water Barrier: Provide water barrier at exterior joints and where called for on Drawings.

B. Protection

1. Do not remove protective covering until finish work in adjacent areas is complete.
2. Protect the installation from damage by work of other Sections.

END OF SECTION 07 95 13 13



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SECTION 07 95 13 16 - ROOF EXPANSION ASSEMBLIES

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for roof expansion assemblies. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Metal-flanged, bellows-type roof expansion assemblies.
 - b. Aluminum roof expansion assemblies.
 - c. Seismic roof expansion assemblies.

C. Performance Requirements

1. General: Provide roof expansion assemblies that, when installed, remain watertight within movement limitations specified by manufacturer.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, joints, splices, locations of joints and splices, intersections, transitions, fittings, and attachments to other work. Where joint assemblies change planes, provide isometric drawings depicting how components interconnect to achieve continuity.
3. Samples: For each type of exposed factory-applied finish required, prepared on Samples of size to adequately show color.
4. Research/Evaluation Reports: For roof expansion assemblies.
5. Warranties: Special warranties specified in this Section.

E. Quality Assurance

1. Fire-Test-Response Characteristics: Provide fire-barrier assemblies with fire-test-response characteristics not less than that of adjacent construction, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Assemblies shall be capable of anticipated movement while maintaining fire rating. Identify assemblies with appropriate markings of applicable testing and inspecting agency.
 - a. Fire-Resistance Ratings: UL 2079 **OR** ASTM E 119, **as directed**.

F. Warranty

1. Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace roof expansion assemblies that leak, deteriorate in excess of rates specified in manufacturer's published product literature, or otherwise fail to perform within Two years from date of Final Completion.
2. Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair or replace components that show evidence of deterioration of factory-applied fluoropolymer finishes within 20 years from date of Final Completion.

1.2 PRODUCTS

A. Metals



1. Galvanized Steel Sheet: ASTM A 653/A 653M, hot-dip zinc-coating designation G90 (Z275), stretcher-leveled standard of flatness and either commercial or forming steel, minimum 0.019 inch (0.5 mm) thick.
2. Stainless-Steel Sheet: ASTM A 666, Type 304, stretcher-leveled standard of flatness, minimum 0.015 inch (0.4 mm) thick.
3. Copper Sheet: ASTM B 370, Temper H00 (cold rolled) unless Temper 060 is required for forming, minimum 16 oz./sq. ft. (0.55 mm thick).
4. Sheet Aluminum: ASTM B 209 (ASTM B 209M); Alloy 3003-H14, 5052-H32, or 6061-T6; minimum 0.032 inch (0.8 mm) thick.
5. Extruded Aluminum: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or 6063-T52, minimum 0.040 inch (1.0 mm) thick.
6. Aluminum Finishes:
 - a. Mill Finish: AA-M10 (Mechanical Finish: as fabricated; no other applied finish unless buffing is required to removed scratches, welding, or grinding produced in fabrication process).
 - b. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
 - c. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - d. Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).
 - e. Class I, Color Anodic Finish: AA-M12C22A42/A44 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - 1) Color: As selected from manufacturer's full range.
 - f. High-Performance Organic Finish (2-Coat Fluoropolymer): AA-C12C40R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: conversion coating; Organic Coating: manufacturer's standard 2-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with AAMA 2604 and with coating and resin manufacturers' written instructions.
 - 1) Color and Gloss: As selected from manufacturer's full range.

B. Miscellaneous Materials

1. Roof Cement: ASTM D 4586, Type II.
2. Elastomeric Sealant: ASTM C 920, elastomeric polyurethane **OR** polysulfide **OR** silicone, **as directed**, polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and to remain watertight.
3. Mineral-Fiber Blanket: ASTM C 665.
4. Flexible Cellular Sponge or Expanded Rubber: ASTM D 1056.
5. Silicone Extrusions: Classified according to ASTM D 2000, UV stabilized, and do not propagate flame.
6. Fasteners: Manufacturer's recommended fasteners, suitable for application and designed to withstand design loads.
 - a. Exposed Penetrating Fasteners: Gasketed screws with hex washer heads matching color of sheet metal.

C. Fire Barriers

1. Fire Barriers: Devices complying with requirements specified in Part 1.1 "Quality Assurance" Article for fire-test-response characteristics and designed for dynamic structural movement



without material degradation or fatigue when tested according to ASTM E 1399. Provide roof expansion assemblies with manufacturer's continuous, standard, flexible fire-barrier seals in back of joint system at locations indicated to provide fire-resistance rating not less than rating of adjacent construction.

D. Bellows-Type Roof Expansion Assemblies

1. Metal-Flanged, Bellows-Type Roof Expansion Assemblies: Provide manufacturer's standard assemblies of sizes and types indicated, with prefabricated units for corner and joint intersections and horizontal and vertical transitions including those to other building expansion joints, splicing units, adhesives, coatings, and other components as recommended by roof expansion assembly manufacturer for complete installation. Fabricate assemblies specifically for roof-to-roof **OR** roof-to-wall **OR** curb-to-curb **OR** curb-to-wall, **as directed**, applications.
2. Provide assemblies consisting of exposed polymeric sheet over foam bellows, securely anchored at both edges to 3- to 4-inch- (76- to 100-mm-) wide sheet metal nailing flanges, either flat or angle formed to fit cant or curbs as required. Insulate bellows with closed-cell, flexible rubber or plastic foam not less than 5/16 inch (8 mm) thick; adhere bellows to underside of polymeric sheet.
 - a. Polymeric Sheet: Manufacturer's standard **OR** Neoprene, 60 mils (1.5 mm) thick **OR** EPDM, 60 mils (1.5 mm) thick, black **OR** EPDM, 60 mils (1.5 mm) thick, white **OR** Reinforced chlorinated polyethylene, 30 mils (0.8 mm) thick **OR** Chlorosulfonated polyethylene, 36 mils (0.9 mm) thick **OR** Glass-reinforced PVC, 40 to 50 mils (1.0 to 1.3 mm) thick, **as directed**.
 - b. Metal Flanges: Zinc-coated (galvanized) steel, minimum 0.019 inch (0.5 mm) thick **OR** Copper, minimum 16 oz./sq. ft. (0.55 mm thick) **OR** Stainless steel, minimum 0.015 inch (0.4 mm) thick **OR** Sheet aluminum, minimum 0.032 inch (0.8 mm) thick, mill finish, **as directed**.
 - 1) Mortar Flanges: Where flanges will be embedded in concrete or mortar, provide manufacturer's standard perforated-metal mortar flanges.
 - c. Moisture Barrier: Manufacturer's standard, flexible, continuous, polymeric moisture barrier looped under roof expansion assemblies at locations indicated. Fill space with blanket-type, mineral-fiber insulation.
 - d. Fire Barrier: Provide manufacturer's standard fire barrier.

E. Aluminum Roof Expansion Assemblies

1. Aluminum Roof Expansion Assemblies: Provide assemblies consisting of aluminum base members with sloped cants and provisions for anchoring and sealing to roofing membrane or flashing in a waterproof-sealed joint. Provide free-to-move, extruded-aluminum cover plate anchored against displacement and waterproofed by integral seals. Provide prefabricated units for corner and joint intersections and horizontal and vertical transitions, including those to other building expansion joints, splicing units, adhesives, coatings, and other components as recommended by roof expansion assembly manufacturer for complete installation. Fabricate assemblies specifically for curb-to-curb **OR** wall, **as directed**, applications.
 - a. Base Frame Members: Extruded aluminum with mill **OR** anodic **OR** high-performance organic, **as directed**, finish.
 - b. Extruded-Aluminum Covers: Minimum 0.080 inch (2.03 mm) **OR** 0.125 inch (3 mm), **as directed**, thick, with mill **OR** clear anodic **OR** color anodic **OR** high-performance organic, **as directed**, finish.
 - c. Formed-Aluminum Covers: Minimum 0.078 inch (2 mm) thick, with mill **OR** clear anodic **OR** color anodic **OR** high-performance organic, **as directed**, finish.
 - d. Moisture Barrier:
 - 1) Semiconcealed, captive, polymeric sheet bellows unit of neoprene, EPDM, reinforced chlorinated polyethylene, or PVC, not less than 30 mils (0.8 mm) thick.
 - 2) Semiconcealed, captive gaskets at both curb members, of neoprene, EPDM, or PVC, with spring-loaded mechanism to maintain positive pressure between gaskets and curb cap.
 - e. Fire Barrier: Provide manufacturer's standard fire barrier.



F. Seismic Roof Expansion Assemblies

1. General: Provide manufacturer's assemblies designed to accommodate seismic movement. Provide prefabricated units for corner and joint intersections and horizontal and vertical transitions including those to other building expansion joints, splicing units, inner seals, adhesives, coatings, and other components as recommended by roof expansion assembly manufacturer for complete installation. Fabricate assemblies specifically for roof-to-roof **OR** roof-to-wall **OR** curb-mounted, **as directed**, applications.
2. Extruded Seals: Two continuous, single-layered elastomeric profiles made of a vinyl inner seal and silicone **OR** neoprene **OR** Santoprene, **as directed**, outer seal, both seals retained in a pair of compatible extruded-aluminum frames.
 - a. Exterior Seal Color: As selected from manufacturer's full range.
3. Aluminum Roof Expansion Assemblies: Assemblies consisting of pairs of aluminum curb units with sloped cants and provisions for anchoring and sealing to roofing membrane or flashing in a waterproof-sealed joint. Provide free-to-move, extruded-aluminum curb cap anchored against displacement and waterproofed by integral seals, with interior of expansion joint filled with blanket-type mineral-fiber insulation.
 - a. Base Frame Members: Extruded aluminum with mill **OR** clear anodic **OR** color anodic **OR** high-performance organic, **as directed**, finish.
 - b. Extruded-Aluminum Covers: Minimum 0.080 inch (2.03 mm) **OR** 0.125 inch (3 mm), **as directed**, thick, with mill **OR** clear anodic **OR** color anodic **OR** high-performance organic, **as directed**, finish.
 - c. Formed-Aluminum Covers: Minimum 0.078 inch (2 mm) thick, with mill **OR** clear anodic **OR** color anodic **OR** high-performance organic, **as directed**, finish.
 - d. Moisture Barrier:
 - 1) Semiconcealed, captive, polymeric sheet bellows unit of neoprene, EPDM, reinforced chlorinated polyethylene, or PVC, not less than 30 mils (0.8 mm) thick.
 - 2) Semiconcealed, captive gaskets at both curb members, of neoprene, EPDM, or PVC, with spring-loaded mechanism to maintain positive pressure between gaskets and curb cap.
 - e. Fire Barrier: Provide manufacturer's standard fire barrier.

1.3 EXECUTION

A. Installation

1. Comply with manufacturer's written instructions for handling and installing roof expansion assemblies and materials unless more stringent requirements are indicated.
2. Coordinate installation of roof expansion assembly materials and associated work so complete assemblies comply with assembly performance requirements.
3. Install fire barriers to provide continuous, uninterrupted fire resistance throughout length of roof expansion assembly, including transitions and end joints.
4. Extend roof expansion assemblies over curbs, parapets, cornices, gutters, valleys, fasciae, and other elements in the construction profile, with factory-fabricated intersections and transitions to provide continuous, uninterrupted, waterproof roof expansion assemblies.
 - a. Install factory-fabricated transitions between roof expansion assemblies and building architectural joint systems, specified in Division 07 Section "Expansion Control", to provide continuous, uninterrupted, watertight construction.
5. Splice roof expansion assemblies with materials provided by roof expansion assembly manufacturer for this purpose, according to manufacturer's written instructions, to provide continuous, uninterrupted, waterproof roof expansion assemblies.
6. Provide uniform profile of roof expansion assembly throughout length of each installation; do not stretch polymeric sheets.
7. Install mineral-fiber blanket insulation to fill joint space within joint and moisture barrier.
8. Bed anchorage flanges in cement or sealant recommended by manufacturer and securely nail to curbs and cant strips as recommended by manufacturer but not less than 6 inches (150 mm) o.c.



9. Anchor roof expansion assemblies complying with manufacturer's written instructions.
 10. Embed flanges not less than 4 inches (100 mm) in bituminous membranes, with hot bitumen or roof cement. Cover with stripping material and install according to requirements in roofing section.
 11. On single-ply roofing, install roof expansion assemblies complying with manufacturer's written instructions. Anchor to cants or curbs and seal to membrane with sealant compatible with roofing membrane and roof expansion assembly. Cover flanges with stripping or flashing and install according to requirements in roofing section.
- B. Protection
1. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensures that roof expansion assemblies are without damage or deterioration at time of Final Completion.

END OF SECTION 07 95 13 16



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Task	Specification	Specification Description
07 95 13 16	07 95 13 13	Architectural Joint Systems



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SECTION 08 11 63 13 - STEEL STORM DOORS

DESCRIPTION OF WORK

This specification covers the furnishing and installation of materials for steel storm doors. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

GENERAL

Definitions

1. Supply and Delivery only: Include supply and delivery to site(s) FOB destination freight prepaid. Unless otherwise specified or scheduled, unloading and handling at site is by Owner.

System Description

2. Performance Requirements: Comply with following:
 - a. Steel Storm Doors: Largest steel storm door size: Meet or exceed performance requirements of Section 2.1 (CSD-1) of ANSI/AAMA 1102.7 and ASTM B 117.
 - b. Steel Storm Doors: Completely assembled storm door measuring at least 914 mm (36 inches) wide x 2 032 mm (80 inches) high with necessary braces and hardware:
 - 1) Sag Test: Meet or exceed ANSI/AAMA 1102.7 Sag Test.
 - 2) Forced Entry Resistance Test: Meet or exceed ANSI/SMA 6001 Paragraph 4.2.4.3 for Heavy Type.
 - 3) Storm Door Screen Insert: Completely assembled screen of 914 mm (36 inches) by 1 524 mm (60 inches) size with necessary braces: Meet or exceed ANSI/SMA 6001 Paragraph 4.2.4.1 Impact Test performance requirements for Medium Type.
 - c. Steel Screen Doors: Completely assembled screen door measuring at least 914 mm (36 inches) wide by 2 032 mm (80 inches) high with necessary braces and hardware:
 - 1) Impact Test: Meet or exceed performance requirements of ANSI/SMA 6001 Paragraph 4.2.4.1 for Medium Type.
 - 2) Sag Test: Meet or exceed ANSI/AAMA 1102.7 Sag Test.
 - d. Door Finish: Subjected to ASTM B117 Salt Spray Fog Test for minimum of 250 hours. Cut tubular section open to check finish performance.

Submittals

3. Product Data.
4. Shop Drawings:
 - a. Include exploded view of manufactured door, similar to ANSI/AAMA 1102.7, page 12.
 - b. Indicate fabrication of all parts, metal thickness, installation details, fastening, and sealing.
 - c. Include sections of typical members and details of latching devices.
5. Samples: Submit full set of finish color samples for color selection.
 - a. For Supply and Deliver Only Contract: Submit one full size sample of each type of storm door with specified finish for acceptance.
6. Quality Assurance/Control Submittals:
 - a. Certificates: Manufacturer's written third party certification that storm doors meet or exceed ANSI/AAMA 1102.7 (CSD-1), Paragraph 2.1.6.5 of ANSI/SMA 6001, ASTM B117, and other specified requirements.
 - b. Manufacturer's installation instructions.
7. Closeout Submittals:
 - a. Operation and maintenance data.
 - b. Special warranty.

Quality Assurance



8. Regulatory Requirements: Comply with following:
 - a. Glazing Materials: Comply with CPSC 16 CFR 1201 or ANSI Z97.1.
 - b. Accessibility:
 - 1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
 - a) Uniform Federal Accessibility Standards (UFAS).
 - 2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
 - 3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
 - 4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
9. Certifications: Comply with ANSI Z34.2.
10. Mock-ups: For Supply and Install Contract: Install one full size mock-up of each type of storm door with specified finish for acceptance.
 - a. Location: As directed.
 - b. Approved Mock-up: Standard for rest of work.
 - c. Approved Mock-up: May remain part of completed project.

Delivery, Storage, And Handling

11. Packing, Shipping, Handling, and Unloading: Pack materials at manufacturing plant to prevent damage during shipping.
 - a. Screens: Label attached signifying compliance with ANSI/AAMA 1102.7 (CSD-1), ANSI/SMA 6001, ASTM B 117 performance requirements.
 - 1) Labels: Include manufacturers name and code identifying plant location and validation date.
 - 2) Labels: Affixed to inside of vertical member of each door.
12. Acceptance at Site: Inspect storm doors upon delivery. Replace damaged or defective materials before installation.
13. Storage and Protection: Store storm doors in manner to protect from weather and other damage.

Project Conditions

14. Field Measurements: Field measure openings for storm doors before start of fabrication.

Scheduling And Sequencing

15. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.

Warranty

16. Special Warranty: Provide one year written covering materials and installation for storm doors.
 - a. Warranty: Include coverage of inserts, closers, chains, hardware, and latches.
 - 1) Screening and glazing not included.
 - 2) Defects resulting from vandalism not included.
 - b. For Supply and Delivery Only Contract:
 - 1) Contractor: Agrees to supply and deliver to Owner, free of charge, any required replacement parts that can be readily installed by Owner without special tools.
 - 2) Contractor: Agrees to supply and deliver free of charge, complete replacement door, when defective part or parts cannot be installed without use of special tools.
 - c. For Supply and Install Contract:
 - 1) Contractor: Agrees to supply and install, free of charge, any required replacement parts or complete replacement door.

PRODUCTS

Steelstorm Doors

17. Storm Doors: Type(s) and size(s) indicated, specified, or scheduled manufactured of steel and provided with pro-hung aluminum frame liner (Z-bar) to fit entrance door apertures requiring frame



- sizes of 762 mm (30 inches) to 940 mm (37 inches) in width and 2 007 mm (79 inches) to 2 134 mm (84 inches) in height.
- a. Storm Doors: Complete with Z-bar frame liner, glazing, replaceable screen insert, durable steel kick plate, adjustable sill sweep, and necessary hardware.
 - b. Assembly: Secure and workmanlike manner permitting storm door to perform properly and assuring its neat and weather-resistant construction.
18. Materials:
- a. Master Frame: Minimum 22 gage (0.85 mm) roll formed steel, or 16 gage (1.6 mm) tubular steel as applicable to item specified.
 - b. Fasteners: Stainless, cadmium plated, or zinc-plated steel screws, nuts, washers, bolts and other miscellaneous fastening devices and hardware in accordance with ASTM B 633 or ASTM B 766.
 - c. Kick Plate: Minimum 18 gage (1.3 mm) embossed galvanized panel for roll formed frame or 16 gage (1.6 mm) flat galvanized steel sheet for tubular steel frame.
 - d. Screen Insert:
 - 1) Screening: ANSI/SMA 6001, Paragraph 4.2.4.1, Medium Type, 12 x 12 stainless steel, at least 0.58 mm (0.023 inch) diameter.
 - 2) Screen Frame: Roll formed or tubular lock seam type formed from not less than 25 gage (0.53 mm) hot dipped galvanized steel or extruded aluminum.
 - e. Glazing Bead, Storm Door Sweep and Screen Spline: Polyvinyl chloride (PVC) or equal material
 - f. Frame Liner (Z-bar): Extruded aluminum, 6063 J5.
 - g. Weatherstripping: Wool pile, or vinyl.
19. Glazing Materials: Comply with CPSC 16 CFR 1201 or ANSI Z97.1.
- a. Tempered Glass: ASTM C 1048, Kind FT. Condition A, Type 1, Class 1, Glazing B Quality.
 - b. Plastic: Extruded polycarbonate clear sheets, minimum 4.5 mm (0.177 inch) thick with following characteristics:
 - 1) Impact Resistance: ASTM D 256, Method A, 12-18 foot-pound per inch.
 - 2) Elongation/Modulus of Elasticity: ASTM D 638, 110 percent maximum 340,000 PSI.
 - 3) Heat Deflection: ASTM D 648, 132.2 degrees C (270 degrees F) at 264 PSI.
 - 4) Abrasion Resistance: Coated on both surfaces to produce abrasion resistance of 3-19 percent maximum haze increase for 500 revolutions of CS-1 OF wheel per ASTM D 1044.
 - c. Glass Thickness: In accordance with ANSI/AAMA 1002.10 Appendix, minimum 5 mm (3/16 inch).
 - 1) Design Wind Pressures: Determined in accordance with applicable codes and regulations.
 - d. Glass: Labeled to show name of manufacturer and type.
 - e. Glazing Material: Installed in rigid removable steel or extruded aluminum subframe.
20. Construction:
- a. Master Frame: Roll Formed tubular lock-seam construction formed from 22 gage (0.85 mm) hot dipped galvanized steel.
 - 1) Corners: Either mitered or butt-jointed and rigidly fastened together by brazing or welding. Insert steel gussets at corners of mitered or butt-jointed storm doors when edge brazing is used.
 - 2) Welded tubular galvanized steel of 16 gage (1.6 mm) wall thickness is not required to use corner blocks or gussets.
 - b. Transom Rail (mullion): Accurately machined or accurately fit frame and rigidly welded to side of stiles.
 - 1) Kick Plate: Rigidly retained in place by steel or aluminum spline.
 - c. Glazing Frames: Mitered joints with corner gussets securely staked or brazed at corners.
 - 1) Inserts: Securely held in door.
 - 2) Provide positive contact between inserts and master frame to stop passage of insects and to prevent rattling.
 - d. Screen Inserts: Constructed to withstand performance requirements of ANSI/SMA 6001, Heavy Type.
 - 1) Screen Frames: Rolled, tubular lock seam construction or extruded aluminum.



- e. Adjustable Expander: Installed at bottom of each storm door to receive vinyl sweep.
 - 1) Adjustment Limit: Minimum 7.9 mm (5/16 inch).
 - 2) Vinyl Door Sweep: Installed in entire length of expander.
- f. Frame Liner (Z-bar): Track to receive weather stripping and necessary installation holes.
 - 1) Head Section of Frame Liner: Formed to function as drip cap.
- 21. Dimensions:
 - a. Widths across Master Frames:
 - 1) For Roll Form Door Minimum 70 mm (2-3/4 inches).
 - 2) For Tubular Doors: Minimum 51 mm (2 inches) with 23.7 mm (15/16 inch) minimum thickness.
 - b. Mullion Bar Following minimum widths across:
 - 1) Roll Form Door 48 mm (1-7/8 inches).
 - 2) Tubular Door: 23.7 mm (15/16 inch). Frame Liner: Minimum 27 mm (1-1/16 inch) return offset on outside face for side flange width for bearing against door buck. Wall Thickness of Frame Liner: Minimum 1.57 mm (0.062 inch). Storm Door: Supported by adequate reinforcing ribs.
 - c. Insert Frame: Maximum 4.8 mm (1/8 inch) overall clearance in width and height and interchangeable in storm doors having same nominal size.
 - d. Master Frame Dimensions: Manufacturing tolerance of plus or minus 4.8 mm (1/8 inch).
- 22. Hardware: Stainless steel, aluminum or other non-corrosive material.
 - a. Cadmium or Zinc Plated Steel: ASTM B 633 or ASTM B 766.
 - b. Include latch equipped with exterior handle, interior locking mechanism with anti-lockout feature, adjustable heavy duty door closer, necessary screws, and hurricane chain with spring.
 - c. Hinges: Install one of following hinge types on each frame liner and storm door:
 - 1) At least 4 concealed 304 stainless steel hinges on bronze oilite bearings, each minimum 75 mm (3 inches) long.
 - 2) At least 3 surface-mounted (H) type galvanized steel hinges.

Accessories

- 23. Joint Sealant: AAMA 800, Type 808.3 Exterior Perimeter Sealing Compound.

Finishes

- 24. Finish: Baked enamel or polyester poly powder coat applied to phosphatized, zinc impregnated or coated hot dipped galvanized steel.
 - a. Finish: Not show fading or corrosion when exposed to salt-spray test specified in this Section.

Source Quality Control

- 25. Testing: Performed by accredited independent testing laboratory.

EXECUTION

Examination

- 26. Site Verification of Conditions:
 - a. Field Measurements: Verify field measurements are as indicated on Shop Drawings.
 - b. Existing Conditions: Examine openings before beginning installation.
 - c. Verify that surfaces to receive storm doors are clean.

Preparation

- 27. Protection: Protect adjacent elements from damage and disfiguration in accordance with Detailed Scope of Work.
 - a. Contractor: Responsible for damage to grounds, plantings, buildings and any other facilities or property caused by construction operations.



- b. Repair or replace damaged elements in accordance with Detailed Scope of Work.
- 28. Existing Storm Doors: Remove existing screen and storm doors and debris from site in accordance with Detailed Scope of Work.
- 29. Prime Door Jambs of Existing Prime Doors: Prepare as necessary to provide for straight, plumb, level, tight and aesthetically appealing installation of steel storm doors.
 - a. Preparatory Work: Include, but not limited to repair of iambs, filling holes and/or dents, removing peeling and scaling paint, etc.

Installation

- 30. General: Install in accordance with ASTM E 737, manufacturer's recommendations, Reference Standards, and approved Shop Drawings.
 - a. Securely fasten doors in place to straight, plumb and level condition, without distortion of door or door frame, and make final adjustments for proper operation and satisfactory weatherstrip contact and seal.
 - b. In high wind areas, install storm door hinges on side to prevailing wind as directed.
- 31. Joint Sealants: Apply in accordance with manufacturers recommendations.
 - a. Surfaces to be Sealed: Clean, dry and free of any foreign matter that would degrade adhesion. Remove existing caulking and joint sealants from areas to receive new joint sealant.
 - b. Prime cleaned surfaces in accordance with sealant manufacturers recommendations.
 - c. Protect surfaces adjacent to joints by masking tape before applying sealant. Remove tape upon finishing sealing work.
 - d. Seal joints between perimeter of door frame and underlying or surrounding construction with joint sealant to accomplish weather-tight installation.
 - e. Maximum Width of Sealed Joint: 13 mm (1/2 inch).
- 32. Dissimilar Materials: Isolate materials from incompatible materials as necessary to prevent deterioration.
 - a. Separate dissimilar metals with bituminous paint, suitable sealant, nonabsorptive plastic or elastomeric tape, or gasket between surfaces.

Adjusting And Cleaning

- 33. Adjusting: At completion of job, check, adjust, and lubricate hardware as required and leave storm doors and hardware in proper operating condition.
- 34. Cleaning: Comply with requirements of Detailed Scope of Work.
 - a. Clean storm doors after installation is completed to remove foreign matter and surface blemishes.
 - b. Scratched or Abraded Surfaces: Touch-up with rust inhibitor primer and enamel paint compatible with factory finish.

Protection

- 35. Installed Work: Protect storm doors from damage after installation.

END OF SECTION 08 11 63 13



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**SECTION 08 11 63 13a - SECURITY WINDOW SCREENS AND DOORS**

DESCRIPTION OF WORK

This specification covers the furnishing and installation of materials for security window screens and doors. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

GENERAL

Definitions

1. Type of Screens (Frames and Screening): Light, Medium, and Heavy Types: As defined by and comply with requirements of ANSI/SMA 6001.
2. Supply and Delivery Only: Include supply and delivery to site(s) FOB destination freight prepaid. Unless otherwise specified or scheduled, unloading and handling at site is by Owner.

System Description

3. Performance Requirements: Comply with following:
 - a. Screens: Comply with ANSI/SMA 6001 performance requirements for Type specified or scheduled.
 - 1) Sag Test Described in ANSI/SMA 6001 Paragraph 4.2.4.2: Applicable to vertical or side hinged operable window screens only.
 - b. Operable Screens: Tested with emergency egress locking system:
 - 1) Screens: Meet or exceed ANSI/SMA 6001 performance requirements for Type specified or scheduled.
 - c. Security Screen Insert for Storm Doors: Completely assembled screen of 914 mm (36 inches) by 1 524 mm (60 inches) size with necessary braces:
 - 1) Impact Test: Meet or exceed ANSI/SMA 6001 Paragraph 4.2.4.1 performance requirements for Heavy Type.
 - d. Security Screen Doors: Completely assembled screen door measuring at least 914 mm (36 inches) wide by 2 032 mm (80 inches) high with necessary braces and hardware:
 - 1) Impact Test: Meet or exceed performance requirements of ANSI/SMA 6001 Paragraph 4.2.4.1 for Heavy Type.
 - 2) Sag Test: Meet or exceed ANSI/AAMA 1102.7 Sag Test.

Submittals

4. Product Data
5. Shop Drawings: Include standard details showing recommendations for installation. Include size of fasteners, maximum dimensions from each end, center-to-center spacing on all four sides, minimum penetration of fasteners into loading material, and maximum clearance between frame and rough opening.
6. Samples: Submit full set of samples of finish colors for color selection.
 - a. For Supply and Deliver Only Contract: Submit one full size sample of each type of security window screen and screen door with specified finish for acceptance.
7. Quality Assurance/Control Submittals:
 - a. Certificates: Manufacturers written certification that security window screens and door screens meet or exceed ANSI/SMA 6001 and other specified requirements.
 - b. Manufacturer's installation instructions.
8. Closeout Submittals:
 - a. Operation and maintenance data.
 - b. Special warranty.



Quality Assurance

9. Regulatory Requirements:
 - a. Egress Requirements: Comply with applicable codes and regulations.
 - b. Provide emergency egress, single point locking release, and bit key lock fire entry from exterior as and where required by applicable codes and regulations.
 - c. Accessibility:
 - 1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
 - a) Uniform Federal Accessibility Standards (UFAS).
 - 2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
 - 3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
 - 4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
10. Certifications: Comply with ANSI Z34.2.
11. Mock-ups: For Supply and Install Contract: Install one full size mock-up of each type of security window screen and screen door with specified finish for acceptance.
 - a. Locations: As directed.
 - b. Approved Mock-ups: Standard for rest of work.
 - c. Approved Mock-ups: May remain part of completed project.

Delivery, Storage, And Handling

12. Packing, Shipping, Handling, and Unloading: Pack materials at manufacturing plant to prevent damage during shipping.
 - a. Screens: Label attached signifying compliance with ANSI/SMA 6001 performance requirements.
13. Acceptance at Site: Inspect screens upon delivery. Replace damaged or defective materials before installation.
14. Storage and Protection: Store screens in manner to protect from weather and other damage.

Project Conditions

15. Field Measurements: Field measure openings for screens before start of fabrication.

Scheduling And Sequencing

16. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.

Warranty

17. Special Warranty: Provide one year written covering materials and installation for security window screens and screen doors.
 - a. Warranty: Include coverage of inserts, hardware, and latches.
 - 1) Screening not included.
 - 2) Defects resulting from vandalism not included.
 - b. For Supply and Delivery Only Contract:
 - 1) Contractor: Agrees to supply and deliver to Owner, free of charge, any required replacement parts that can be readily installed by Owner without special tools.
 - 2) Contractor: Agrees to supply and deliver free of charge, complete replacement security window screen or screen door, when defective part or parts cannot be installed without use of special tools.
 - c. For Supply and Install Contract:
 - 1) Contractor: Agrees to supply and install, free of charge, any required replacement parts or complete replacement screen.

PRODUCTS

Security Window Screens And Screen Doors



18. General: Manufactured of commercially accepted materials, free from blemishes, dents, and scratches or any other defects, which are visible when viewed at distance of 1 800 mm (6 ft), or which might otherwise affect their serviceability or appearance.
 - a. Screens: Type(s) and size(s) indicated, specified, or scheduled with necessary hardware, anchors, and equipment.
 - b. Screens: Label attached signifying compliance with ANSI/SMA 6001 requirements.
19. Framing and Cross Brace Members: Made of material which will provide sufficient strength to meet performance requirements of ANSI/SMA 6001, Types as specified or scheduled.
 - a. Thickness: Thickness necessary to provide durability and meet performance requirements.
 - b. Material: Steel or aluminum as specified or scheduled complying with applicable Federal Specification or ASTM tests and specifications for chemical, physical or mechanical properties.
 - c. Light Type: Mechanical comers acceptable.
 - d. Medium and Heavy Type: Provide continuously face welded corner joints.
20. Screening: ANSI/SMA 6001 Section 4.3.1, type 304 stainless steel (carbon steel not allowed), Types as specified and scheduled.
 - a. Light Type: Minimum 16 by 16 mesh, 0.46 mm (0.018 inch) diameter.
 - b. Medium Type: Minimum 12 by 12 mesh, 0.58 mm (0.023 inch) diameter.
 - c. Heavy Type: Minimum 12 by 12 mesh, 0.71 mm (0.028 inch) diameter with tensile (high tensile) strength of 1.43 kg per lineal mm width (800 pounds per linear inch width).
 - d. Certification: Provide certificate of compliance with specified requirements.
 - e. Assembly: Assembled in secure manner to perform as specified to assure neat construction.
 - 1) Welding or Brazing Flux: Completely removed immediately upon completion of welding or brazing operation.
 - f. Window Screens: Include warning label indicating that screen will not stop child from falling out of window in accordance with SMA 7001.
21. Operable Screens: Frame, or frame and subframe assembly, as required, scribe angles (where required), hinged main frame as required, screening, egress locking system from interior, and concealed hinges.
 - a. Screening: Type as specified or scheduled.
 - b. Main and Subframes: Steel or extruded aluminum as specified or scheduled and shall conceal locking mechanism from exterior, Type as specified or scheduled.
 - 1) Aluminum: ANSI/SMA 1004, extruded aluminum.
 - c. Operable Screens: May be mounted with vertically or horizontally positioned hinge as indicated.
 - d. Operating Hardware: Releasable from interior but properly guarded to prevent access from exterior when window is open.
22. Fixed Screens:
 - a. Fixed Frame: Steel or extruded aluminum as specified or scheduled.
 - b. Screening: Type as specified or scheduled.
23. Storm Door Screen Inserts: Main frame for application to existing storm door.
 - a. Frames: Steel or extruded aluminum as specified or scheduled.
 - b. Screening: ANSI/SMA 6001 Heavy Type.
24. Security Screen Doors: Fully assembled pre-hung doors with Z-bar frame, sill expanders with necessary hardware.
 - a. Doors Frames: Steel or extruded aluminum as specified or scheduled, ANSI/SMA 6001 Heavy Type.
 - b. Screening: ANSI/SMA 6001 Heavy Type.

Aluminum Security Screen Doors

25. Aluminum Screen Doors: Type(s) and size(s) indicated, specified, or scheduled manufactured and provided with prehung aluminum frame line (Z-bar) to fit entrance door apertures requiring frame sizes of 762 mm (30 inches) to 940 mm (37 inches) in width and 2 007 mm (79 inches) to 2 134 mm (84 inches) in height.
 - a. Doors: Sized to fit existing openings.
26. Materials:



- a. Master Frame and Mullions: ANSI/SMA 3001, extruded aluminum and minimum 151 kPa (22,000 PSI) tensile strength.
 - b. Kick Plate: Embossed or Corrugated Aluminum: Minimum 1.27 mm (0.50 inch) embossed or corrugated thickness, fabricated of minimum 1.02 mm (0.040 inch) thick material.
 - c. Screening: Secure by use of aluminum spline integrally mounted and secured with fasteners.
27. Bottom of Door: Provide bottom expander door sweep of non-hardening rubber or extruded vinyl plastic, adjustable to 15.8 mm (5/8 inch).
- a. Bottom Expander: Minimum 1.4 mm (0.055 inch) wall thickness.
28. Door Master Frame Construction: Mitered joint construction and joined at corners by welding or mechanical joints.
- a. Frame Members: Minimum 60 mm (2-3/8 inch) width across flat surface and minimum 31 mm (1-1/4 inch) thickness.
 - b. Wall Thickness: Minimum 1.57 mm (0.062 inch).
 - c. Mitered Comer Joint Construction: inert gas tungsten arc or heliarc welding to provide screen doors to comply with performance requirements.
 - 1) Weld: Penetrate on both exterior and interior sides of joint.
 - 2) Dress weld beads and flat surfaces (edge surfaces not included) to smooth flush surface within satin finish.
 - 3) Minimum Width of Weld: 9.5 mm (3/8 inch) prior to dressing.
 - 4) Minimum Penetration of Weld Build-up: Minimum of 2.4 mm (3/32 inch).
 - d. Mechanical Comer Joints: Screw boss or gusset construction using screw fasteners standard to manufacturer to provide screen doors to comply with performance requirements.
 - e. Master Frame Dimensions: Manufacturing tolerance of plus/minus 4.8 mm (1/8 inch).
 - f. Extrusion Tolerances: In accordance with Aluminum Extruded Products Division of Aluminum Association standards.
29. Mullion Bars: Hollow extruded shape designed to permit being used as kick panel mullion or as upper mullion.
- a. Mullion Bars: Minimum 50 mm (2 inch) width across flat surface and minimum 31 mm (1-1/4 inch) thickness.
 - b. Wall Thickness: Minimum 1.57 mm (0.062 inch).
 - c. Mullions: Accurately machined to fit frame and joined to side stiles by inert gas tungsten arc or heliarc welding or by mechanical clip designed for compatibility.
 - d. Dress weld beads down to make smooth flush surface.
 - e. Provide main frame and mullion bar with 4.8 mm (3/16 inch) deep grooves to accommodate kick plate.
 - f. Utilize weather resisting cement utilized to provide maximum strength and rigidity.
30. Head and Side Z-bars: Designed to receive weatherstripping.
- a. Z-bars: Prepunched installation holes and hinges attached with machine screws.
 - b. Head Section: Formed to function as drip cap.
 - c. Frame Liner: Z-bar of extruded aluminum, minimum 1.57 mm (0.062 inch) wall thickness.
 - d. Weatherstripping: Wool pile or vinyl.
31. Each Door: Three hinges attached to pre-punched Z-bar.
- a. Hinges: Full or 1/2 surface hinges, with three bronze oilite bushings per hinge.

Steel Security Screen Doors

32. Steel Screen Doors: Type(s) and size(s) indicated, specified, or scheduled manufactured of steel and provided with pre-hung aluminum frame liner (Z-bar) to fit entrance door apertures requiring frame sizes of 762 mm (30 inches) to 940 mm (37 inches) in width and 2 007 mm (79 inches) to 2 134 mm (84 inches) in height.
33. Materials:
 - a. Master Frame: Not be less than 22 gage (0.85 mm) roll formed steel, or 16 gage (1.6 mm) tubular steel as applicable to hem specified.
 - b. Kick Plate: At least 18 gage (1.3 mm) embossed galvanized panel for roll formed frame or 16 gage (1.6 mm) flat galvanized steel sheet for tubular steel frame.



- c. Screen Insert:
 - 1) Screening: Secured with fasteners.
 - 2) Screen Frame: Roll formed or tubular lock seam type formed from not less than 25 gage (0.53 mm) hot dipped galvanized steel or extruded aluminum.
 - d. Door Sweep Spline: Polyvinyl chloride (PVC) or equal material
 - e. Frame Liner (Z-bar): Extruded aluminum, 6063 J5.
 - f. Weatherstripping: Wool pile, or vinyl.
34. Construction:
- a. Master Frame: Roll Formed tubular lock-seam construction formed from 22 gage (0.85 mm) hot dipped galvanized steel.
 - 1) Corners: Either mitered or butt-jointed and rigidly fastened together by brazing or welding. Insert steel gussets at corners of mitered or butt-jointed screen doors when edge brazing is used.
 - 2) Welded tubular galvanized steel of 16 gage (1.6 mm) wall thickness is not required to use corner blocks or gussets.
 - b. Transom Rail (mullion): Accurately machined or fit frame and rigidly welded to side of stiles.
 - 1) Kick Plate: Rigidly retained in place by steel or aluminum spline, or form fitted.
 - c. Adjustable Expander Installed at bottom of each screen door to receive vinyl sweep.
 - 1) Adjustment Limit: At least 7.9 mm (5/16 inch).
 - 2) Vinyl Door Sweep: Installed in entire length of expander.
 - d. Frame Liner (Z-bar): Track to receive weather stripping and necessary installation holes.
 - 1) Head Section of Frame Liner Formed to function as drip cap.
35. Dimensions:
- a. Widths across Master Frames:
 - 1) For Roll Form Door: Minimum 70 mm (2-3/4 inches).
 - 2) For Tubular Doors: Minimum 51 mm (2 inches) with 23.7 mm (15/16 inch) minimum thickness.
 - b. Mullion Bar: Following minimum widths across:
 - 1) Roll Form Door: 48 mm (1-7/8 inches).
 - 2) Tubular Door: 23.7 mm (15/16 inch). Frame Liner: Not less than 27 mm (1-1/16 inch) return offset on outside face for side flange width for bearing against door buck. Wall Thickness of Frame Liner: Minimum 1.57 mm (0.062 inch). Screen Door: Supported adequate reinforcing ribs.
 - c. Master Frame Dimensions: Manufacturing tolerance of plus or minus 4.8 mm (1/8 inch).
36. Hinges: Install one of following hinge types on each frame liner and screen door:
- a. At least four concealed 304 stainless steel hinges on bronze oilite bearings, each minimum 75 mm (3 inches) long.
 - b. At least three surface-mounted (H) type galvanized steel hinges.

Accessories

37. Hardware: Designed to afford ease of operation, perform functions for which it is intended, and securely attached to screen.
- a. Materials: Stainless steel, aluminum, or made corrosion resistant by plating.
 - 1) Material: Compatible with frame material.
 - 2) Stainless Steel: Alloys of 302, and 304.
 - 3) Aluminum: Extrusions from commercially produced 6063-T5 alloy.
 - 4) Cadmium or Zinc Plated Steel: ASTM B 633 or ASTM B 766.
 - 5) Plastic parts not allowed.
 - b. Fasteners: Stainless, cadmium plated, or zinc-plated steel screws, nuts, washers, bolts, and other miscellaneous fastening devices and hardware.
 - c. Hinges: Concealed from exterior, with compression guards, and of sufficient strength to comply with performance requirements of ANSI/SMA 6001.
 - d. Locking System: Non-corrosive materials permitting emergency egress and of sufficient strength to comply with performance requirements of ANSI/SMA 6001.
 - 1) Provide single point release as and where required by applicable codes and regulations.



- 2) Provide bit key lock fire entry from exterior if required by applicable codes and regulations.
 - 3) Locking Hardware: Remain completely concealed from exterior viewing and tampering with lock bolts positively locked when in thrown position, so that they cannot be operated from direct pressure on bolts.
38. Security Screen Door Hardware: Include latch with exterior handle, interior locking mechanism with anti-lockout feature, adjustable heavy duty door closer, necessary screws, and hurricane chain with spring.
 39. Window Screens: Include warning label that screen will not stop child from falling out of window in accordance with SMA 7001.
 40. Anchors: Non-magnetic stainless steel or other non-corrosive material compatible with screen.
 - a. Anchors Exposed when Screen is Closed and Locked: Non-removable security type.

Finishes

41. Screens: Factory applied baked on enamel or polyester powder coat finish.
 - a. Exposed Surfaces: Clean and free from serious surface blemishes.
 - b. Dress and finish exposed welded joints.
 - c. Color: As selected from manufacturers standard colors.

Source Quality Control

42. Testing: Performed by accredited independent testing laboratory.

EXECUTION

Examination

43. Site Verification of Conditions:
 - a. Field Measurements: Verify field measurements are as indicated on Shop Drawings.
 - b. Existing Conditions: Examine openings before beginning installation.
 - c. Verify that surfaces to receive security screens are clean.
 - d. Do not proceed with installation until conditions are satisfactory.

Preparation

44. Protection: Protect adjacent elements from damage and disfiguration in accordance with Detailed Scope of Work.
 - a. Contractor: Responsible for damage to grounds, plantings, buildings and any other facilities or property caused by construction operations.
 - b. Repair or replace damaged elements in accordance with Detailed Scope of Work.
45. Existing Window Screens and Screen Doors: Remove existing window screens and screen doors and debris from site in accordance with Detailed Scope of Work.
46. Preparation: Prepare openings and existing frames in accordance with ASTM E 737 for storm doors and storm windows.
 - a. Existing Window and Door Jambs: Prepare as necessary to provide for straight, plumb, level, tight and aesthetically appealing installation of new window screens and screen doors.
 - b. Preparatory Work: Include, but not limited to repair of jambs, filling holes and/or dents, removing peeling and scaling paint, etc.

Installation

47. General: Install in accordance with ASTM E 737 for storm doors and storm windows, manufacturers recommendations, Reference Standards, and approved Shop Drawings.
 - a. Window Screens and Screen Doors: Securely anchor in place to straight, plumb and level condition, without distortion.
 - b. Comply with applicable codes and regulations regarding egress requirements and fireman entry.



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48. Dissimilar Materials: Isolate materials from incompatible materials as necessary to prevent deterioration.
 - a. Separate dissimilar metals with bituminous paint, suitable sealant, nonabsorptive plastic or elastomeric tape, or gasket between surfaces.
 - b. Coat aluminum in direct contact with concrete, masonry, steel, or other non-compatible materials with bituminous paint, zinc chromate primer, or other suitable insulating material.

Adjusting And Cleaning

49. Adjusting: At completion of job, check, adjust, and lubricate hardware as required and leave window screens, screen doors, and hardware in proper operating condition.
50. Cleaning: Comply with requirements of Detailed Scope of Work.
 - a. Clean window screens and screen doors after installation is completed to remove foreign matter and surface blemishes.
 - b. Scratched or Abraded Surfaces: Touch-up with rust inhibitor primer and enamel paint compatible with factory finish.

Protection

51. Installed Work: Protect window screens and screen doors from damage after installation.

END OF SECTION 08 11 63 13a



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**SECTION 08 11 63 23 - ALUMINUM STORM DOORS**

DESCRIPTION OF WORK

This specification covers the furnishing and installation of materials for aluminum storm doors. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

GENERAL

Definitions

1. Supply and Delivery Only: Include supply and delivery to site(s) FOB destination freight prepaid. Unless otherwise specified or scheduled, unloading and handling at site is by Owner

System Description

2. Performance Requirements: Comply with following:
 - a. Aluminum Storm Doors: ANSI/AAMA 1102.7, Performance Class 25 - 1.2 kPa (25 PSF) Design Pressure, 1.8 kPa (37.5 PSF) Test Pressure.
 - b. Stainless Steel Screen Insert: Completely assembled screen of 914 mm (36 inches) by 1 524 mm (60 inches) size with necessary braces:
 - 1) Impact Test: Meet or exceed ANSI/SMA 6001 Paragraph 4.2.4.1 performance requirements for Medium Type.
 - c. Aluminum Screen Doors: Completely assembled screen door measuring at least 914 mm (36 inches) wide by 2 032 mm (80 inches) high with necessary braces and hardware:
 - 1) Impact Test: Meet or exceed performance requirements of ANSI/SMA 6001 Paragraph 4.2.4.1 for Medium Type.
 - 2) Sag Test: Meet or exceed ANSI/AAMA 1102.7 Sag Test.

Submittals

3. Product Data.
4. Shop Drawings:
 - a. Include exploded view of manufactured door, similar to AAMA 1102.7, page 12.
 - b. Indicate fabrication of all parts, metal thickness, installation details, fastening, and sealing.
 - c. Include sections of typical members and details of latching devices.
5. Samples: Submit full set of finish color samples for color selection.
 - a. For Supply and Deliver Only Contract: Submit one full size sample of each type of storm door with specified finish for acceptance.
6. Quality Assurance/Control Submittals:
 - a. Certificates: Manufacturers written third party certification that storm doors meet or exceed ANSI/AAMA 1102.7, HUD 39a, and other specified requirements.
 - b. Manufacturers installation instructions.
7. Closeout Submittals:
 - a. Operation and maintenance data.
 - b. Special warranty.

Quality Assurance

8. Regulatory Requirements: Comply with following:
 - a. Glazing Materials: Comply with CPSC 16 CFR 1201 or ANSI Z97.1.
 - b. Accessibility:
 - 1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
 - a) Uniform Federal Accessibility Standards (UFAS).



- 2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
 - 3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
 - 4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
9. Certifications: Comply with HUD 39a, ANSI Z34.1, and HUD 24 CFR 200.935.
10. Mock-ups: For Supply and Install Contract: Install one full size mock-up of each type of storm door with specified finish for acceptance.
- a. Location: As directed.
 - b. Approved Mock-up: Standard for rest of work.
 - c. Approved Mock-up: May remain part of completed project.

Delivery, Storage, And Handling

11. Packing, Shipping, Handling, and Unloading: Pack materials at manufacturing plant to prevent damage during shipping.
 - a. Storm Doors: Label in accordance with HUD UM 39a signifying compliance with ANSI/AAMA 1102.7 performance requirements.
12. Acceptance at Site: Inspect storm doors upon delivery. Replace damaged or defective materials before installation.
13. Storage and Protection: Store storm doors in manner to protect from weather and other damage.

Project Conditions

14. Field Measurements: Field measure openings for storm doors before start of fabrication.

Scheduling And Sequencing

15. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.

Warranty

16. Special Warranty: Provide one year written covering materials and installation for storm doors.
 - a. Warranty: Include coverage of inserts, closers, chains, hardware, and latches.
 - 1) Screening and glazing not included.
 - 2) Defects resulting from vandalism riot included.
 - b. For Supply and Delivery Only Contract:
 - 1) Contractor: Agrees to supply and deliver to Owner, free of charge, any required replacement parts that can be readily installed by Owner without special tools.
 - 2) Contractor: Agrees to supply and deliver free of charge, complete replacement door, when defective part or parts cannot be installed without use of special tools.
 - c. For Supply and Install Contract:
 - 1) Contractor: Agrees to supply and install, free of charge, any required replacement parts or complete replacement storm door.

PRODUCTS

Aluminum Storm And Screen Doors

17. Storm Doors: Type(s) and size(s) indicated, specified, or scheduled with mechanical or welded comer construction complete with tempered glass or plastic glazing inserts where storm glazing is specified or scheduled, screen inserts where specified or scheduled, durable metal kick panel, push plate, adjustable bottom expander with sill sweep, necessary hardware, fasteners, and miscellaneous equipment.
 - a. Screen Doors: Meet or exceed Performance Requirements in this Section.
 - b. Storm Doors: Meet or exceed applicable requirements of AAMA/ANSI 1102.7, Performance Class 60 and HUD UM 39a.
 - c. Storm Doors: Self-storing or seasonal replacement as specified or scheduled.
 - d. Door Construction: Not necessary to remove door from its installed position to reglaze, rescreen, or replace kick plate, push plate, or protective grille.



- e. Glazed Sash and Glazing Materials: Permit reglazing without special tools.
- f. Doors: Sized to fit existing openings.
- 18. Finished Master Frame, Extruded Screen Insert Frame and Z-bar: Minimum 1.4 mm (0.055 inch) wall thickness.
 - a. Z-bar: Adequate reinforcing ribs to support door.
- 19. Glazing Materials: Comply with CPSC 16 CFR 1201 or ANSI Z97.1.
 - a. Tempered Glass: ASTM C 1048, Kind FT, Condition A, Type 1, Class 1, Glazing B Quality.
 - b. Plastic: Extruded polycarbonate clear sheets, minimum 4.5 mm (0.177 inch) thick with following characteristics:
 - 1) Impact Resistance: ASTM D 256, Method A, 12-18 foot-pound per inch.
 - 2) Elongation/Modulus of Elasticity: ASTM D 638, 110 percent maximum/340,000 PSI.
 - 3) Heat Deflection: ASTM D 648, 132.2 degrees C (270 degrees F) at 264 PSI.
 - 4) Abrasion Resistance: Coated on both surfaces to produce abrasion resistance of 3-19 percent maximum haze increase for 500 revolutions of CS-1 OF wheel per ASTM D 1044.
 - c. Glass Thickness: In accordance with AAMA 1002.10 Appendix, minimum 5 mm (3/16 inch).
 - 1) Design Wind Pressures: Determined in accordance with applicable codes and regulations.
 - d. Glass: Labeled to show name of manufacturer and type.
 - e. Glazing Material: Installed in rigid removable aluminum sub-frame.
- 20. Screens: Manufacturer's standard design.
 - a. Screens Not Part of Door Frame: Extruded aluminum frames, of suitable alloy, and of sufficient rigidity, crossbraced as required, to lie flat against door and to prevent excessive bow in frame members and sag in screening.
 - 1) Screen Spline: Firmly jointed in secure manner.
 - b. Screening: Aluminum Wire Fabric: One of following as specified or scheduled:
 - 1) Regular Aluminum: FS RR-W-365, Type VII, 18 x 16 or 18 by 18 regular, 0.28 mm (0.011 inch) wire.
 - 2) Heavy Aluminum: FS RR-W-365, Type VII, 18 x 14 regular, 0.33 mm (0.013 inch) wire.
 - c. When screen is completely assembled with insect screening and spline in place, outside dimension as measured from midpoint of opposite framing members shall not vary more than 4.8 mm (3/16 inch) from outside dimension as measured at extreme ends of such framing members.
 - d. Screening: Fastened to frame in manner to permit replacement of screening.
- 21. Stainless Steel Screen: As specified or scheduled:
 - a. Screen Frames: Rolled, tubular lock seam construction formed from not less than 25 gage (0.53 mm) hot-dipped galvanized steel or 0.66 mm (0.026 inch) minimum aluminum extruded 6063-T5 alloy (with galvanic protection).
 - b. Screening: Stainless Steel: ANSI/SMA 6001 Medium Type, 12 x 12 mesh stainless steel with wire diameter of 0.58 mm (0.023 inch).
 - c. Provide screen with fastening devices for application to specific windows for which they are intended and of sufficient strength to perform satisfactorily.
- 22. Bottom of Door: Provide bottom expander door sweep of non-hardening rubber or extruded vinyl plastic, adjustable to 15.8 mm (5/8 inch).
 - a. Bottom Expander: Minimum 1.4 mm (0.055 inch) wall thickness.
- 23. Kick Plate: Embossed or Corrugated Aluminum: Minimum 1.27 mm (0.50 inch) embossed or corrugated thickness, fabricated of minimum 1.02 mm (0.040 inch) thick material.
- 24. Hardware: Aluminum, stainless steel, or other non-corrosive materials compatible with aluminum.
 - a. Cadmium or Zinc Plated Steel: ASTM B 633 or ASTM B 766.
 - b. Include latch with exterior handle and interior locking mechanism with anti-lockout feature, adjustable heavy duty door closer, necessary screws, hurricane chain with spring.
 - c. Each Door: 3 hinges attached to Z-bar.
 - d. Hinges: Full or 1/2 surface hinges, with 3 bronze bushings per hinge.
- 25. Optional Accessories:
 - a. Optional Protective Grille: Perforated aluminum sheet, 0.61 mm (0.24 inches) minimum thickness, riveted or screwed to door frame to completely cover exterior of screen.



- b. Optional Pushplate: Embossed aluminum strip 150 mm (6 inches) high, 1.02 mm (0.040 inch) minimum thickness.
 - 1) Overall Height of Mullions and Pushplate: Minimum of 200 mm (8 inches) and installed opposite and centered with latch.

Hollow Core Aluminum Storm Doors

- 26. Door: Hollow extruded smooth surface master frame, 2 hollow extruded smooth surface mullion or cross bars; 2 extruded screen frame inserts, extruded side and head Z-bars, and extruded external telescoping bottom expander.
 - a. Extrusions: Manufactured from 6063-T5 extruded aluminum alloy, minimum 1.57 mm (0.062 inch) thick, minimum 151 600 kPa (22,000 PSI) tensile strength.
 - b. Glazing Strip, Bottom Sweep, Screening Spline and Z-bar Seal: Virgin polyvinyl plastic.
- 27. Door Master Frame Comer Construction: Mitered joint construction and joined at comers by welding or mechanical joints.
 - a. Mitered Comer Joint Construction: Inert gas tungsten arc or heliarc welding to provide storm doors to comply with performance requirements.
 - 1) Weld: Penetrate on both exterior and interior sides of joint.
 - 2) Dress weld beads and flat surfaces (edge surfaces not included) to smooth flush surface within satin finish.
 - 3) Minimum Width of Weld: 9.5 mm (3/8 inch) prior to dressing.
 - 4) Minimum Penetration of Weld Build-up: Minimum of 2.4 mm (3/32 inch).
 - b. Mechanical Comer Joints: Screw boss or gusset construction using screw fasteners standard to manufacturer to provide storm doors to comply with Performance Requirements in this Section.
- 28. Mullion Bars: Hollow extruded shape designed to permit being used as kick panel mullion or as upper mullion.
 - a. Mullions: Accurately machined to fit frame and joined to side stiles by inert gas tungsten arc or heliarc welding.
 - b. Dress weld beads down to make smooth flush surface.
 - c. Provide top surface of extrusions for both center and bottom mullion bars with channel to accommodate inserts.
 - d. Provide main frame and mullion bar with 4.8 mm (3/16 inch) deep grooves to accommodate kick plate.
 - e. Utilize weather resisting cement utilized to provide maximum strength and rigidity and rattle proof operation.
 - f. Bottom Mullion Bar: Receive top of kick plate.
 - g. Mullion Bar: Same thickness as frame and have minimum 50 mm (2 inch) face.
- 29. Head and Side Z-bars: Designed to receive vinyl plastic closure strip for maximum seal against air and dust infiltration.
 - a. Head Z-bar: Designed and extruded to also function as drip cap over top of door.
 - b. Z-bars: Prepunched installation holes and hinges attached with machine screws.
- 30. Finished Master Frame: Minimum 60 mm (2-3/8 inch) width across flat surface and minimum 25 mm (1 inch) thickness.
 - a. Mullion Bars: Minimum 50 mm (2 inch) width across flat surface and minimum 25 mm (1 inch) thickness.
 - b. Wall Thickness: Minimum 1.4 mm (0.055 inch).
 - c. Extruded Screen Insert Frames: 19 mm (3/4 inch) wide, minimum 7.9 mm (5/16 inch) thick, and minimum 1.57 mm (0.062 inch) wall thickness.
 - d. Z-bars: Minimum 1.4 mm (0.055 inch) wall thickness plus adequate reinforcing ribs to support door.
 - e. Insert Frame: Fabricated to have minimum overall clearance of 4.8 mm (1/8 inch) in width and height, and interchangeable in doors of same nominal size.
 - f. Master Frame Dimensions: Manufacturing tolerance of plus/minus 4.8 mm (1/8 inch).
 - g. Extrusion Tolerances: In accordance with Aluminum Extruded Products Division of Aluminum Association standards.



31. Glazing Insert Frames: Extruded with mitered joint construction secured at comers by staking into comer gussets.
 - a. Inserts: Equal height making them interchangeable on doors with upper and lower openings.
 - b. Inserts: Held in door by aluminum clips and machine screws.
 - c. Install maximum of 6 rivnuts into door per insert.
 - d. Install rivnuts in master frame, 2 on each side and top of each insert, located not to interfere with installation of door closer or safety chain.
 - e. Insert: Positive contact with master frame to stop passage of insects and prevent rattling.
32. Screening Insert Frames: Extruded tubular with mitered joint construction and secured at comers by staking into comer gussets.
 - a. Make square comer gussets of 0.46 mm (0.180 inch) minimum extruded aluminum to fit firmly against extruded insert frames to minimize twist and distortion.
 - b. Insert screening into groove provided in frame and secure by vinyl spline.
 - c. Inserts in Doors with Upper and Lower Openings: Equal height making them interchangeable, and secured into master frame by same method as specified for glazed inserts.
33. Hinges: 3 knuckle construction, not less than 98 mm (3-7/8 inches) in length, with minimum of 3 prepunched screw holes in hinge leaf of minimum thickness 0.31 mm (0.120 inch) plus adequate longitudinal reinforcing ribs to support door.
 - a. Each Door: Supported with not less than 4 built-in type hinges employing raised knuckle on extruded Z-bar to receive half-extruded aluminum hinge leaf joined at knuckle by using 2 stainless steel or cadmium plated steel pins pivoting through oilite or nylon bushings.
 - b. Pins: Held securely in place by cadmium plated steel compression springs.
 - c. Hinge: Allow door to open 180 degrees.

Solid Core (Laminated) Storm Door

34. Materials:
 - a. Main Frame and Glass Edge Surround Members (if not part of main frame): Aluminum of sufficient strength to comply with performance requirements of ANSI/AAMA 1102.7.
 - b. Reinforcing Members: Aluminum or other non-corrosive materials compatible with aluminum.
 - 1) Carbon Steel: Cadmium or zinc-plated in accordance with ASTM B 633 or ASTM B 766.
35. Finished Master Frame: Extruded screen insert frame and Z-bar minimum 1.4 mm (0.055 inch) wall thickness.
 - a. Z-bar: Adequate reinforcing ribs to support door.
36. Door: Laminated construction consisting of minimum 19.1 mm (3/4 inch) thick particle board, grade 1-M-3 with seamless aluminum skins bonded together.
 - a. Particle Board Core Material: Completely sealed with polyurethane for moisture protection.
 - b. Ureaformaldehyde binders not allowed.
37. Screws, Nuts, Washers, Bolts, Rivets and Other Fastening Devices: Aluminum, stainless steel or other non-corrosive materials compatible with aluminum.
 - a. Cadmium or Zinc-plated Steel: ASTM B 633 or ASTM B 766.
38. Weatherstrip: Weatherstrip Z-bars with woven pile so that there is no metal to metal contact between main frame and Z-bar.
 - a. Install weatherstripping in specially extruded ports and in accordance with AAMA 701.2.
39. Anti-galling Devices: Non-corrosive materials compatible with aluminum and of sufficient strength to perform as designed.

Accessories

40. Joint Sealant: AAMA 800, Type 808.3 Exterior Perimeter Sealing Compound.

Finishes

41. Finish:
 - a. Aluminum Finish: Provide one of following as specified or scheduled:
 - 1) Factory applied pigmented organic coating, AAMA 603.8.



- a) Color: As selected from manufacturer's standard colors.
- 2) Clear Anodized: Factory applied anodic coating, AAMA 607.1, Class 1.
- b. Exposed Surfaces of Aluminum Members: Clean and free from serious surface blemishes.
- c. Dress and finish exposed welded joints.

Source Quality Control

- 42. Testing: Performed under Third Party Administrator in compliance with HUD 39a, ANSI Z34.1, and HUD 24 CFR 200.935.

EXECUTION

Examination

- 43. Site Verification of Conditions:
 - a. Field Measurements: Verify field measurements are as indicated on Shop Drawings.
 - b. Existing Conditions: Examine openings before beginning installation.
 - c. Verify that surfaces to receive storm doors are clean.
 - d. Do not proceed with installation until conditions are satisfactory.

Preparation

- 44. Protection: Protect adjacent elements from damage and disfiguration in accordance with Detailed Scope of Work.
 - a. Contractor: Responsible for damage to grounds, plantings, buildings and any other facilities or property caused by construction operations.
 - b. Repair or replace damaged elements in accordance with Detailed Scope of Work.
- 45. Existing Storm Doors: Remove existing screen and storm doors and debris from site in accordance with Detailed Scope of Work.
- 46. Preparation: Prepare openings and existing frames in accordance with ASTM E 737.
 - a. Prime Door Jambs of Existing Prime Doors: Prepare as necessary to provide for straight, plumb, level, tight and aesthetically appealing installation of new storm doors.
 - b. Preparatory Work: Include, but not limited to repair of jambs, filling holes and/or dents, removing peeling and scaling paint, etc.

Installation

- 47. General: Install in accordance with ASTM E 737, manufacturer's recommendations, Reference Standards, and approved Shop Drawings.
 - a. Securely fasten storm doors in place to straight, plumb and level condition, without distortion of door or door frame, and make final adjustments for proper operation and satisfactory weatherstrip contact and seal.
 - b. In high wind areas, install storm door hinges on side to prevailing wind as directed.
- 48. Joint Sealants: Apply in accordance with manufacturer's recommendations.
 - a. Surfaces to be Sealed: Clean, dry and free of any foreign matter that would degrade adhesion. Remove existing caulking and joint sealants from areas to receive new joint sealant.
 - b. Prime cleaned surfaces in accordance with sealant manufacturer's recommendations.
 - c. Protect surfaces adjacent to joints by masking tape before applying sealant. Remove tape upon finishing sealing work.
 - d. Seal joints between perimeter of storm door frame and underlying or surrounding construction with joint sealant to accomplish weather-tight installation.
 - e. Maximum Width of Sealed Joint: 13 mm (1/2 inch).
- 49. Dissimilar Materials: Isolate materials from incompatible materials as necessary to prevent deterioration.
 - a. Separate dissimilar metals with bituminous paint, suitable sealant, nonabsorptive plastic or elastomeric tape, or gasket between surfaces.



- b. Coat aluminum in direct contact with concrete, masonry, steel, or other non-compatible materials with bituminous paint, zinc chromate primer, or other suitable insulating material.

Adjusting And Cleaning

- 50. Adjusting: At completion of job, check, adjust, and lubricate hardware as required and leave storm doors and hardware in proper operating condition.
- 51. Cleaning: Comply with requirements of Detailed Scope of Work.
 - a. Clean storm doors after installation is completed to remove foreign matter and surface blemishes.
 - b. Scratched or Abraded Surfaces: Touch-up with rust inhibitor primer and enamel paint compatible with factory finish.

Protection

- 52. Installed Work: Protect storm doors from damage after installation.

END OF SECTION 08 11 63 23



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SECTION 08 11 73 00 - SLIDING METAL FIRE DOORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for sliding metal fire doors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Single-leaf, power-operated and manually operated sliding door with or without pass door.
 - b. Biparting, power-operated and manually operated sliding door with or without pass door.
 - c. Multiple-leaf, power-operated and manually operated sliding door with or without pass door.

C. Performance Requirements

1. Structural Performance: Provide horizontal sliding doors capable of withstanding the effects of gravity loads and the following loads and stresses without evidencing permanent deformation of door components:
 - a. Wind Load: Uniform pressure (velocity pressure) of 20 lbf/sq. ft. (960 Pa), **unless required otherwise by the location of the work**, acting inward or outward.

D. Submittals

1. Product Data: For each type of product indicated.
 - a. Fire-Rated Doors: Include description of fire-release system including testing and resetting instructions.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
3. Product Certificates: For sliding metal fire doors, signed by product manufacturer.
4. Oversize Construction Certification: For door assemblies required to be fire rated and that exceed size limitations of labeled assemblies, signed by authorized representative of testing agency.
5. Operation and Maintenance Data: For sliding metal fire doors to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Fire-Rated Sliding Door Assemblies: Provide assemblies complying with NFPA 80 that are identical to door assemblies tested for fire-test-response characteristics according to NFPA 252 or UL 10B, and that are listed and labeled for fire ratings indicated by UL, FMG, ITS, or another testing agency acceptable to authorities having jurisdiction.
 - a. Test Pressure: Test at as close to neutral pressure as possible.
 - b. Oversize Fire-Rated Sliding Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a testing agency acceptable to authorities having jurisdiction that doors comply with all standard construction requirements of tested and labeled fire-rated door assemblies except for size.
 - c. Provide units with labels showing 250 deg F (139 deg C) **OR** 450 deg F (250 deg C) **OR** 650 deg F (361 deg C), **as directed**, temperature-rise ratings.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.



1.2 PRODUCTS

A. Materials

1. Cold-Rolled Steel Sheets: ASTM A 1008/A 1008M, Commercial Steel (CS), or Drawing Steel (DS), Type B, exposed, matte finish.
2. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B, with A60 (ZF180) **OR** A90 (ZF275), **as directed**, zinc-iron-alloy (galvannealed) coating or G90 (Z275) **OR** G60 (Z180), **as directed**, zinc coating; restricted flatness.
3. Stainless-Steel Sheets: ASTM A 240/A 240M, Type 304 **OR** 316, **as directed**; stretcher-leveled standard of flatness; No. 4 satin **OR** 6 dull, **as directed**, finish.
4. Hardware and Fasteners: Manufacturer's standard units **OR** Hot-dip galvanize per ASTM A 153/A 153M where items are used on galvanized steel exterior doors **OR** Stainless steel **OR** Stainless steel where indicated, **as directed**.

B. Sliding Metal Fire Doors

1. Overhead-Supported Doors: Provide composite **OR** hollow-metal **OR** tubular-frame, **as directed**, type construction fire door assemblies with wall-mounted overhead track support and the following fire-protection rating and panel facing sheet material and thickness:
2. Bottom-Support Doors: Provide bottom-support, tubular-frame-type construction fire door assemblies with floor track, top guides, and the following fire-protection rating, temperature-rise rating, and face sheet material and thickness:
 - a. Fire-Protection Rating: 4 hours **OR** 3 hours **OR** 1-1/2 hours **OR** 3/4 hour **OR** As indicated, **as directed**.
 - b. Panel Facing:
 - 1) Steel: 0.033-inch (0.8-mm) **OR** 0.043-inch (1.1-mm) **OR** 0.053-inch (1.35-mm) **OR** 0.067-inch (1.7-mm), **as directed**, minimum thickness.
 - 2) Metallic-Coated Steel: 0.040-inch (1.0-mm) **OR** 0.052-inch (1.3-mm) **OR** 0.064-inch (1.6-mm) **OR** 0.079-inch (2.0-mm), **as directed**, nominal thickness.
 - 3) Stainless Steel: 0.038-inch (0.96-mm) **OR** 0.050-inch (1.3-mm) **OR** 0.062-inch (1.57-mm) **OR** 0.078-inch (1.98-mm), **as directed**, nominal thickness.
3. Operating Hardware: Manufacturer's standard, labeled, automatic-closing-type, sliding fire door assemblies complete with track, adjustable roller guides, binders, floor stops, cables, sheaves, counterweights, and fusible links. Furnish necessary hangers, fittings, and fasteners required for attaching hardware to door and for door sliding operation, including latch or handle for manual operation. Provide hot-dip galvanized steel **OR** electrogalvanized steel **OR** factory-prime-painted steel **OR** stainless-steel, **as directed**, hardware.
4. Weight Boxes: 0.064-inch- (1.6-mm-) thick, metallic-coated steel counterweight boxes or guards; size as required for counterweights and clearance.
5. Crush Plates: 3/16-inch-thick by 6-inch-wide (4.8-mm-thick by 150-mm-wide), continuous steel plates on hollow concrete masonry walls.
6. Track Hood: Formed, metallic-coated steel sheet **OR** stainless-steel, **as directed**; size as required for clearance and to protect tracks on exterior installations.
7. Weather Stripping: UL-classified, brush-style weather stripping with attachments for mounting at head, jambs, and bottom surface of door.
8. Motorized Operator: UL-approved, high-starting torque, reversing motor and adjustable speed operator with thermal-overload protection. Include fusible-link release to disengage operator and to allow door to close automatically.
 - a. Design operator for current characteristics of electrical service supplied. Provide UL-listed, 1/2-hp, 208- to 230-V ac, single-phase **OR** 208-V ac, 3-phase **OR** 220-V ac, 3-phase **OR** 480-V ac, 3-phase, **as directed**, 60-cycle motor with NEMA 250, Type 1 enclosure and 24-V ac, secondary control voltage.
 - b. Equip door for completely automatic operation with clutch, speed reducer, brake, limit switches, electric reverse edge, brackets, bolts, and release for manual operation. Control equipment includes two pull cords **OR** two 3-button control stations with push buttons labeled "OPEN," "CLOSE," and "STOP" **OR** two motion detectors **OR** two loop detectors



OR two photoelectric obstruction detectors **OR** time delay for closing, **as directed**, and electric interlock for pass door.

9. Interconnecting Device: Device for connecting fusible links for doors on both sides of wall.
10. Door Release Devices: Electromagnetic release devices compatible with smoke detectors or building's fire alarm system.
11. Fire Detection: Provide early warning, photoelectric smoke detectors or ionization detectors to be coupled to electromagnetic door release devices.
12. Pass Door: UL-listed swing door and frame.
13. Pass Door Hardware: Factory installed with one and one-half pairs of mortise spring hinges **OR** butt hinges and closer, **as directed**, and mortise latchset **OR** mortise lock **OR** exit device **OR** panic device, **as directed**.
 - a. Provide hardware complying with Division 08 Section "Door Hardware".
14. Vision Panels: Factory fabricated in door with integral removable glass stops. Provide UL-approved, wired glass panels or other fire-resistive glazing product acceptable to authorities having jurisdiction; do not exceed area allowed for door rating.

C. Fabrication

1. Composite-Type Doors: Fabricate in modular panels. Bond face materials to both sides of core and reinforce perimeter with minimum 0.043-inch- (1.1-mm-) thick, internal steel channel. Encase panel edges with minimum 0.067-inch- (1.7-mm-) thick, steel channel. Back joints in face sheets with minimum 0.043-inch- (1.1-mm-) thick, steel H column. Connect panels with H column and cover plate. Attach armor edges and astragals to doors.
2. Hollow-Metal Doors: Bond face materials to both sides of core and reinforce perimeter with minimum 0.043-inch- (1.1-mm-) thick, internal steel channel. Back joints in face sheets with minimum 0.043-inch- (1.1-mm-) thick, steel H column. Weld and fill joints and grind exposed welds smooth. Attach armor edges and astragals to doors.
3. Tubular-Frame Doors: Fabricate perimeter frame and internal stiffeners of minimum 0.043-inch- (1.1-mm-) thick steel tubes. Miter corner joints in frame and weld frame and stiffener joints. Locate joints in face sheets over stiffeners. Weld and fill joints and grind exposed welds smooth. Attach armor edges and astragals to doors.
4. Core Construction: Provide core materials complying with fire-protection-rating and temperature-rise requirements.
 - a. Resin-impregnated honeycomb.
 - b. Mineral-fiber board.
 - c. Urethane.
 - d. Fiberglass.
 - e. Calcium silicate
 - f. Inorganic mineral.
 - g. Manufacturer's standard.

D. Steel Finishes

1. General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Preparation for Shop Priming: After galvanizing, thoroughly clean metal of grease, dirt, oil, flux, and other foreign matter, and treat with metallic-phosphate pretreatment.
3. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface-preparation specifications and environmental exposure conditions of sliding metal fire doors:
 - a. Exteriors (SSPC Zone 1B): SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - b. Interiors (SSPC Zone 1A): SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
4. Prime Finish: Immediately after cleaning and pretreating, apply manufacturer's standard rust-inhibiting primer on **OR** zinc-rich primer on metallic-coated, **as directed**, steel doors for field painting.
5. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat. Comply with



paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).

- a. Color and Gloss: As selected from manufacturer's full range.

1.3 EXECUTION

A. Installation

1. Install sliding metal fire doors according to NFPA 80 and manufacturer's written instructions for type of door operation indicated and fire-protection rating required.
 - a. Interface fire-detection devices with building's fire alarm system.
2. Drill necessary holes cleanly, with no broken areas or spalls, for installation of fasteners in concrete or masonry. Remove and replace damaged masonry as directed.

B. Adjusting And Cleaning

1. Operate sliding metal fire doors on completion of installation to ensure satisfactory operation. Check moving parts for proper alignment and lubrication. Make adjustments for smooth, easy operation.
 - a. Test door closing when activated by detector or alarm-connected, fire-release system. Reset door-closing mechanism after successful test.
2. Clean surfaces and refinish abraded or damaged surfaces to match factory finish.

END OF SECTION 08 11 73 00



SECTION 08 12 13 13 - STEEL DOORS AND FRAMES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for steel doors and frames. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Standard hollow metal doors and frames.
 - b. Custom hollow metal doors and frames.

C. Definitions

1. Minimum Thickness: Minimum thickness of base metal without coatings.
2. Standard Hollow Metal Work: Hollow metal work fabricated according to ANSI/SDI A250.8.
3. Custom Hollow Metal Work: Hollow metal work fabricated according to ANSI/NAAMM-HMMA 861.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include elevations, door edge details, frame profiles, metal thicknesses, preparations for hardware, and other details.
3. Samples for Verification: For each type of exposed finish required.
4. Schedule: Prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings.
5. Oversize Construction Certification: For assemblies required to be fire rated and exceeding limitations of labeled assemblies.
6. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each type of hollow metal door and frame assembly.

E. Quality Assurance

1. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure **OR** as close to neutral pressure as possible, **as directed**, according to NFPA 252 **OR** IBC Standard 716.5, **as directed**, or UL 10B **OR** UL 10C, **as directed**.
 - a. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
 - b. Temperature-Rise Limit: Where indicated **OR** At vertical exit enclosures and exit passageways, **as directed**, provide doors that have a maximum transmitted temperature end point of not more than 450 deg F (250 deg C) above ambient after 30 minutes of standard fire-test exposure.
2. Fire-Rated, Borrowed-Light Frame Assemblies: Assemblies complying with NFPA 80 that are listed and labeled, by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9 **OR** IBC Standard 716.5, **as directed**. Label each individual glazed lite.
3. Smoke-Control Door Assemblies: Comply with NFPA 105 or UL 1784 **OR** IBC Standard 716.5, **as directed**.

F. Delivery, Storage, And Handling



1. Deliver hollow metal work palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
 - a. Provide additional protection to prevent damage to finish of factory-finished units.
2. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.
3. Store hollow metal work under cover at Project site. Place in stacks of five units maximum in a vertical position with heads up, spaced by blocking, on minimum 4-inch- (102-mm-) high wood blocking. Do not store in a manner that traps excess humidity.
 - a. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

1.2 PRODUCTS

A. Materials

1. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.
2. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.
3. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum A40 (ZF120) **OR** G60 (Z180) or A60 (ZF180), **as directed**, metallic coating.
4. Frame Anchors: ASTM A 591/A 591M, Commercial Steel (CS), 40Z (12G) coating designation; mill phosphatized.
 - a. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.
5. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.
6. Powder-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow metal frames of type indicated.
7. Grout: ASTM C 476, except with a maximum slump of 4 inches (102 mm), as measured according to ASTM C 143/C 143M.
8. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool with 6- to 12-lb/cu. ft. (96- to 192-kg/cu. m) density; with maximum flame-spread and smoke-development indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.
9. Glazing: Comply with requirements in Division 08 Section "Glazing".
10. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil (0.4-mm) dry film thickness per coat.

B. Standard Hollow Metal Doors

1. General: Provide doors of design indicated, not less than thickness indicated; fabricated with smooth surfaces, without visible joints or seams on exposed faces unless otherwise indicated. Comply with ANSI/SDI A250.8.
 - a. Design: Flush panel **OR** Embossed panel **OR** As indicated, **as directed**.
 - b. Core Construction: Manufacturer's standard kraft-paper honeycomb, polystyrene, polyurethane, polyisocyanurate, mineral-board, or vertical steel-stiffener core.
 - 1) Fire Door Core: As required to provide fire-protection and temperature-rise ratings indicated.
 - 2) Thermal-Rated (Insulated) Doors: Where indicated, provide doors fabricated with thermal-resistance value (R-value) of not less than 4.0 deg F x h x sq. ft./Btu (0.704 K x sq. m/W) **OR** 6.0 deg F x h x sq. ft./Btu (1.057 K x sq. m/W) **OR** 12.3 deg F x h x sq. ft./Btu (2.166 K x sq. m/W), **as directed**, when tested according to ASTM C 1363.
 - a) Locations: Exterior doors and interior doors where indicated, **as directed**.



- c. Vertical Edges for Single-Acting Doors: Beveled edge **OR** Square edge **OR** Manufacturer's standard, **as directed**.
 - 1) Beveled Edge: 1/8 inch in 2 inches (3 mm in 50 mm).
 - d. Vertical Edges for Double-Acting Doors: Round vertical edges with 2-1/8-inch (54-mm) radius.
 - e. Top and Bottom Edges: Closed with flush or inverted 0.042-inch- (1.0-mm-) thick, end closures or channels of same material as face sheets.
 - f. Tolerances: Comply with SDI 117, "Manufacturing Tolerances for Standard Steel Doors and Frames."
2. Exterior Doors: Face sheets fabricated from metallic-coated steel sheet. Provide doors complying with ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level:
 - a. Level 1 and Physical Performance Level C (Standard Duty), Model 1 (Full Flush) **OR** Model 2 (Seamless), **as directed**.
 - 1) Width: 1-3/4 inches (44.5 mm) **OR** 1-3/8 inches (34.9 mm) **OR** As indicated on Drawings, **as directed**.
 - b. Level 2 and Physical Performance Level B (Heavy Duty), Model 1 (Full Flush) **OR** Model 2 (Seamless), **as directed**.
 - c. Level 3 and Physical Performance Level A (Extra Heavy Duty), Model 1 (Full Flush) **OR** Model 2 (Seamless) **OR** Model 3 (Stile and Rail), **as directed**.
 - d. Level 4 and Physical Performance Level A (Maximum Duty), Model 1 (Full Flush) **OR** Model 2 (Seamless), **as directed**.
 3. Interior Doors: Face sheets fabricated from cold-rolled steel sheet unless metallic-coated sheet is indicated. Provide doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level:
 - a. Level 1 and Physical Performance Level C (Standard Duty), Model 1 (Full Flush) **OR** Model 2 (Seamless), **as directed**.
 - 1) Width: 1-3/4 inches (44.5 mm) **OR** 1-3/8 inches (34.9 mm) **OR** As indicated on Drawings, **as directed**.
 - b. Level 2 and Physical Performance Level B (Heavy Duty), Model 1 (Full Flush) **OR** Model 2 (Seamless), **as directed**.
 - c. Level 3 and Physical Performance Level A (Extra Heavy Duty), Model 1 (Full Flush) **OR** Model 2 (Seamless) **OR** Model 3 (Stile and Rail), **as directed**.
 - d. Level 4 and Physical Performance Level A (Maximum Duty), Model 1 (Full Flush) **OR** Model 2 (Seamless), **as directed**.
 4. Hardware Reinforcement: Fabricate according to ANSI/SDI A250.6 with reinforcing plates from same material as door face sheets.
 5. Fabricate concealed stiffeners and hardware reinforcement from either cold- or hot-rolled steel sheet.
- C. Standard Hollow Metal Frames
1. General: Comply with ANSI/SDI A250.8 and with details indicated for type and profile.
 2. Exterior Frames: Fabricated from metallic-coated steel sheet.
 - a. Fabricate frames with mitered or coped corners.
 - b. Fabricate frames as knocked down **OR** face welded **OR** full profile welded, **as directed**, unless otherwise indicated.
 - c. Frames for Level 1 Steel Doors: 0.042-inch- (1.0-mm-) thick steel sheet.
 - d. Frames for Level 2 Steel Doors: 0.053-inch- (1.3-mm-) thick steel sheet.
 - e. Frames for Level 3 Steel Doors: 0.053-inch- (1.3-mm-) thick steel sheet.
 - f. Frames for Level 4 Steel Doors: 0.067-inch- (1.7-mm-) thick steel sheet.
 3. Interior Frames: Fabricated from cold-rolled steel sheet unless metallic-coated sheet is indicated.
 - a. Fabricate frames with mitered or coped corners.
 - b. Fabricate frames as knocked down **OR** face welded **OR** full profile welded, **as directed**, unless otherwise indicated.
 - c. Fabricate knocked-down, drywall slip-on frames for in-place gypsum board partitions, **as directed**.



- d. Frames for Level 1 Steel Doors: 0.042-inch- (1.0-mm-) thick steel sheet.
 - e. Frames for Level 2 Steel Doors: 0.053-inch- (1.3-mm-) thick steel sheet.
 - f. Frames for Level 3 Steel Doors: 0.053-inch- (1.3-mm-) thick steel sheet.
 - g. Frames for Level 4 Steel Doors: 0.067-inch- (1.7-mm-) thick steel sheet.
 - h. Frames for Wood Doors: 0.042-inch- (1.0-mm-) **OR** 0.053-inch- (1.3-mm-) **OR** 0.067-inch- (1.7-mm-), **as directed**, thick steel sheet.
 - i. Frames for Borrowed Lights: 0.042-inch- (1.0-mm-) thick steel sheet **OR** 0.053-inch- (1.3-mm-) thick steel sheet **OR** 0.067-inch- (1.7-mm-) thick steel sheet **OR** Same as adjacent door frame, **as directed**.
4. Hardware Reinforcement: Fabricate according to ANSI/SDI A250.6 with reinforcement plates from same material as frames.

D. Custom Hollow Metal Doors

- 1. General: Provide doors not less than 1-3/4 inches (44.5 mm) thick, of seamless hollow construction unless otherwise indicated. Construct doors with smooth surfaces without visible joints or seams on exposed faces. Comply with ANSI/NAAMM-HMMA 861.
- 2. Exterior Door Face Sheets: Fabricated from metallic-coated steel sheet, minimum 0.053 inch (1.3 mm) thick.
- 3. Interior Door Face Sheets: Fabricated from cold-rolled steel sheet unless metallic-coated sheet is indicated, minimum 0.042 inch (1.0 mm) thick.
- 4. Core Construction: Provide thermal-resistance-rated cores for exterior doors and interior doors where indicated, **as directed**.
 - a. Steel-Stiffened Core: 0.026-inch- (0.7-mm-) thick, steel vertical stiffeners of same material as face sheets extending full-door height, with vertical webs spaced not more than 6 inches (152 mm) apart, spot welded to face sheets a maximum of 5 inches (127 mm) o.c. Spaces filled between stiffeners with glass- or mineral-fiber insulation.
 - 1) Fire Door Core: As required to provide fire-protection and temperature-rise ratings indicated.
 - 2) Thermal-Rated (Insulated) Doors: Where indicated, provide doors fabricated with thermal-resistance value (R-value) of not less than 4.0 deg F x h x sq. ft./Btu (0.704 K x sq. m/W) **OR** 6.0 deg F x h x sq. ft./Btu (1.057 K x sq. m/W), **as directed**, when tested according to ASTM C 1363.
- 5. Vertical Edges for Single-Acting Doors: Beveled 1/8 inch in 2 inches (3 mm in 50 mm).
- 6. Vertical Edges for Double-Acting Doors: Round vertical edges with 2-1/8-inch (54-mm) radius.
- 7. Top and Bottom Channels: Closed with continuous channels, minimum 0.053 inch (1.3 mm) thick, of same material as face sheets and spot welded to both face sheets.
- 8. Hardware Reinforcement: Fabricate according to ANSI/NAAMM-HMMA 861 with reinforcing plates from same material as door face sheets.

E. Custom Hollow Metal Frames

- 1. General: Fabricate frames of construction indicated. Close contact edges of corner joints tight with faces mitered and stops butted or mitered. Continuously weld faces and soffits and finish faces smooth. Comply with ANSI/NAAMM-HMMA 861.
 - a. Door Frames for Openings 48 Inches (1219 mm) Wide or Less: Fabricated from 0.053-inch- (1.3-mm-) thick steel sheet.
 - b. Door Frames for Openings More Than 48 Inches (1219 mm) Wide: Fabricated from 0.067-inch- (1.7-mm-) thick steel sheet.
 - c. Sidelight and Transom Frames: Fabricated from same thickness material as adjacent door frame.
 - d. Borrowed-Light Frames: Fabricated from 0.053-inch- (1.3-mm-) thick steel sheet.
- 2. Exterior Frames: Formed from metallic-coated steel sheet.
- 3. Interior Frames: Fabricated from cold-rolled steel sheet unless metallic-coated sheet is indicated.
- 4. Hardware Reinforcement: Fabricate according to ANSI/NAAMM-HMMA 861 with reinforcing plates from same material as frame.



5. Head Reinforcement: Provide minimum 0.093-inch- (2.3-mm-) thick, steel channel or angle stiffener for opening widths more than 48 inches (1219 mm).
- F. Frame Anchors
1. Jamb Anchors:
 - a. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.042 inch (1.0 mm) thick, with corrugated or perforated straps not less than 2 inches (50 mm) wide by 10 inches (250 mm) long; or wire anchors not less than 0.177 inch (4.5 mm) thick.
 - b. Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.042 inch (1.0 mm) thick.
 - c. Compression Type for Drywall Slip-on Frames: Adjustable compression anchors.
 - d. Postinstalled Expansion Type for In-Place Concrete or Masonry: Minimum 3/8-inch- (9.5-mm-) diameter bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.
 2. Floor Anchors: Formed from same material as frames, not less than 0.042 inch (1.0 mm) thick, and as follows:
 - a. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
 - b. Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2-inch (50-mm) height adjustment. Terminate bottom of frames at finish floor surface.
- G. Hollow Metal Panels
1. Provide hollow metal panels of same materials, construction, and finish as specified for adjoining hollow metal work.
- H. Stops And Moldings
1. Moldings for Glazed Lites in Doors: Minimum 0.032 inch (0.8 mm) thick, fabricated from same material as door face sheet in which they are installed.
 2. Fixed Frame Moldings: Formed integral with hollow metal frames, a minimum of 5/8 inch (16 mm) high unless otherwise indicated.
 3. Loose Stops for Glazed Lites in Frames: Minimum 0.032 inch (0.8 mm) thick, fabricated from same material as frames in which they are installed.
 4. Terminated Stops: Where indicated on interior door frames, terminate stops 6 inches (152 mm) above finish floor with a 45-degree **OR** 90-degree, **as directed**, angle cut, and close open end of stop with steel sheet closure. Cover opening in extension of frame with welded-steel filler plate, with welds ground smooth and flush with frame.
- I. Louvers
1. Provide louvers for interior doors, where indicated, that comply with SDI 111C, with blades or baffles formed of 0.020-inch- (0.5-mm-) thick, cold-rolled steel sheet set into 0.032-inch- (0.8-mm-) thick steel frame.
 - a. Sightproof Louver: Stationary louvers constructed with inverted V-shaped or Y-shaped blades.
 - b. Lightproof Louver: Stationary louvers constructed with baffles to prevent light from passing from one side to the other, any angle.
 - c. Fire-Rated Automatic Louvers: Louvers constructed with movable blades closed by actuating fusible link, and listed and labeled for use in fire-rated door assemblies of type and fire-resistance rating indicated by same testing and inspecting agency that established fire-resistance rating of door assembly.
- J. Accessories
1. Mullions and Transom Bars: Join to adjacent members by welding or rigid mechanical anchors.
 2. Ceiling Struts: Minimum 1/4-inch-thick by 1-inch- (6.4-mm-thick by 25.4-mm-) wide steel.
 3. Grout Guards: Formed from same material as frames, not less than 0.016 inch (0.4 mm) thick.



K. Fabrication

1. Fabricate hollow metal work to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.
2. Tolerances: Fabricate hollow metal work to tolerances indicated in SDI 117 **OR** ANSI/NAAMM-HMMA 861, **as directed**.
3. Hollow Metal Doors:
 - a. Exterior Doors: Provide weep-hole openings in bottom of exterior doors to permit moisture to escape. Seal joints in top edges of doors against water penetration.
 - b. Glazed Lites: Factory cut openings in doors.
 - c. Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch (19 mm) beyond edge of door on which astragal is mounted.
4. Hollow Metal Frames: Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.
 - a. Welded Frames: Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible.
 - b. Sidelight and Transom Bar Frames: Provide closed tubular members with no visible face seams or joints, fabricated from same material as door frame. Fasten members at crossings and to jambs by butt welding.
 - c. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 - d. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.
 - e. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
 - f. Jamb Anchors: Provide number and spacing of anchors as follows:
 - 1) Masonry Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
 - a) Two anchors per jamb up to 60 inches (1524 mm) high.
 - b) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
 - c) Four anchors per jamb from 90 to 120 inches (2286 to 3048 mm) high.
 - d) Four anchors per jamb plus 1 additional anchor per jamb for each 24 inches (610 mm) or fraction thereof above 120 inches (3048 mm) high.
 - 2) Stud-Wall Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
 - a) Three anchors per jamb up to 60 inches (1524 mm) high.
 - b) Four anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
 - c) Five anchors per jamb from 90 to 96 inches (2286 to 2438 mm) high.
 - d) Five anchors per jamb plus 1 additional anchor per jamb for each 24 inches (610 mm) or fraction thereof above 96 inches (2438 mm) high.
 - e) Two anchors per head for frames above 42 inches (1066 mm) wide and mounted in metal-stud partitions.
 - 3) Compression Type: Not less than two anchors in each jamb.
 - 4) Postinstalled Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.
 - g. Door Silencers: Except on weather-stripped doors, drill stops to receive door silencers as follows. Keep holes clear during construction.
 - 1) Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
 - 2) Double-Door Frames: Drill stop in head jamb to receive two door silencers.



5. Fabricate concealed stiffeners, edge channels, and hardware reinforcement from either cold- or hot-rolled steel sheet.
6. Hardware Preparation: Factory prepare hollow metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to the Door Hardware Schedule and templates furnished as specified in Division 08 Section "Door Hardware".
 - a. Locate hardware as indicated, or if not indicated, according to ANSI/SDI A250.8 **OR** ANSI/NAAMM-HMMA 861.
 - b. Reinforce doors and frames to receive nontemplated, mortised and surface-mounted door hardware.
 - c. Comply with applicable requirements in ANSI/SDI A250.6 and ANSI/DHI A115 Series specifications for preparation of hollow metal work for hardware.
 - d. Coordinate locations of conduit and wiring boxes for electrical connections with Division 26.
7. Stops and Moldings: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with butted or mitered hairline joints.
 - a. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow metal work.
 - b. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
 - c. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
 - d. Provide loose stops and moldings on inside of hollow metal work.
 - e. Coordinate rabbet width between fixed and removable stops with type of glazing and type of installation indicated.

L. Steel Finishes

1. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
 - a. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.
2. Factory-Applied Paint Finish: Manufacturer's standard, complying with ANSI/SDI A250.3 for performance and acceptance criteria.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.

1.3 EXECUTION

A. Installation

1. General: Install hollow metal work plumb, rigid, properly aligned, and securely fastened in place; comply with Drawings and manufacturer's written instructions.
2. Hollow Metal Frames: Install hollow metal frames of size and profile indicated. Comply with ANSI/SDI A250.11 **OR** HMMA 840, **as directed**.
 - a. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
 - 1) At fire-protection-rated openings, install frames according to NFPA 80.
 - 2) Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
 - 3) Install frames with removable glazing stops located on secure side of opening.
 - 4) Install door silencers in frames before grouting.
 - 5) Remove temporary braces necessary for installation only after frames have been properly set and secured.
 - 6) Check plumbness, squareness, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.



- 7) Field apply bituminous coating to backs of frames that are filled with grout containing antifreezing agents.
- b. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.
 - 1) Floor anchors may be set with powder-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.
- c. Metal-Stud Partitions: Solidly pack mineral-fiber insulation behind frames.
- d. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout.
- e. Concrete Walls: Solidly fill space between frames and concrete with grout. Take precautions, including bracing frames, to ensure that frames are not deformed or damaged by grout forces.
- f. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
- g. In-Place Gypsum Board Partitions: Secure frames in place with postinstalled expansion anchors through floor anchors at each jamb. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
- h. Ceiling Struts: Extend struts vertically from top of frame at each jamb to overhead structural supports or substrates above frame unless frame is anchored to masonry or to other structural support at each jamb. Bend top of struts to provide flush contact for securing to supporting construction. Provide adjustable wedged or bolted anchorage to frame jamb members.
- i. Installation Tolerances: Adjust hollow metal door frames for squareness, alignment, twist, and plumb to the following tolerances:
 - 1) Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - 2) Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - 3) Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - 4) Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs at floor.
3. Hollow Metal Doors: Fit hollow metal doors accurately in frames, within clearances specified below. Shim as necessary.
 - a. Non-Fire-Rated Standard Steel Doors:
 - 1) Jambs and Head: 1/8 inch (3 mm) plus or minus 1/16 inch (1.6 mm).
 - 2) Between Edges of Pairs of Doors: 1/8 inch (3 mm) plus or minus 1/16 inch (1.6 mm).
 - 3) Between Bottom of Door and Top of Threshold: Maximum 3/8 inch (9.5 mm).
 - 4) Between Bottom of Door and Top of Finish Floor (No Threshold): Maximum 3/4 inch (19 mm).
 - b. Fire-Rated Doors: Install doors with clearances according to NFPA 80.
 - c. Smoke-Control Doors: Install doors according to NFPA 105 **OR** IBC Standard 716.5, **as directed**.
4. Glazing: Comply with installation requirements in Division 08 Section "Glazing" and with hollow metal manufacturer's written instructions.
 - a. Secure stops with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c. and not more than 2 inches (50 mm) o.c. from each corner.

B. Adjusting And Cleaning

1. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including hollow metal work that is warped, bowed, or otherwise unacceptable.
2. Remove grout and other bonding material from hollow metal work immediately after installation.



3. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.
4. Metallic-Coated Surfaces: Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.

END OF SECTION 08 12 13 13



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**SECTION 08 12 13 13a - STEEL ENTRY DOORS**

1.1 DESCRIPTION OF WORK

- A. This specification covers the furnishing and installation of materials for steel entry doors. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 GENERAL

A. Definitions

1. Supply and Delivery Only: Include supply and delivery to site(s) FOB destination freight prepaid. Unless otherwise specified or scheduled, unloading and handling at site is by Owner.

B. System Description

1. Door Assemblies: Include doors, frames, and hardware
 - a. Provide with fire rating as indicated or specified.
 - b. Door and Frame Assemblies: Comply with dimensional requirements of SDI 100.
 - c. Exterior Doors: Sealed, weatherstripped and provided with thresholds.
2. Insulated Entry Door System (Assembly) Performance Requirements:
 - a. Mechanical Properties: Comply with ANSI/SDI A151.1, Level C (250,000 cycles).
 - b. Air Infiltration: ANSI/ISDSI 101 and ASTM E 283, not exceed 0.029 cu m/s/mm (0.20 CFM/foot) of crack length at test pressure of 75 Pa (1.57 PSF).
 - c. Water Resistance: ANSI/ISDSI 104 and ASTM E 331, no leakage at test pressure of 75 Pa (1.57 PSF).
 - d. Thermal Performance: ANSI/ISDSI 107, minimum acceptance criteria as defined in standard except U-Value of 1.42 W/sq. m C (0.25 BTU/HR/SF degree F).
 - e. Acoustical Performance: ANSI/ISDSI 103, Minimum Sound Transmission Class (STC) of 24.
3. Hollow Core Heavy Duty System (Assembly) Performance Requirements:
 - a. Mechanical Properties: Comply with ANSI/SDI A151.1, Level B (500,000 cycles).
 - b. Air Infiltration: SDI 116 and ASTM E 283, not exceed 0.072 cu m/s/mm (0.50 CFM/foot) of crack length at test pressure of 75 Pa (1.57 PSF).
 - c. Water Resistance: ASTM E 331, no leakage at test pressure of 75 Pa (1.57 PSF).
4. Insulated Heavy Duty Door System (Assembly) Performance Requirements:
 - a. Mechanical Properties: Comply with ANSI/SDI A151.1, Level B (500,000 cycles).
 - b. Air Infiltration: ANSI/ISDSI 101/ASTM E 283, not exceed 0.029 cu m/s/mm (0.20 CFM/foot) of crack length at test pressure of 75 Pa (1.57 PSF).
 - c. Water Resistance: ANSI/ISDSI 104 and ASTM E 331, no leakage at test pressure of 75 Pa (1.57 PSF).
 - d. Thermal Performance: ANSI/ISDSI 107, minimum acceptance criteria as defined in standard except U-Value of 1.42 W/sq. m C (0.25 BTU/HR SF degree F) is required.
 - e. Acoustical Performance: ANSI/ISDSI 103, Minimum Sound Transmission Class (STC) of 24.
5. Security Door System (Assembly) Performance Requirements:
 - a. Mechanical Properties: Comply with ANSI/SDI A151.1, Level A (1,000,000 cycles).
 - b. Air Infiltration: SDI 116 and ASTM E 283, not exceed 0.72 cu m/s/mm (0.50 CFM/foot) of crack length at test pressure of 75 Pa (1.57 PSF).
 - c. Water Resistance: ASTM E 331, no leakage at test pressure of 75 Pa (1.57 PSF).
 - d. Forced Entry: ASTM F 476, Grade 40.

C. Submittals



1. Product Data.
2. Shop Drawings:
 - a. Include details showing recommendations for installation of doors. Include size of fasteners, spacing, minimum penetration of fasteners into load-bearing material and maximum clearance between frame and rough opening.
3. Samples: Submit full set of finish color samples for color selection.
 - a. For Supply and Deliver Only Contract: Submit one full size sample of each type of steel entry door with specified finish for acceptance.
4. Quality Assurance/Control Submittals:
 - a. Test Reports: Results of testing by accredited independent laboratory demonstrating compliance of door systems with specified performance requirements.
 - 1) Indicate that tests were performed in accordance with standard referenced.
 - 2) Weak Link Testing. Submit reports for each model door in its weakest condition in order to quality superior variations of same model.
 - b. Certificates: Manufacturer's written certification that door systems meet or exceed specified requirements.
 - c. Manufacturer's installation instructions.
5. Closeout Submittals:
 - a. Operation and maintenance data.
 - b. Special warranty.

D. Quality Assurance

1. Regulatory Requirements: Comply with following:
 - a. Fire Rated Label: Determined using ASTM E 152 and bear label of UL or other recognized fire rating program.
 - b. Glazing Materials: Comply with CPSC 16 CFR 1201 or ANSI Z97.1.
 - c. Accessibility:
 - 1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
 - a) Uniform Federal Accessibility Standards (UFAS).
 - 2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
 - 3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
 - 4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
2. Certifications:
 - a. Door Systems: Meet or exceed performance requirements and other requirements specified and be labeled under HUD accepted Materials Releases.
 - b. Some Material Releases (MR) do not include all of performance requirements specified. Therefore, additional testing, certification may be required for submission with HUD Material Releases.
 - 1) Material Releases are part of HUD Technical Suitability of Building Products Program. Contact: Department of Housing and Urban Development, Manufactured Housing and Construction Standards, 451 7th Street, SW, Washington, D.C. 20410-8000.
3. Mock-ups: Install one mock-up of each type of entry door system including doors, frames, hardware, weatherstripping, thresholds, and accessories.
 - a. Location: As directed.
 - b. Approved Mock-up: Standard for rest of work.
 - c. Approved Mock-up: May remain part of completed project.

E. Delivery, Storage, And Handling

1. Packing, Shipping, Handling, and Unloading: Pack materials at manufacturing plant to prevent damage during shipping.
2. Acceptance at Site: Inspect door systems upon delivery. Replace damaged or defective materials before installation.



- F. Project Conditions
 - 1. Field Measurements: Field measure openings for door systems before start of fabrication.
- G. Scheduling And Sequencing
 - 1. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.
- H. Warranty
 - 1. Special Warranty: Provide one year written warranty covering materials and installation for steel entry doors.
 - a. Warranty: Include coverage of hardware.
 - 1) Glazing not included.
 - 2) Defects resulting from vandalism not included.
 - b. For Supply and Delivery Only Contract:
 - 1) Contractor: Agrees to supply and deliver to Owner, free of charge, any required replacement parts that can be readily installed by Owner without special tools.
 - 2) Contractor: Agrees to supply and deliver free of charge, complete replacement door, when defective part or parts cannot be installed without use of special tools.
 - c. For Supply and Install Contract:
 - 1) Contractor: Agrees to supply and install, free of charge, any required replacement parts or complete replacement door.

1.3 PRODUCTS

- A. Doors
 - 1. Doors: Consist of two steel face sheets, wood or steel stiles and rails with full support lock reinforcement.
 - a. Thickness: Nominal 44.4 mm (1-3/4 inch)
 - b. Steel Face: Minimum of 24 gage (0.57 mm) galvanized and bonderized steel.
 - c. Wood Stiles and Rails: Kiln dried clear Ponderosa Pine, Douglas Fir, or equal.
 - d. Embossed Designs: Emboss 24 gage (0.57 mm) doors and 18 gage (1.07 mm) doors to achieve scheduled or indicated designs.
 - 2. Hollow Core Heavy Duty Doors: Fabricated of 18 gage (1.07 mm) minimum steel face sheets, stiles, top and bottom closures.
 - a. Comply with Performance Requirements in this Section.
 - b. Fire Rating: When required, provide B Label, 1-1/2 hour fire rating.
 - 3. Insulated Heavy Duty Doors: Fabricated of 18 gage (1.07 mm) minimum steel face sheets, stiles, top and bottom closures.
 - a. Comply with Performance Requirements in this Section.
 - b. Fire Rating: When required, provide B Label, 1-1/2 hour fire rating.
 - 4. Security Doors: Comply with SDI 100, Models 1, 1A, 2, or 2A, minimum 16 gage (1.35 mm) steel face sheets .
 - a. Comply with Performance Requirements in this Section.
 - b. Fire Rating: When required, provide B Label, 1-1/2 hour fire rating.
 - 5. Hardware Preparation:
 - a. Door System: Facilitate installation of standard cylindrical and/or full mortise locks with multiple point throw if specified.
 - b. 24 gage (0.57 mm) Doors: Prepare to receive three 102 mm (4 inch) full mortise or bun hinges flush with edge of door.
 - c. 18 Gage (1.07 mm) and Heavier Doors: Prepare to receive three 114 mm (4-1/2 inch) full mortise or butt hinges flush with edge of door.
 - 6. Insulated Doors: Solid foam core of polyurethane, or polystyrene.
 - a. Core: Fully adhere to steel face sheets, stiles, rails and lock block and completely fill void.
- B. Frames
 - 1. Wood Frames: Kiln dried Ponderosa Pine, toxic treated, and primed.



2. Steel Frames and/or Adapter Frames: Minimum of 18 gage (1.07 mm) galvanized bonderized steel, pre-drilled and reinforced for hinges as required.
 - a. Shape of Frame: Generally L-shaped.
3. Hollow Core Heavy Duty Door Frames: Fabricated of 16 gage (1.35 mm) minimum thickness.
 - a. When required, provide B Label, 1-1/2 hour fire rating.
4. Insulated Heavy Duty Door Frames: Fabricated of 16 gage (1.35 mm) minimum thickness.
 - a. When required, provide B Label, 1-1/2 hour fire rating.
5. Security Door Frames: Comply with SDI 100, minimum of 14 gage (1.70 mm) galvanized bonderized steel, pre-drilled and reinforced for hinges as required.
 - a. When required, provide B Label, 1-1/2 hour fire rating.
 - b. Comply with Performance Requirements in this Section.
6. Frames: Weatherstripped at head, jambs and threshold.

C. Hardware

1. General: Comply with ANSI/BHMA A156.1 and applicable accessibility regulatory requirements and perform functions for which it was intended.
2. Butts and Hinges: ANSI/BHMA A156.1, as scheduled.
 - a. Install non-rising pins (NRP) on out-swing doors.
 - b. Self Closing: ANSI/BHMA A156.17.
 - c. Security Door Comply with Performance Requirements in this Section.
3. Fire Rate Doors Hardware: Comply with NFPA 80.
 - a. Exit Doors: Comply with NFPA 101 (Life Safety Code) for exit doors, as well as other requirements specified.
 - b. Labeling and Listing: Listed in UL Building Materials Directory.
 - 1) In Lieu of UL Labeling and Listing: Test reports from nationally recognized testing agency showing that hardware has been tested in accordance with UL test methods and conforms to NFPA requirements.
 - c. Install minimum latch throw as specified on label of individual door.
 - d. Provide hardware listed by UL, except where heavier materials, larger sizes or higher grades are specified.
 - e. Closers: ANSI/BHMA A156.4.
4. Lock Sets: As scheduled. Comply with following standards:
 - a. Bored and Preassembled Locks and Latches: ANSI/BHMA A156.2, Grade 2.
 - b. Dead Bolt: ANSI/BHMA A156.5.
 - c. Mortise Locks and Latches: ANSI/BHMA A156.13, Grade 1 or Security Grade, single or multiple throw.
 - d. Interconnected Deadlock and Passage Set: ANSI/BHMA A156.12, Grade 2.
 - e. Cylindrical Lock: Grade 2, cylindrical deadbolt lock/passage set combination.
 - f. Security Door Locksets: ANSI/BHMA A156.13 Security Grade or UL 437 Key locks.
 - 1) Comply with Performance Requirements in this Section.
 - g. Keys: Provide two keys for each lock provided. Provide master keying and keying alike on any locks as directed at no additional charge.
 - h. Locks: Provide with interchangeable cores.
5. Door Viewers: ANSI/BHMA A156.16.

D. Accessories

1. Glazing Materials: Comply with CPSC 16 CFR 1201 or ANSI Z97.1.
 - a. Glass: ASTM C 1036, Type 1, Class 1, Glazing B Quality.
 - 1) Fire Rated Doors: ASTM C 1036, Type 11, Class 1, Glazing Quality, wired glass.
 - b. Tempered Glass: ASTM C 1048, Kind FT. Condition A, Type 1, Class 1, Glazing B Quality.
 - c. Plastic: Extruded polycarbonate clear sheets, minimum 3 mm (0.118 inch) thick with following characteristics:
 - 1) Impact Resistance: ASTM D 256, Method A, 12-18 foot-pound per inch.
 - 2) Elongation/Modulus of Elasticity: ASTM D 638, 110 percent maximum/340,000 PSI.
 - 3) Heat Deflection: ASTM D 648, 132.2 degrees C (270 degrees F) at 264 PSI.



- 4) Abrasion Resistance: Coated on both surfaces to produce abrasion resistance of 3-19 percent maximum haze increase for 500 revolutions of CS-1 OF wheel per ASTM D 1044.
 - d. Insulating Glass Units: HUD UM 82 and ASTM E 774, Class C.
 - 1) Provide insulating glass units in insulated doors and insulated heavy duty doors.
 - e. Glass Thickness: In accordance with AAMA 1002.10 Appendix, minimum 5 mm (3/16 inch).
 - 1) Design Wind Pressures: Determined in accordance with applicable codes and regulations.
 - f. Glass: Labeled to show name of manufacturer and type.
2. Joint Sealants:
- a. Exterior Joint Sealant: AAMA 800, Type 808.3 Exterior Perimeter Sealing Compound.
 - b. Back-up Material: Standard preformed and pre-compressed foam material, round rod or semi-circular type, permanently elastic, mildew resistant, nonmigratory, nonstaining, and compatible with joint substrates and with sealant.
 - 1) Materials impregnated with oil, solvents, or bituminous materials not allowed.
 - 2) Provide type as recommended by sealant manufacturer for particular installation.
 - 3) Material: Neoprene, butyl, polyurethane, vinyl, or polyethylene rod.
 - c. Interior Joint Sealant: ASTM C 834, latex acrylic.
3. Weatherstripping and Thresholds: Comply with FS 00-A-200-9D, Alloy 6063-T-5; ASTM D 2287, Grade as required; MIL-S-6855, Class 11, Grade 40 (Solid neoprene); and MIL-R-6130C, Type 11, Grade C (Sponge neoprene).
- a. Weatherstripping for Doors and Frames: Adjustable types with replaceable contact stops. Types are listed below:
 - 1) Type A1 (for bottom of door with threshold greater than 6 mm (1/4 inch)): Solid neoprene or vinyl strips mounted in extruded aluminum retainers.
 - 2) Type B (for bottom of door with thresholds less than 6 mm (1/4 inch) in height): Curved vinyl strips with extruded aluminum retainers.
 - 3) Type C (for door frame heads and jambs): Extruded aluminum retainer with extruded solid vinyl insert.
 - 4) Type D1 (for door frame heads and jambs): Closed cell sponge neoprene or vinyl strip with leveled edge mounted in extruded aluminum retainer.
 - b. Rain Drips: Extruded aluminum with sufficient projection.
 - c. Fasteners: Cad plated steel, brass plated steel, black oxide plated steel, or stainless steel.
 - 1) Threshold to Concrete: Provide lead expansion shields.
 - 2) Exposed Finish: Match finish of weatherstrip.
- E. Finishes
1. Entry Door System: Clean and free from serious surface blemishes.
 - a. Exposed Surfaces: ASTM A 525 hot dipped galvanized, minimum A40 (or G60) Electrolytic Class B coating weight.
 - b. Primer: Factory final finished including primer meeting performance requirements of ANSI A224.1.
 - c. Finish Coat: One of the following as specified or scheduled:
 - 1) Factory Finished: Electrostatically factory applied baked on enamel finish.
 - a) Color: As selected from manufacturers' list of colors.
 - 2) Field painted under Division 9 Section "Painting."
- F. Source Quality Control
1. Testing: Performed by accredited independent testing laboratory.
 2. Shop Tests:
 - a. Mechanical Properties Tests: ANSI/SDI A151.1, perform on lightest gage frame and leaf.
 - 1) Security Doors: ASTM F 476.
 - 2) Doors with Glass Lites: Mechanical test not required.
 - b. Air Infiltration and Water Resistance Tests: Perform on door with largest glass lite. Retest variations in frame to leaf sealing system.
 - 1) Air Infiltration Tests: ANSI/ISDSI 101, SDI 116, and ASTM E 283.
 - 2) Water Resistance Tests: ANSI/ISDSI 104 and ASTM E 331.



- c. Thermal Performance Tests: Perform on heaviest gage frame and leaf with largest area of glass. Retest variation in thermal design aspects of door such as different insulation, type of thermal break, or type of frame.
 - 1) Thermal Performance Tests: ANSI/ISDSI 107 and SDI 113.
- d. Test Sample Size for Door System: Minimum 914 mm (36 inches) by 1 727 mm (68 inches), complete with hardware and subframe.

1.4 EXECUTION

A. Examination

1. Site Verification of Conditions:
 - a. Field Measurements: Verify field measurements are as indicated on Shop Drawings.
 - b. Existing Conditions: Examine openings before beginning installation.
 - c. Do not proceed with installation until conditions are satisfactory.

B. Preparation

1. Protection: Protect adjacent elements from damage and disfiguration in accordance with Detailed Scope of Work.
 - a. Contractor: Responsible for damage to grounds, plantings, buildings and any other facilities or property caused by construction operations.
 - b. Adequately enclose and protect against weather any interior space where installation is incomplete at end of working day.
 - c. Repair or replace damaged elements in accordance with Detailed Scope of Work.
2. Existing Entry Doors: Remove existing entry doors and debris from site in accordance with Detailed Scope of Work.
3. Prepare existing openings in accordance with ANSI/ISDSI 102, SDI 105, ASTM E 737, manufacturer's recommendations, and approved Shop Drawings.

C. Installation

1. General: Install in accordance with ANSI/ISDSI 102, SDI 105, ASTM E 737, manufacturer's recommendations, and approved Shop Drawings.
 - a. Install doors and frames securely, water tight, straight, plumb and level without distortion.
2. Weatherstripping and Thresholds: Accurately cut, fit, align, and secure to maintain weatherproof seal without hampering operation of door.
 - a. Rain Drips: Install on door heads which are not protected by canopy or soffit.
 - b. Secure thresholds to concrete with stainless screws or equal and lead expansion shields.
 - c. Blocking: Provide as necessary to secure hardware. Prime cut wood surfaces with wood sealer before weatherstripping is installed.
3. Joint Sealants: Apply in accordance with manufacturers recommendations.
 - a. Surfaces to be Sealed: Clean, dry and free of any foreign matter that would degrade adhesion. Remove existing caulking and joint sealants from areas to receive new joint sealant.
 - b. Prime cleaned surfaces in accordance with sealant manufacturer's recommendations.
 - c. Protect surfaces adjacent to joints by masking tape before applying sealant. Remove tape upon finishing sealing work.
 - d. Seal door frames and thresholds where joining other materials on exterior and interior with joint sealant to accomplish weather-tight installation.
 - e. Maximum Width of Sealed Joint: 13 mm (1/2 inch).

D. Adjusting And Cleaning

1. Adjusting: At completion of job, check, adjust, and lubricate hardware as required and leave doors and hardware in proper operating condition.
2. Cleaning: Comply with requirements of Detailed Scope of Work.



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- a. Clean doors, after installation is completed, to remove foreign matter and surface blemishes.
 - b. Scratched or Abraded Surfaces: Touch-up with rust inhibitor primer and enamel paint compatible with factory finish.

E. Protection

1. Installed Work: Protect doors from damage after installation.

END OF SECTION 08 12 13 13a



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SECTION 08 12 13 13b - STAINLESS STEEL DOORS AND FRAMES

1.1 GENERAL

A. Description

1. This specification covers the furnishing and installation of stainless steel doors and frames. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Stainless-steel, hollow-metal doors and panels.
 - b. Stainless-steel, hollow-metal frames.

C. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, core descriptions, fire-resistance rating, temperature-rise ratings, and finishes.
2. Shop Drawings: Include the following:
 - a. Elevations of each door design.
 - b. Details of doors, including vertical and horizontal edge details and metal thicknesses.
 - c. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
 - d. Locations of reinforcement and preparations for hardware.
 - e. Details of each different wall opening condition.
 - f. Details of anchorages, joints, field splices, and connections.
 - g. Details of accessories.
 - h. Details of moldings, removable stops, and glazing.
 - i. Details of conduit and preparations for power, signal, and control systems.
3. Samples:
 - a. Finishes: For each type of exposed finish required, prepared on Samples of not less than 3 by 5 inches (75 by 125 mm).
 - b. Doors: Include section of vertical-edge, top, and bottom construction; core construction; glazing; and hinge and other applied hardware reinforcement.
 - c. Frames: Show profile, corner joint, floor and wall anchors, and silencers. Include separate section showing fixed hollow-metal panels and glazing if applicable.
4. Schedule: Provide a schedule of stainless-steel, hollow-metal work prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with a door hardware schedule.
5. Oversize Construction Certification: For assemblies required to be fire rated and exceeding limitations of labeled assemblies.
6. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each type of stainless-steel, hollow-metal door and frame assembly.

D. Quality Assurance

1. Source Limitations: Obtain stainless-steel, hollow-metal work from single source from single manufacturer.
2. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C.
 - a. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
 - b. Temperature-Rise Limit: Where indicated **OR** At vertical exit enclosures and exit passageways, **as directed**, provide doors that have a maximum transmitted temperature



end point of not more than 450 deg F (250 deg C) above ambient after 30 minutes of standard fire-test exposure.

3. Smoke- and Draft-Control Door Assemblies: Where indicated **OR** At corridors, smoke barriers, and smoke partitions, **as directed**, provide assemblies tested according to UL 1784 and installed in compliance with NFPA 105.
 - a. Air Leakage Rate: Maximum air leakage of 0.3 cfm/sq. ft. (3 cu. m per minute/sq. m) at the tested pressure differential of 0.3-inch wg (75 Pa) of water.
4. Fire-Rated, Borrowed-Light Frame Assemblies: Assemblies that are listed and labeled, by a testing agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9. Label each individual glazed lite. Install in compliance with NFPA 80.
5. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling

1. Deliver doors and frames palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
2. Shipping Spreaders: Deliver welded frames with two removable spreader bars across bottom of frames, tack welded or mechanically attached to jambs and mullions.
3. Store doors and frames under cover at Project site. Place units in a vertical position with heads up, spaced by blocking, on minimum 4-inch- (100-mm-) high wood blocking. Avoid using nonvented plastic or canvas shelters that could create a humidity chamber.
 - a. If wrappers on doors become wet, remove cartons immediately. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

F. Project Conditions

1. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

G. Coordination

1. Coordinate installation of anchorages for stainless-steel frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

1.2 PRODUCTS

A. Stainless-Steel Doors

1. Description: Stainless-steel doors, not less than 1-3/4 inches (44 mm) thick, of seamed **OR** seamless, **as directed**, hollow-metal construction. Construct doors with smooth, flush surfaces without visible joints or seams on faces.
 - a. Face Sheets: Fabricate from 0.050-inch- (1.27-mm-) **OR** 0.062-inch- (1.59-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick, stainless-steel sheet.
 - b. Core Construction: Fabricate doors with core indicated.
 - 1) Welded Steel-Stiffened Core: 0.031-inch- (0.79-mm-) thick, stainless-steel **OR** 0.030-inch- (0.76-mm-) nominal thickness uncoated steel **OR** 0.034-inch- (0.86-mm-) nominal thickness metallic-coated steel, **as directed**, vertical stiffeners extending full-door height, spaced not more than 6 inches (152 mm) apart, spot welded to face sheets a maximum of 5 inches (127 mm) o.c. Fill spaces between stiffeners with mineral-fiber insulation.
 - 2) Laminated Core: Honeycomb of resin-impregnated kraft paper with maximum 1-inch (25.4-mm) cells or foam-plastic insulation fastened to face sheets with waterproof adhesive.
 - a) Foam-Plastic Insulated Doors: Thermal-resistance value (R-value) of not less than 4.0 deg F x h x sq. ft./Btu (0.704 K x sq. m/W) **OR** 6.0 deg F x h x sq.



- ft./Btu (1.057 K x sq. m/W) **OR** 12.3 deg F x h x sq. ft./Btu (2.166 K x sq. m/W), **as directed**, when tested according to ASTM C 1363.
- i. Locations: Exterior doors and interior doors, where indicated.
- 3) Laminated Steel-Stiffened Core: 0.031-inch- (0.79-mm-) thick, stainless-steel **OR** 0.030-inch- (0.76-mm-) nominal thickness uncoated steel **OR** 0.034-inch- (0.86-mm-) nominal thickness metallic-coated steel, **as directed**, vertical stiffeners extending full-door height, spaced not more than 6 inches (152 mm) apart, fastened to face sheets with waterproof adhesive. Fill spaces between stiffeners with mineral-fiber insulation.
- 4) Fire-Rated Door Core: As required to provide fire-protection and temperature-rise ratings indicated.
- c. Vertical Edges for Single-Acting Doors: Beveled 1/8 inch in 2 inches (3 mm in 50 mm).
- d. Vertical Edges for Double-Acting Doors: Round vertical edges with 2-1/8-inch (54-mm) radius.
- e. Moldings for Glazed Lites in Doors: 0.038-inch- (0.95-mm-) thick stainless steel.
- f. Loose Stops for Glazed Lites in Doors: 0.038-inch- (0.95-mm-) thick stainless steel.
- g. Top and Bottom Channels: Closed with continuous channels, 0.062-inch- (1.59-mm-) thick stainless steel **OR** 0.060-inch- (1.52-mm-) nominal thickness uncoated steel **OR** 0.064-inch- (1.63-mm-) nominal thickness metallic-coated steel, **as directed**.
- 1) Spot welded to both face sheets.
OR
Securely fastened using adhesive.
- h. Hardware Reinforcement: Fabricate according to ANSI/NAAMM-HMMA 866 with reinforcing plates from stainless **OR** uncoated **OR** metallic-coated, **as directed**, steel.
- i. Electrical Hardware Enclosures: Provide enclosures and junction boxes within doors for electrically operated door hardware, interconnected with UL-approved, 1/2-inch- (12.7-mm-) diameter conduit and connectors.
- 1) Where indicated for installation of wiring, provide access plates to junction boxes, fabricate from same material and thickness as face sheet and fasten with at least four security fasteners spaced not more than 6 inches (152 mm) o.c.
2. Performance: Level A, ANSI A250.4.
3. Materials:
- a. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, Type 304 **OR** Type 316 **OR** Type 317LMN **OR** 904L, **as directed**.
- b. Steel Sheet: ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, Commercial Steel (CS), Type B.
- c. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum G60 (Z180) or A60 (ZF180) metallic coating.
- d. Foam-Plastic Insulation: Manufacturer's standard polystyrene **OR** urethane, **as directed**, board insulation with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E 84. Enclose insulation completely within door.
- e. Mineral-Fiber Insulation: Insulation composed of rock-wool fibers, slag-wool fibers, or glass fibers.
4. Stainless-Steel Finishes:
- a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- b. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
- 1) Run grain of directional finishes with long dimension of each piece.
- 2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
- 3) Directional Satin Finish: No. 4.
- 4) Dull Satin Finish: No. 6.
- 5) Mirrorlike Reflective, Nondirectional Polish: No. 8.
- c. Bright, Cold-Rolled, Unpolished Finish: No. 2B. Factory primed for field finish, **as directed**.



- B. Stainless-Steel Panels
1. Provide stainless-steel panels of same construction, materials, and finish as specified for adjoining stainless-steel doors.
- C. Stainless-Steel Frames
1. Description: Fabricate stainless-steel frames of construction indicated, with faces of corners mitered and contact edges closed tight.
 - a. Door Frames: Machine mitered, faces only welded **OR** Saw mitered and full (continuously) welded **OR** Machine mitered and full welded **OR** Knock down **OR** Slip on **OR** As indicated, **as directed**.
 - 1) Weld frames according to HMMA 820.
 - b. Sidelight, Transom and Borrowed-Light Frames: Machine mitered, faces only welded **OR** Saw mitered and full (continuously) welded **OR** Machine mitered and full welded, **as directed**.
 - c. Door Frames for Openings 48 Inches (1219 mm) Wide or Less: Fabricate from 0.062-inch- (1.59-mm-) **OR** 0.078-inch- (1.98-mm-) **OR** 0.109-inch- (2.78-mm-), **as directed**, thick, stainless-steel sheet.
 - d. Door Frames for Openings More Than 48 Inches (1219 mm) Wide: Fabricate from 0.078-inch- (1.98-mm-) **OR** 0.109-inch- (2.78-mm-), **as directed**, thick, stainless-steel sheet.
 - e. Borrowed-Light Frames: Fabricate from 0.062-inch- (1.59-mm-) **OR** 0.078-inch- (1.98-mm-) **OR** 0.109-inch- (2.78-mm-), **as directed**, thick, stainless-steel sheet.
 - f. Sidelight and Transom Frames: Fabricate from stainless-steel sheet of same thickness as adjacent door frame.
 - g. Glazing and Panel Stops: Formed integral with stainless-steel frames, minimum 5/8 inch (16 mm) high, unless otherwise indicated.
 - h. Loose Stops for Glazed Lites and Panels: 0.038-inch- (0.95-mm-) thick stainless steel.
 - i. Hardware Reinforcement: Fabricate according to ANSI/NAAMM-HMMA 866 with reinforcing plates from stainless **OR** uncoated **OR** metallic-coated, **as directed**, steel.
 - j. Head Reinforcement: 0.109-inch- (2.78-mm-) thick, stainless-steel channel or angle stiffener for openings widths more than 48 inches (1219 mm).
 - k. Jamb Anchors:
 - 1) Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.062-inch- (1.59-mm-) thick stainless steel **OR** 0.060-inch- (1.52-mm-) nominal thickness uncoated steel **OR** 0.064-inch- (1.63-mm-) nominal thickness metallic-coated steel, **as directed**, with corrugated or perforated straps not less than 2 inches (50 mm) wide by 10 inches (250 mm) long; or wire anchors not less than 0.156 inch (4.0 mm) thick.
 - 2) Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.050-inch- (1.27-mm-) thick stainless steel **OR** 0.048-inch- (1.21-mm-) nominal thickness uncoated steel **OR** 0.052-inch- (1.32-mm-) nominal thickness metallic-coated steel, **as directed**.
 - 3) Compression Type for Slip-on Frames: Fabricate adjustable compression anchors from stainless **OR** uncoated **OR** metallic-coated, **as directed**, steel.
 - 4) Postinstalled Expansion Type for In-Place Concrete or Masonry: Minimum 3/8-inch- (9.5-mm-) diameter, stainless-steel **OR** uncoated steel **OR** metallic-coated steel, **as directed**, bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.
 - l. Floor Anchors: Not less than 0.078-inch- (1.98-mm-) thick stainless steel **OR** 0.075-inch- (1.90-mm-) nominal thickness uncoated steel **OR** 0.079-inch- (2.01-mm-) nominal thickness metallic-coated steel, **as directed**, and as follows:
 - 1) Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
 - 2) Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2-inch (50-mm) height adjustment. Terminate bottom of frames at finish floor surface.



- m. Ceiling Struts: Minimum 3/8-inch-thick by 2-inch- (9.5-mm-thick by 50-mm-) wide from stainless **OR** uncoated **OR** metallic-coated, **as directed**, steel.
 - n. Plaster Guards: Not less than 0.019-inch- (0.48-mm-) thick stainless steel **OR** 0.018-inch- (0.46-mm-) nominal thickness uncoated steel **OR** 0.022-inch- (0.56-mm-) nominal thickness metallic-coated steel, **as directed**.
2. Performance: Level A, ANSI A250.4.
3. Materials:
- a. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, Type 304 **OR** Type 316 **OR** Type 317LMN **OR** 904L, **as directed**.
 - b. Steel Sheet: ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, Commercial Steel (CS), Type B.
 - c. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum G60 (Z180) or A60 (ZF180) metallic coating.
 - d. Frame Anchors: Stainless-steel sheet. Same type as door face.
OR
Frame Anchors: Steel sheet **OR** Metallic-coated steel sheet, **as directed**, hot-dip galvanized according to ASTM A 153/A 153M, Class B.
 - e. Inserts, Bolts, and Anchor Fasteners: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2 (ASTM F 738M and ASTM F 836M, Alloy Group 1 or 4) for bolts and nuts.
OR
Inserts, Bolts, and Anchor Fasteners: Hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.
4. Finishes:
- a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 - b. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1) Run grain of directional finishes with long dimension of each piece.
 - 2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - 3) Directional Satin Finish: No. 4.
 - 4) Dull Satin Finish: No. 6.
 - 5) Mirrorlike Reflective, Nondirectional Polish: No. 8.
 - c. Bright, Cold-Rolled, Unpolished Finish: No. 2B. Factory primed for field finish, **as directed**.
- D. Accessories
- 1. Glazing: Comply with requirements in Division 08 Section "Glazing".
 - 2. Grout: Comply with ASTM C 476, with a slump of not more than 4 inches (102 mm) as measured according to ASTM C 143/C 143M.
 - 3. Corrosion-Resistant Coating: Cold-applied asphalt mastic, compounded for 15-mil (0.4-mm) dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.
 - 4. Mineral Fiber Insulation: Insulation composed of rock-wool fibers, slag-wool fibers, or glass fibers.
- E. Fabrication
- 1. Stainless-Steel Door Fabrication: Stainless-steel doors to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal.
 - a. Seamed Edge Construction: Both vertical door edges joined by visible, continuous interlocking seam (lock seam) full height of door.
OR
Seamed Edge Construction: Both vertical door edges joined by visible seam that is projection, spot, or tack welded on inside edges of door at minimum 6 inches (152 mm) o.c.



- b. Seamless Edge Construction: Door face sheets joined at vertical edges by continuous weld extending full height of door; with edges ground and polished, providing smooth, flush surfaces with no visible seams.
- c. Exterior Doors: Close top edges flush and seal joints against water penetration. Provide weep-hole openings in bottom of exterior doors to permit moisture to escape.
- d. Stops and Moldings: Factory cut openings in doors. Provide stops and moldings around glazed lites. Form corners of stops and moldings with butted or mitered hairline joints.
 - 1) Glazed Lites: Provide fixed stops and moldings welded on secure side of door.
 - 2) Coordinate rabbet width between fixed and removable stops with type of glazing and type of installation indicated.
- e. Hardware Preparation: Factory prepare stainless-steel doors to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping, according to the Door Hardware Schedule and templates furnished as specified in Division 8 Section "Door Hardware".
 - 1) Reinforce doors to receive nontemplated mortised and surface-mounted door hardware.
- f. Locate hardware as indicated, or if not indicated, according to HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."
- g. Tolerances: Fabricate doors to tolerances indicated in ANSI/NAAMM-HMMA 866.
2. Stainless-Steel Frame Fabrication: Fabricate stainless-steel frames to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.
 - a. Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible. Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated from same thickness metal as frames.
 - b. Mullions, Rails and Transom Bars: Provide closed tubular members with no visible face seams or joints. Fasten members at crossings and to jambs by butt welding according to joint designs in HMMA 820.
 - 1) Provide false head member to receive lower ceiling where frames extend to finish ceilings of different heights.
 - c. Provide countersunk, flat-, or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 - d. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
 - e. Jamb Anchors: Provide number and spacing of anchors as follows:
 - 1) Masonry Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
 - a) Two anchors per jamb up to 60 inches (1524 mm) in height.
 - b) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) in height.
 - c) Four anchors per jamb from 90 to 96 inches (2286 to 2438 mm) in height.
 - d) Four anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof more than 96 inches (2438 mm) in height.
 - 2) Stud-Wall Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
 - a) Three anchors per jamb up to 60 inches (1524 mm) in height.
 - b) Four anchors per jamb from 60 to 90 inches (1524 to 2286 mm) in height.
 - c) Five anchors per jamb from 90 to 96 inches (2286 to 2438 mm) in height.
 - d) Five anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof more than 96 inches (2438 mm) in height.
 - e) Two anchors per head for frames more than 42 inches (1066 mm) wide and mounted in metal-stud partitions.



- 3) Compression Type: Not less than two anchors in each jamb.
- 4) Postinstalled Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.
- f. Head Reinforcement: For frames more than 48 inches (1219 mm) wide, provide continuous head reinforcement for full width of opening, welded to back of frame at head.
- g. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Provide plastic plugs to keep holes clear during construction.
 - 1) Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
 - 2) Double-Door Frames: Drill stop in head jamb to receive two door silencers.
- h. Stops and Moldings: Provide stops and moldings around glazed lites and solid panels where indicated. Form corners of stops and moldings with butted or mitered hairline joints.
 - 1) Single Glazed Lites: Provide fixed stops and moldings welded on secure side of door or frame.
 - 2) Multiple Glazed Lites: Provide fixed and removable stops and moldings such that each lite is capable of being removed independently.
 - 3) Coordinate rabbet width between fixed and removable stops with type of glazing or panel and type of installation indicated.
 - 4) Terminated Stops: Where indicated for interior door frames, terminate stops 6 inches (152 mm) above finish floor with a 45 **OR** 90, **as directed**,-degree angle cut, and close open end of stop with stainless-steel sheet closure. Cover opening in extension of frame with welded-stainless-steel filler plate, with welds ground smooth and flush with frame.
- i. Hardware Preparation: Factory prepare stainless-steel frames to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping, according to the Door Hardware Schedule and templates furnished as specified in Division 08 Section "Door Hardware (scheduled By Describing Products)".
 - 1) Reinforce frames to receive nontemplated mortised and surface-mounted door hardware.
 - 2) Locate hardware as indicated, or if not indicated, according to HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."
- j. Plaster Guards: Weld guards to frame at back of hardware mortises and mounting holes in frames to be grouted.
- k. Tolerances: Fabricate frames to tolerances indicated in ANSI/NAAMM-HMMA 866.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of stainless-steel doors and frames.
2. Examine roughing-in for embedded and built-in anchors to verify actual locations of stainless-steel, door-frame connections before frame installation.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.
2. Prior to installation and with installation spreaders in place, adjust and securely brace stainless-steel door frames for squareness, alignment, twist, and plumb to the following tolerances:
 - a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.



- c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a perpendicular line from head to floor.
3. Drill and tap doors and frames to receive nontemplated mortised and surface-mounted door hardware.

C. Installation

1. General: Install stainless-steel doors and frames plumb, rigid, properly aligned, and securely fastened in place; comply with ANSI/NAAMM-HMMA 866 and manufacturer's written instructions.
2. Stainless-Steel Frames: Install stainless-steel frames of size and profile indicated.
 - a. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
 - 1) At fire-protection-rated openings, install frames according to NFPA 80.
 - 2) Where frames are fabricated in sections due to shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
 - 3) Install frames with removable glazing stops located on secure side of opening.
 - 4) Install door silencers in frames before grouting.
 - 5) Remove temporary braces necessary for installation only after frames have been properly set and secured.
 - 6) Check plumb, squareness, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
 - 7) Apply corrosion-resistant coating to backs of grout-filled frames.
 - b. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor and secure with postinstalled expansion anchors.
 - 1) Floor anchors may be set with powder-actuated fasteners instead of postinstalled expansion anchors, if so indicated and approved on Shop Drawings.
 - c. Metal-Stud Partitions: Solidly pack mineral-fiber insulation behind frames.
 - d. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
 - e. In-Place Gypsum Board Partitions: Secure frames in place with postinstalled expansion anchors through floor anchors at each jamb. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
 - f. Ceiling Struts: Extend struts vertically from top of frame at each jamb to supporting construction above, unless frame is anchored to masonry or to other structural support at each jamb. Bend top of struts to provide flush contact for securing to supporting construction above. Provide adjustable wedged or bolted anchorage to frame jamb members.
 - g. Grouted Frames: Solidly fill space between frames and substrate with grout. Take precautions, including bracing frames, to ensure that frames are not deformed or damaged by grout forces.
 - h. Installation Tolerances: Adjust stainless-steel frames for squareness, alignment, twist, and plumb to the following tolerances:
 - 1) Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - 2) Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - 3) Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - 4) Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs at floor.
3. Stainless-Steel Doors: Fit non-fire-rated doors accurately in frames with the following clearances:
 - a. Non-Fire-Rated Doors:



- 1) Jambs and Head: 1/8 inch (3 mm) plus or minus 1/16 inch (1.6 mm).
 - 2) Between Edges of Pairs of Doors: 1/8 inch (3 mm) plus or minus 1/16 inch (1.6 mm).
 - 3) Between Bottom of Door and Top of Threshold: Maximum 3/8 inch (9.5 mm).
 - 4) Between Bottom of Door and Top of Finish Floor (No Threshold): Maximum 3/4 inch (19 mm).
- b. Fire-Rated Doors: Install doors with clearances according to NFPA 80.
 - c. Smoke-Control Doors: Install doors according to NFPA 105.
4. Glazing: Install glazing in sidelights, transoms, and borrowed lights to comply with installation requirements in Division 08 Section "Glazing".
- a. Secure stops with countersunk, flat-, or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c., and not more than 2 inches (50 mm) o.c. from each corner.
- D. Adjusting And Cleaning
1. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work including stainless-steel doors or frames that are warped, bowed, or otherwise unacceptable.
 2. Clean grout and other bonding material off stainless-steel doors and frames immediately after installation.
 3. Stainless-Steel Touchup: Immediately after erection, smooth any abraded areas of stainless steel and polish to match undamaged finish.

END OF SECTION 08 12 13 13b



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Task	Specification	Specification Description
08 13 13 13	08 12 13 13	Steel Doors And Frames
08 13 13 13	08 12 13 13b	Stainless Steel Doors And Frames



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SECTION 08 13 73 00 - FOLDING DOORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for folding doors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Accordion folding doors.
 - b. Panel folding doors.
 - c. Bifold doors.
 - d. Bifold mirror doors.
 - e. Fire-rated folding doors.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, attachments to other work.
 - a. Fire-Release System: Describe system, including testing and resetting instructions.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each exposed product and for each color and texture specified.
4. Product Schedule: For folding doors. Use same designations indicated on Drawings.
5. Product certificates.
6. Maintenance data.

D. Quality Assurance

1. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
2. Fire-Rated Folding Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing according to NFPA 252 **OR** IBC Standard 716.5 **OR** UL 10B, **as directed**.
 - a. Oversize Fire-Rated Folding Doors: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
3. Project Conditions
 - a. Environmental Limitations: Do not deliver or install folding doors until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - b. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication

1.2 PRODUCTS

A. Accordion Folding Doors

1. General: Top-supported, horizontal-sliding, manually operated accordion folding doors, with chain controlling the spacing and extension of pantographic or X-type accordion folding frames.



- Inner and outer covers are continuous surface facings that attach to and completely cover the folding frames and are pleated as the door is retracted.
2. Outer Covering: Of type indicated below, complying with indicated surface-burning characteristics; attached to door support frames in a concealed manner at sufficient intervals to prevent sagging and separation and to permit on-site removal and repair, with vertical seams located in valleys and material hemmed at top and bottom.
 - a. Vinyl reinforced with woven backing weighing not less than 20 oz./linear yd. (567 g/m).
 - 1) Color, Texture, and Pattern: As selected from manufacturer's full range.
 - b. Fabric weighing not less than 16 oz./linear yd. (496 g/m), treated to resist stains.
 - 1) Color, Texture, and Pattern: As selected from manufacturer's full range.
 - c. Manufacturer's standard nonwoven carpet, needle punched with fused fibers to prevent unraveling.
 - 1) Color, Texture, and Pattern: As selected from manufacturer's full range.
 3. Sweep Seals: Manufacturer's standard top and bottom sweep seals on both **OR** one, **as directed**, side(s).
 4. Carriers: Four-wheel carriers at lead post and two-wheel carriers at intermediate spacing, as necessary for size and weight of partition, to ensure secure, easy, and quiet operation.
 - a. Doors 96 Inches (2438 mm) High or Less: Nylon wheels on steel shafts.
 - b. Doors More Than 96 Inches (2438 mm) High: Ball-bearing wheels with nylon tread and steel shafts.
 5. Tracks: Manufacturer's standard metal track made of extruded aluminum or formed steel with factory-applied, corrosion-resistant finish. Limit track deflection, independent of structural supporting system, to no more than 80 percent of bottom clearance. Design and fabricate track to support accordion folding doors and enable their operation without damage to track, folding unit, or adjacent surfaces; complying with the following requirements:
 - a. Head Trim: Prefinished wood molding for surface-mounted tracks.
 - b. Center stop for center-opening partitions.
 - c. Galvanized-steel sheet or aluminum subchannel for forming pocket for recessed suspension track.
 - d. Metal ceiling contact guard to protect finished ceiling surface from damage by moving top sweep seals; with finish matching other exposed metal.
 - e. Curved track sections with ceiling clips to accommodate configuration indicated.
 - f. Glide switch to divert door to auxiliary track.
 - g. Pivot switch to change track direction.
 - h. Cross-track switch to allow one door to cross another.
 6. Hardware: Manufacturer's standard heavy-duty, manually operated metal pulls and latches as follows:
 - a. Finish: Clear-anodized aluminum **OR** Satin stainless steel **OR** Dull chromium-finish brass **OR** Dull chromium-finish steel, **as directed**.
 - b. Latch: Operable from both **OR** one, **as directed**, side(s) of closed door with coin-slot release on opposite side, **as directed**.
 - c. Lock: Manufacturer's standard key-operated cylinder lock, operable from both sides **OR** Manufacturer's standard key-operated cylinder lock, operable from one side; privacy lock on other side **OR** Deadlock to receive cylinder, operable from both sides. Refer to Division 08 Section "Door Hardware" for cylinder requirements **OR** Deadlock to receive cylinder, operable from both sides, **as directed**.
 - d. Foot bolts on lead post where indicated. Secure to post to avoid interference with seals.
 7. Jamb Molding: Manufacturer's standard wood or metal molding at closing jamb as required for light-tight jamb closure.
 8. Lead Posts and Jamb Posts: Not less than 0.048-inch- (1.2-mm-) thick steel **OR** extruded aluminum, **as directed**, formed for rigidity and light seal at supporting construction.
 - a. Nonferrous jamb strip for single-operating partitions to ensure tight closure by engaging rubber bumper on lead post.
 9. Meeting Post: Fixed single jamb for single-stacked doors **OR** Center meeting post for center-opening doors, **as directed**.



10. Stacking: Tiebacks to maintain door in stacked position.
11. Stacking Configuration: Stack single doors at one end of opening **OR** center-opening doors at both ends of opening **OR** doors in pockets with hinged pocket doors, **as directed**.
12. Opening Size: As directed or as indicated on Drawings.

B. Panel Folding Doors

1. General: Top-supported, horizontal-sliding, manually operated panel folding doors, with panels joined by continuous hinge connectors for the full height of panels.
2. Core Material and Thickness: Manufacturer's standard.
3. Panel Width: 4-inch (100-mm) **OR** 5-inch (125-mm) **OR** 6-inch (150-mm) **OR** 8-inch (200-mm), **as directed**, nominal width.
4. Panel Facing: Facings that comply with indicated surface-burning characteristics.
 - a. Vinyl Facing: Vinyl not less than 7 mils (0.175 mm) thick, factory bonded to core.
 - 1) Color and Texture: As selected from manufacturer's full range.
 - b. Vinyl Facing with Woven Backing: Vinyl reinforced with woven backing weighing not less than 12 oz./linear yd. (372 g/m), factory bonded to core.
 - 1) Color and Texture: As selected from manufacturer's full range.
 - c. Plastic-Laminate Facing: Grade VGS, high-pressure plastic laminate complying with NEMA LD 3; adhesive applied under pressure to core.
 - 1) Color, Texture, and Pattern: As selected from manufacturer's full range.
 - d. Wood-Veneer Facing: as directed by the Owner, wood veneer, laminated to core, with manufacturer's standard clear **OR** stained, **as directed**, transparent finish.
 - 1) Stain Color: As selected from manufacturer's full range.
5. Carriers: Four-wheel carriers at lead post and two-wheel carriers at intermediate spacing, as necessary for size and weight of partition, to ensure secure, easy, and quiet operation.
 - a. Panels 5 Inches (125 mm) Wide or Less: Nylon wheels and axles.
 - b. Panels More Than 5 Inches (125 mm) Wide: Ball-bearing wheels with nylon tread and steel shafts.
6. Tracks: Manufacturer's standard surface-mounted **OR** recessed, **as directed**, extruded-aluminum or steel track with factory-applied, corrosion-resistant finish. Limit track deflection, independent of structural supporting system, to no more than 80 percent of bottom clearance. Design and fabricate track to support operation without damage to track, folding unit, or adjacent surfaces; complying with the following requirements:
 - a. Prefinished ceiling guard/channel for recessed tracks.
 - b. Center stop for biparting partitions.
 - c. Galvanized-steel sheet or aluminum subchannel for forming pocket for recessed suspension track.
 - d. Nonferrous jamb strip for single-operating partitions to ensure tight closure by engaging rubber bumper on lead post.
 - e. Curved track sections to accommodate configuration indicated.
 - f. Glide switch to divert door to auxiliary track.
 - g. Pivot switch to change track direction.
 - h. Cross-track switch to allow one door to cross another.
7. Hinge Connector: Manufacturer's standard extruded-vinyl hinge connector.
 - a. Color: As selected from manufacturer's full range **OR** Match or coordinate with facing color, **as directed**.
8. Hardware: Manufacturer's standard heavy-duty, manually operated metal pulls and latches as follows:
 - a. Finish: Clear-anodized aluminum **OR** Satin stainless steel **OR** Dull chromium-finish brass **OR** Dull chromium-finish steel, **as directed**.
 - b. Latch: Operable from both **OR** one, **as directed**, side(s) of closed door.
 - c. Lock: Manufacturer's standard key-operated cylinder lock, operable from both sides **OR** Manufacturer's standard key-operated cylinder lock, operable from one side; privacy lock on other side **OR** Deadlock to receive cylinder, operable from both sides. Refer to Division 08 Section "Door Hardware" for cylinder requirements **OR** Deadlock to receive cylinder, operable from both sides, **as directed**.



- d. Foot bolts on lead post where indicated. Secure to post to avoid interference with seals.
9. Jamb Molding: Manufacturer's standard wood or metal molding at closing jamb as required for light-tight jamb closure.
 - a. Wood: Match species and finish of panel facing.
 - b. Metal: Manufacturer's standard finish.
10. Wood Track Molding: Manufacturer's standard wood molding on each side of surface-mounted track to match species and finish of panel facings. Install with tight, hairline joints with all fasteners concealed.
11. Meeting Post: Fixed single jamb for single-stacked doors **OR** Center meeting post for biparting doors, **as directed**.
12. Stacking: Tiebacks to maintain door in stacked position.

C. Bifold Doors

1. General: Metal folding doors hinged together in pairs and supported on pivots at jamb, with floor and overhead track and door guide pins.
2. Metal Panels: Sizes as indicated, formed from nominal 0.024-inch- (0.6-mm-) thick, cold-rolled steel sheet. Channel form vertical edges and weld cross bracing to panel and channel-formed edges.
 - a. Surface Profile: Fully louvered **OR** Flush **OR** Paneled **OR** Louvered and paneled, **as directed**.
 - b. Configuration: Two **OR** Four, **as directed**, -panel bifold.
 - c. Sheet Metal Texture: Smooth **OR** Simulated leather, **as directed**.
 - d. Protective Finish: Hot-dip galvanized coating applied to panels, stiffeners, hinges, and decorative trim.
 - e. Baked Finish: Baked-enamel factory finish in white **OR** ivory **OR** custom color as selected, **as directed**.
3. Hardware: Manufacturer's standard felt pads, screws, and pulls in standard finish. Hinges, pivots, and manufacturer's standard wheels factory installed and as follows:
 - a. Hinges: 3 self-aligning hinges.
 - b. Guides and Pivots: Not less than 5/16-inch- (7.9-mm-) diameter, adjustable screw-type, weight-bearing, zinc-plated pivot rod held in place by nylon rod clamp assemblies; with not less than 1/4-inch- (6.4-mm-) diameter, spring-loaded, self-aligning, zinc-plated steel guide rods and top pivot rods held in place by nylon sleeves.
 - c. Track: Prefinished rolled steel with baked-enamel paint finish **OR** Aluminum extrusion, Alloy 6063-T5, 0.05 inch (1.3 mm) thick, with manufacturer's standard metal finish, **as directed**.

D. Bifold Mirror Doors

1. General: Folding doors hinged together in pairs and supported on pivots at jamb, with floor and overhead track and door guide pins.
2. Steel-Panel Door Construction: Sizes as indicated, flush profile, formed from nominal 0.024-inch- (0.6-mm-) thick, cold-rolled steel sheet. Channel form vertical edges and weld cross bracing to panel- and channel-formed edges. Attach mirrored glass facing to steel sheet by means of mechanically attached channels at top and bottom and by dual-faced cushion tape.
 - a. Configuration: Two **OR** Four, **as directed**, -panel bifold.
 - b. Protective Finish: Hot-dip galvanized coating applied to panels, stiffeners, hinges, and decorative trim.
 - c. Baked Finish: Baked-enamel factory finish in white **OR** custom color as selected, **as directed**.
3. Metal-Framed Door Construction: Aluminum **OR** Steel, **as directed**, stiles and mechanically fitted rails with screw-attached stiffeners and with mirrored-glass facing attached securely to frames.
 - a. Panel Style: Exposed **OR** Concealed, **as directed**, frame.
 - b. Configuration: Two **OR** Four, **as directed**, -panel bifold.



- c. Baked Finish: Electrostatically applied, baked-enamel factory finish in white **OR** custom color as selected, **as directed**.
- d. Bright, Reflective Metallic Finish: Chrome **OR** Gold **OR** Selected from manufacturer's full range, **as directed**.
4. Mirror Facing: Smooth **OR** Beveled, **as directed**, -edged, silvered, mirrored, film-backed safety glass complying with 16 CFR 1201 for Category II safety glass; with ASTM C 1036 for Type I (transparent, flat), Class 1 (clear), Quality q2 (mirror) annealed float glass; with the following:
 - a. Glass Thickness: 3 mm thick for doors up to 84 inches (2133 mm) in height **OR** 4 mm thick for doors with height more than 84 inches (2133 mm), **as directed**.
 - b. Edge Protection: Vertical mirror edges protected by metal **OR** Mylar, **as directed**, trim.
 - c. Film-Backed Safety Mirrors: Apply film backing with pressure-sensitive adhesive coating over mirror-backing paint as recommended in writing by film-backing manufacturer to produce a surface free of bubbles, blisters, and other imperfections.
5. Hardware: Manufacturer's standard felt pads, screws, and pulls in standard finish. Hinges, pivots, and manufacturer's standard wheels factory installed and as follows:
 - a. Hinges: 3 self-aligning hinges.
 - b. Guides and Pivots: Manufacturer's standard.
 - c. Guides and Pivots: Spring-loaded, zinc-plated steel guides and tops, and adjustable bottom pivot pins with nylon bushings and tips.
 - d. Guides and Pivots: Not less than 5/16-inch- (7.9-mm-) diameter, adjustable screw-type, weight-bearing, zinc-plated pivot rod held in place by nylon rod clamp assemblies; with not less than 1/4-inch- (6.4-mm-) diameter, spring-loaded, self-aligning, zinc-plated steel guide rods and top pivot rods held in place by nylon sleeves.
6. Track: Prefinished rolled steel with baked-enamel paint finish **OR** Aluminum extrusion, Alloy 6063-T5, 0.05 inch (1.3 mm) thick, with manufacturer's standard metal finish, **as directed**.

E. Fire-Rated Folding Doors

1. General: Electrically **OR** Gravity-, **as directed**, operated, automatic- or self-closing, UL- or ITS-listed, biparting folding fire-rated assembly; top supported from overhead track or dual tracks without floor guides; complete with hardware, seals, track, closing devices, releasing devices, controls, pocket doors, and accessories necessary for intended operation and complying with the following requirements:
 - a. Assembly remains in normal open (stacked) position. Signal from fire-alarm system initiates self-closing operation.
 - b. Controls allow manual operation in either conventional or emergency mode. When opened manually during emergency mode, control mechanism automatically closes assembly.
2. Fire Rating: 1 **OR** 1-1/2 **OR** 3, **as directed**, hour(s).
3. Panel Construction: Formed-steel **OR** Formed stainless-steel, **as directed**, sheet panels connected by formed-steel **OR** formed stainless-steel, **as directed**, hinges.
4. Fire Insulation:
 - a. Cover interior surface of both series of panels in parallel panel doors with continuous fire-resistant blanket secured to each panel with metal clip system.
 - b. Extend fire insulation from bottom edge of panels to tracks and meet at interior centers of fixed jamb and lead post, forming an effective fire barrier.
5. Perimeter Seals and Closures: Manufacturer's standard vinyl or neoprene vertical seals, horizontal top and bottom seals, and closures identical to products tested for fire rating indicated, and forming an effective smoke and draft seal.
6. Track and Trolley System: 1 track or 2 parallel steel tracks on 8-inch (200-mm) centers, with ball-bearing roller trolleys and adjustable steel hanger rods for overhead support; designed for type of operation, size, and weight of fire-rated folding door indicated. Provide a continuous system of track sections and accessories identical to products tested for fire rating indicated, to accommodate configuration and layout indicated for door operation and storage.
7. Lead Posts: Formed from not less than 0.026-inch (0.66-mm-) thick steel **OR** stainless-steel, **as directed**, sheet, connected to door panels by specially adapted panels and equipped with manufacturer's standard handle on each side.
8. Electric Operators and Controls:



- a. Operators: Factory-assembled power-drive unit consisting of motor, remote-located, **as directed**, control panel, limit switches, torque-limiting devices, clutch, reversing magnetic motor operator, leading-edge obstruction detectors, and key-switch control for conventional operation.
 - 1) Motor: 1/2 hp, controlled by reversing magnetic starter and equipped with overload protection.
 - 2) Limit Switches: To prevent overtravel.
 - 3) Roller Chain or Cable: Connected to lead posts by means of vertical stabilizer bar assembly.
 - 4) Drive Mechanism: Protected by torque limiter and emergency clutch.
 - 5) Travel Speed: 18 inches (450 mm) per second, maximum; 6 inches (150 mm) per second, minimum.
 - b. In case of fire, closing system is activated by building's fire- and smoke-detection equipment and automatically closes fire-rated folding doors.
 - c. Electrical Service: Equip for 120 V, single phase, 60-cycle ac.
 - d. Battery: Electrical current connects through relay to battery charger that continuously charges 12-V dc battery and automatically maintains battery at capacity. Automatic audible signal device sounds off if battery falls below or exceeds proper charge, power loss has occurred, or high-ac line voltage has been experienced.
 - e. Leading-Edge Obstruction Detector:
 - 1) Equip with pressure-sensitive leading edge that, on contact with an obstruction, causes door to stop and pause before attempting to re-close.
 - 2) Disable leading-edge obstruction detector until fire-rated folding door has opened pocket door.
 - f. Fire-rated folding doors can be manually opened at any time by pushing against leading edge.
 - g. Audible alarm sounds at automatic closing of door.
9. Accessories:
- a. Vision panels.
 - b. Exit Hardware: Located on both sides of fire-rated folding door. In emergency mode, slight pressure on hardware causes door to open a minimum of 32 inches (812 mm), pause for 3 seconds, and then automatically close. Furnish hardware that can be field programmable to allow automatic opening distances of up to the entire opening width. In conventional mode, hardware is used to operate door and move it back into storage pocket.
10. Finishes:
- a. Baked-enamel finish for panels and hinges in colors selected from manufacturer's full range.
 - b. Manufacturer's standard finish for handles.
11. Pocket Door:
- a. Solid-core pocket doors with reverse-action spring **OR** continuous, **as directed**, hinge; 90-degree minimum swing.
 - b. Face Finish: Match adjacent finishes.
 - c. Magnetic Catch: Holding force of no more than 30 lbf (133 N).
 - d. Maximum Opening Force: 50 lbf (222 N).
 - e. Bumper on interior side of pocket door as required by fire-rated folding door manufacturer to prevent interference with opening or retracting operation of fire-rated folding door.
 - f. Coordinate pocket door sizes with fire-rated folding door manufacturer.

1.3 EXECUTION

A. Preparation



1. For folding doors supported by or anchored to permanent construction, advise installers of specific requirements for placement of anchorage devices. Furnish installers of other work with templates and drawings showing locations of anchorage devices and similar items.
 2. In path of fire-rated folding doors, level floor with header to tolerance of plus or minus 1/16 inch (1.6 mm) across opening; grind or fill floor as necessary.
- B. Installation
1. General: Install folding doors complying with manufacturer's written installation instructions. Install track in one piece.
 - a. Comply with NFPA 80 for installing fire-rated folding doors.
 2. Standard Floor Clearances: 1/4 to 3/4 inch (6.4 to 19 mm) maximum (above floor finish).
 - a. Comply with NFPA 80 for clearances required for fire-rated folding doors.
 3. Coordinate provisions for electrical service, sensing devices, and final connections for fire-rated folding doors.
- C. Adjusting
1. Adjust units as necessary to ensure smooth, quiet operation without warping or binding. Adjust hardware to function smoothly. Confirm that latches engage accurately and securely without forcing or binding.
 - a. Fire-Rated Folding Doors: Verify that all operations are functional and comply with requirements of authorities having jurisdiction.
 2. Pocket Doors: Adjust to operate smoothly and easily, without binding or warping. Adjust hardware to function smoothly. Confirm that latches and locks engage accurately and securely without forcing or binding.
- D. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-rated folding doors.

END OF SECTION 08 13 73 00



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SECTION 08 31 13 00 - ACCESS DOORS AND FRAMES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for access doors and frames. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Access doors and frames for walls and ceilings.
 - b. Floor access doors and frames.

C. Submittals

1. Product Data: For each type of access door and frame indicated.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
3. Samples: For each door face material in specified finish.
4. Schedule: Types, locations, sizes, latching or locking provisions, and other data pertinent to installation.

D. Quality Assurance

1. Fire-Rated Access Doors and Frames: Units complying with NFPA 80 that are identical to access door and frame assemblies tested for fire-test-response characteristics per the following test method and that are listed and labeled by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:
 - a. NFPA 252 or UL 10B for vertical access doors and frames.
 - b. ASTM E 119 or UL 263 for horizontal access doors and frames.

1.2 PRODUCTS

A. Steel Materials

1. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
 - a. ASTM A 123/A 123M, for galvanizing steel and iron products.
 - b. ASTM A 153/A 153M, for galvanizing steel and iron hardware.
2. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.
 - a. ASTM A 123/A 123M, for galvanizing steel and iron products
 - b. ASTM A 153/A 153M, for galvanizing steel and iron hardware.
3. Steel Sheet: Uncoated or electrolytic zinc-coated, ASTM A 591/A 591M with cold-rolled steel sheet substrate complying with ASTM A 1008/A 1008M, Commercial Steel (CS), exposed.
4. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS) with A60 (ZF180) zinc-iron-alloy (galvannealed) coating or G60 (Z180) mill-phosphatized zinc coating.
5. Steel Finishes: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - a. Surface Preparation for Steel Sheet: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, or other contaminants that could impair paint bond. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
 - b. Surface Preparation for Metallic-Coated Steel Sheet: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it. Clean welds,



mechanical connections, and abraded areas, and apply galvanizing repair paint specified below to comply with ASTM A 780.

- 1) Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.
- c. Factory-Primed Finish: Apply shop primer immediately after cleaning and pretreating.
- d. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).
- e. Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils (0.04 mm). Prepare, treat, and coat metal to comply with resin manufacturer's written instructions.
6. Drywall Beads: Edge trim formed from 0.0299-inch (0.76-mm) zinc-coated steel sheet formed to receive joint compound and in size to suit thickness of gypsum board.
7. Plaster Beads: Casing bead formed from 0.0299-inch (0.76-mm) zinc-coated steel sheet with flange formed out of expanded metal lath and in size to suit thickness of plaster.

B. Stainless-Steel Materials

1. Rolled-Stainless-Steel Floor Plate: ASTM A 793, manufacturer's standard finish.
2. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 304 **OR** 316 **OR** Type 317LMN **OR** 904L, **as directed**. Remove tool and die marks and stretch lines or blend into finish.
 - a. Finish: Directional Satin Finish, No. 4 **OR** Manufacturer's standard, **as directed**.

C. Aluminum Materials

1. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T6, mill finish.
2. Aluminum-Alloy Rolled Tread Plate: ASTM B 632/B 632M, Alloy 6061-T6, mill finish.
3. Aluminum Sheet: ASTM B 209 (ASTM B 209M).
 - a. Mill Finish: AA-M10 (Mechanical Finish: as fabricated, unspecified).
 - b. Anodic Finish: Class II, clear anodic coating complying with AAMA 611 **OR** Class I, clear anodic coating complying with AAMA 611, **as directed**.
 - c. Baked-Enamel Finish: Manufacturer's standard.

D. Access Doors And Frames For Walls And Ceilings

1. Flush Access Doors and Frames with Exposed Trim: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
 - a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal, set flush with exposed face flange of frame.
 - c. Frame: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal with 1-inch- (25-mm-) **OR** 1-1/4-inch- (32-mm-), **as directed**, wide, surface-mounted trim.
 - d. Hinges: Spring-loaded, concealed-pin type **OR** Continuous piano, **as directed**.
 - e. Latch: Cam latch **OR** Slam latch **OR** Self-latching bolt, **as directed**, operated by screwdriver **OR** knurled knob **OR** hex head wrench **OR** pinned hex head wrench **OR** spanner head wrench **OR** flush key **OR** ring turn, **as directed**, with interior release.
 - f. Lock: Cylinder **OR** Mortise cylinder, **as directed**.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
2. Flush Access Doors and Trimless Frames: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
 - a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal, set flush with surrounding finish surfaces.



- c. Frame: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal with drywall **OR** plaster, **as directed**, bead flange.
 - d. Hinges: Spring-loaded, concealed-pin type **OR** Continuous piano, **as directed**.
 - e. Latch: Cam latch **OR** Slam latch **OR** Self-latching bolt, **as directed**, operated by screwdriver **OR** knurled knob **OR** hex head wrench **OR** pinned hex head wrench **OR** spanner head wrench **OR** flush key **OR** ring turn, **as directed**, with interior release.
 - f. Lock: Cylinder **OR** Mortise cylinder, **as directed**.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
3. Recessed Access Doors and Trimless Frames: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
- a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal in the form of a pan recessed 5/8 inch (16 mm) **OR** 1 inch (25 mm), **as directed**, for gypsum board **OR** plaster **OR** acoustical tile, **as directed**, infill.
 - c. Frame: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal with drywall bead for gypsum board surfaces **OR** with plaster bead for plaster surfaces **OR** designed for insertion into acoustical tile ceiling, **as directed**.
 - d. Hinges: Spring-loaded, concealed-pin type **OR** Concealed pivoting rod hinge, **as directed**.
 - e. Latch: Cam latch **OR** Slam latch **OR** Self-latching bolt, **as directed**, operated by screwdriver **OR** knurled knob **OR** hex head wrench **OR** pinned hex head wrench **OR** spanner head wrench **OR** flush key **OR** ring turn, **as directed**, with interior release.
 - f. Lock: Cylinder **OR** Mortise cylinder, **as directed**.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
4. Aluminum Flush Access Doors and Frames with Exposed Trim: Fabricated from aluminum sheet and extruded-aluminum shapes.
- a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.080-inch- (2.0-mm-), **as directed**, thick aluminum sheet.
 - c. Frame: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick extruded aluminum with 1-1/4-inch- (32-mm-) wide rolled flange.
 - d. Hinges: Concealed continuous aluminum.
 - e. Latch: Screwdriver-operated cam latch.
5. Lightweight Flush Access Doors and Frames with Exposed Trim: Fabricated from lightweight metal.
- a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.018-inch- (0.45-mm-) thick steel sheet.
 - c. Frame: Minimum 0.045-inch- (1.1-mm-) thick extruded aluminum with 1-1/4-inch- (32-mm-) wide rolled flange.
 - d. Hinges: Continuous piano.
 - e. Latch: Screwdriver-operated cam latch.
6. Plastic Flush Access Doors and Frames with Exposed Trim: Fabricated from 1/8-inch- (3.2-mm-) thick high-impact plastic with UV stabilizer.
- a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Flush to frame with rounded corners.
 - c. Frame: 1 piece, 3/4 inch (19 mm) deep.
 - d. Latch: Snap latch.
 - e. Finish: White with textured exposed surfaces.
7. Exterior Flush Access Doors and Frames with Exposed Trim: Weatherproof with extruded door gasket.
- a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.040-inch- (1.0-mm-), **as directed**, thick, metallic-coated steel sheet; flush panel construction with manufacturer's standard 2-inch- (50-mm-) thick fiberglass insulation.
 - c. Frame: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick extruded aluminum.
 - d. Hinges: Continuous piano, zinc plated.



- e. Lock: Dual-action handles with key lock.
8. Fire-Rated, Insulated, Flush Access Doors and Frames with Exposed Trim: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
- Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - Fire-Resistance Rating: Not less than that indicated **OR** that of adjacent construction **OR** 45 minutes **OR** 1 hour **OR** 1-1/2 hours **OR** 2 hours **OR** 3 hours, **as directed**.
 - Temperature Rise Rating: 250 deg F (139 deg C) at the end of 30 minutes.
 - Door: Flush panel with a core of mineral-fiber insulation enclosed in sheet metal with a minimum thickness of 0.036 inch (0.9 mm), **as directed**.
 - Frame: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal with 1-inch- (25-mm-), **as directed**, wide, surface-mounted trim.
 - Hinges: Concealed-pin type **OR** Continuous piano, **as directed**.
 - Automatic Closer: Spring type.
 - Latch: Self-latching device operated by knurled knob **OR** flush key **OR** ring turn, **as directed**, with interior release.
 - Lock: Self-latching device with cylinder **OR** mortise cylinder, **as directed**, lock.
 - Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
9. Fire-Rated, Insulated, Flush Access Doors and Trimless Frames: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
- Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - Fire-Resistance Rating: Not less than that indicated **OR** that of adjacent construction **OR** 45 minutes **OR** 1 hour **OR** 1-1/2 hours **OR** 2 hours **OR** 3 hours, **as directed**.
 - Temperature Rise Rating: 250 deg F (139 deg C) at the end of 30 minutes.
 - Door: Flush panel with a core of mineral-fiber insulation enclosed in sheet metal with a minimum thickness of 0.036 inch (0.9 mm), **as directed**.
 - Frame: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal with drywall **OR** plaster, **as directed**, bead.
 - Hinges: Concealed-pin type **OR** Continuous piano, **as directed**.
 - Automatic Closer: Spring type.
 - Latch: Self-latching device operated by knurled knob **OR** flush key **OR** ring turn, **as directed**, with interior release.
 - Lock: Self-latching device with cylinder **OR** mortise cylinder, **as directed**, lock.
 - Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
10. Fire Rated, Uninsulated, Flush Access Doors and Frames with Exposed Trim: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
- Locations: Wall surfaces.
 - Fire-Resistance Rating: Not less than that indicated **OR** that of adjacent construction **OR** 45 minutes **OR** 1 hour **OR** 1-1/2 hours **OR** 2 hours **OR** 3 hours, **as directed**.
 - Door: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal, flush construction.
 - Frame: Minimum 0.060-inch- (1.5-mm-), **as directed**, thick sheet metal with 1-inch- (25-mm-) **OR** 1-1/4-inch- (32-mm-), **as directed**, wide, surface-mounted trim.
 - Hinges: Concealed-pin type **OR** Continuous piano, **as directed**.
 - Automatic Closer: Spring type.
 - Latch: Self-latching device operated by knurled knob **OR** flush key **OR** ring turn, **as directed**, with interior release.
 - Lock: Self-latching device with cylinder **OR** mortise cylinder, **as directed**, lock.
 - Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
11. Medium-Security, Flush Access Doors and Frames with Exposed Trim: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
- Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - Door: Minimum 0.105-inch- (2.7-mm-) thick sheet metal, flush construction.



- c. Frame: Minimum 0.105-inch- (2.7-mm-) thick sheet metal with 1-inch- (25-mm-) **OR** 1-1/4-inch- (32-mm-), **as directed**, wide, surface-mounted trim.
 - d. Hinges: Concealed continuous piano.
 - e. Lock: Detention.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
12. Medium-Security, Flush Access Doors with Trimless Frames: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
- a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.105-inch- (2.7-mm-) thick sheet metal, flush construction.
 - c. Frame: Minimum 0.105-inch- (2.7-mm-) thick sheet metal with drywall **OR** plaster, **as directed**, bead.
 - d. Hinges: Concealed continuous piano.
 - e. Lock: Detention.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
13. High-Security, Flush Access Doors and Frames with Exposed Trim: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet and angles.
- a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.135-inch- (3.4-mm-) thick sheet metal, flush construction.
 - c. Frame: Minimum 3/16-by-2-by-2-inch (4.7-by-50-by-50-mm) angle welded with joints ground smooth.
 - d. Hinges: Heavy-duty steel welded to door and frame.
 - e. Lock: Heavy-duty, detention deadbolt.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
14. Maximum-Security, Flush Access Doors and Frames with Exposed Trim: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet and angles.
- a. Locations: Wall **OR** Ceiling **OR** Wall and ceiling, **as directed**, surfaces.
 - b. Door: Minimum 0.180-inch- (4.55-mm-) thick sheet metal, flush construction.
 - c. Frame: Minimum 3/16-by-2-by-2-by-3-inch (4.7-by-50-by-50-by-76-mm) angle welded with joints ground smooth.
 - d. Hinges: Heavy-duty steel welded to door and frame.
 - e. Lock: Heavy-duty detention deadbolt.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
15. Fire-Rated, Insulated, Medium-Security, Flush Access Doors and Frames with Exposed Trim: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
- a. Locations: Wall surfaces.
 - b. Fire-Resistance Rating: Not less than that indicated **OR** that of adjacent construction **OR** 45 minutes **OR** 1 hour **OR** 1-1/2 hours **OR** 2 hours **OR** 3 hours, **as directed**.
 - c. Temperature Rise Rating: 250 deg F (139 deg C) at the end of 30 minutes.
 - d. Door: Flush panel with a core of 2-inch- (50-mm-) thick, mineral-fiber insulation enclosed in sheet metal with a minimum thickness of 0.075 inch (1.9 mm).
 - e. Frame: Minimum 0.060-inch- (1.5-mm-) thick sheet metal with 1-inch- (25-mm-) **OR** 1-1/4-inch- (32-mm-), **as directed**, wide, surface-mounted trim.
 - f. Hinges: Concealed-pin type **OR** Continuous piano, **as directed**.
 - g. Automatic Closer: Spring type.
 - h. Lock: Self-latching device with detention lock.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".
16. Fire-Rated, Insulated, Medium-Security, Flush Access Doors with Trimless Frames: Fabricated from steel **OR** metallic-coated steel **OR** stainless-steel, **as directed**, sheet.
- a. Locations: Wall surfaces.
 - b. Fire-Resistance Rating: Not less than that indicated **OR** that of adjacent construction **OR** 45 minutes **OR** 1 hour **OR** 1-1/2 hours **OR** 2 hours **OR** 3 hours, **as directed**.



- c. Temperature Rise Rating: 250 deg F (139 deg C) at the end of 30 minutes.
- d. Door: Flush panel with a core of 2-inch- (50-mm-) thick, mineral-fiber insulation enclosed in sheet metal with a minimum thickness of 0.075 inch (1.9 mm).
- e. Frame: Minimum 0.060-inch- (1.5-mm-) thick sheet metal with drywall **OR** plaster, **as directed**, bead.
- f. Hinges: Concealed-pin type **OR** Continuous piano, **as directed**.
- g. Automatic Closer: Spring type.
- h. Lock: Self-latching device with detention lock.
 - 1) Lock Preparation: Prepare door panel to accept cylinder specified in Division 08 Section "Door Hardware".

E. Floor Access Doors And Frames

1. Floor Doors, General: Equip each door with adjustable counterbalancing springs, heavy-duty hold-open arm that automatically locks door open at 90 degrees, release handle with red vinyl grip that allows for one-handed closure, and recessed lift handle.
2. Aluminum Floor Door: Single **OR** Double, **as directed**, -leaf opening. Extruded-aluminum angle frame with 1/4-inch- (6.4-mm-) thick, diamond-pattern, aluminum tread plate door; nonwatertight; loading capacity to support 150-lbf/sq. ft. (7.2-kN/sq. m) pedestrian live load **OR** 300-lbf/sq. ft. (14.4-kN/sq. m) pedestrian live load **OR** AASHTO H20 concentrated wheel load, without impact, **as directed**.
3. Watertight Aluminum Floor Door: Single **OR** Double, **as directed**, -leaf opening. Extruded-aluminum gutter frame with NPS 1-1/2 (DN 40) drainage coupling and 1/4-inch- (6.4-mm-) thick, diamond-pattern, aluminum tread plate door; watertight; loading capacity to support 150-lbf/sq. ft. (7.2-kN/sq. m) pedestrian live load **OR** 300-lbf/sq. ft. (14.4-kN/sq. m) pedestrian live load **OR** AASHTO H20 concentrated wheel load, without impact, **as directed**.
4. Steel Angle-Frame Floor Door: Single **OR** Double, **as directed**, -leaf opening. Prime-painted structural **OR** Galvanized structural **OR** Stainless, **as directed**, -steel frame with 3/16- or 1/4-inch- (4.8- or 6.4-mm-) **OR** 3/16-inch- (4.8-mm-) **OR** 1/4-inch- (6.4-mm-), **as directed**, thick, diamond-pattern, prime-painted structural **OR** galvanized structural **OR** stainless, **as directed**, -steel tread plate door; nonwatertight; loading capacity to support 150-lbf/sq. ft. (7.2-kN/sq. m) pedestrian live load **OR** 300-lbf/sq. ft. (14.4-kN/sq. m) pedestrian live load **OR** AASHTO H20 concentrated wheel, **as directed**, load.
 - a. Fire-Resistance Rating: Not less than that indicated **OR** that of adjacent construction **OR** 45 minutes **OR** 1 hour **OR** 1-1/2 hours **OR** 2 hours **OR** 3 hours, **as directed**.
 - b. Finish painted in yellow with wording "FIRE DOOR - DO NOT STORE MATERIALS ON SURFACE."
5. Watertight Steel Gutter-Frame Floor Door: Single **OR** Double, **as directed**, -leaf opening. Prime-painted structural **OR** Galvanized structural **OR** Stainless, **as directed**, -steel channel frame forming gutter with NPS 1-1/2 (DN 40) drainage coupling and 3/16- or 1/4-inch- (4.8- or 6.4-mm-) **OR** 3/16-inch- (4.8-mm-) **OR** 1/4-inch- (6.4-mm-), **as directed**, thick, diamond-pattern, prime-painted structural **OR** galvanized structural **OR** stainless, **as directed**, -steel tread plate door; watertight; loading capacity to support 150-lbf/sq. ft. (7.2-kN/sq. m) pedestrian live load **OR** 300-lbf/sq. ft. (14.4-kN/sq. m) pedestrian live load **OR** AASHTO H20 concentrated wheel, **as directed**, load.
 - a. Fire-Resistance Rating: Not less than that indicated **OR** that of adjacent construction **OR** 45 minutes **OR** 1 hour **OR** 1-1/2 hours **OR** 2 hours **OR** 3 hours, **as directed**.
 - b. Finish painted in yellow with wording "FIRE DOOR - DO NOT STORE MATERIALS ON SURFACE."
6. Hardware: Provide the following:
 - a. Hinges: Heavy-duty, zinc-coated steel **OR** aluminum **OR** stainless-steel **OR** brass, **as directed**, butt hinges with stainless-steel pins.
 - b. Latch: Stainless-steel slam latch.
 - c. Lock: Staple for a padlock **OR** Recessed hasp **OR** Keyed deadlock bolt **OR** Hasp and staple, **as directed**.



- d. Hardware Material: Manufacturer's standard **OR** Stainless steel, including latch and lifting mechanism assemblies, hold-open arms, and all brackets, hinges, pins, and fasteners, **as directed**.
 7. Insulation: Fiberglass **OR** Urethane, **as directed**, with liner pan.
 8. Safety Accessories: Safety chains **OR** net **OR** railing, **as directed**.
- F. Fabrication
1. General: Provide access door and frame assemblies manufactured as integral units ready for installation.
 2. Metal Surfaces: For metal surfaces exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.
 3. Doors and Frames: Grind exposed welds smooth and flush with adjacent surfaces. Furnish attachment devices and fasteners of type required to secure access panels to types of supports indicated.
 4. Recessed Access Doors: Form face of panel to provide recess for application of applied finish. Reinforce panel as required to prevent buckling.
 5. Latching Mechanisms: Furnish number required to hold doors in flush, smooth plane when closed.
 - a. For cylinder lock, furnish two keys per lock and key all locks alike.
 - b. For recessed panel doors, provide access sleeves for each locking device. Furnish plastic grommets and install in holes cut through finish.
 6. Extruded Aluminum: After fabrication, apply manufacturer's standard protective coating on aluminum that will come in contact with concrete.

1.3 EXECUTION

- A. Installation
1. Comply with manufacturer's written instructions for installing access doors and frames.
 2. Set frames accurately in position and attach securely to supports with plane of face panels aligned with adjacent finish surfaces.
 3. Install doors flush with adjacent finish surfaces or recessed to receive finish material.
- B. Adjusting And Cleaning
1. Adjust doors and hardware after installation for proper operation.
 2. Remove and replace doors and frames that are warped, bowed, or otherwise damaged.

END OF SECTION 08 31 13 00



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SECTION 08 33 13 00 - OVERHEAD COILING DOORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for overhead coiling doors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Service doors with integral pass doors.
 - b. Insulated service doors with integral pass doors.
 - c. Counter doors.
 - d. Fire-rated service doors with integral pass doors.
 - e. Fire-rated, insulated service doors with integral pass doors.
 - f. Fire-rated counter doors.

C. Performance Requirements

1. Delegated Design: Design overhead coiling doors, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance, Exterior Doors: Exterior overhead coiling doors shall withstand the wind loads, the effects of gravity loads, and loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.
 - a. Wind Loads: As indicated on Drawings **OR** Uniform pressure (velocity pressure) of 20 lbf/sq. ft. (960 Pa), acting inward and outward, **as directed**.
 - 1) Basic Wind Speed: 85 mph (38 m/s) **OR** 90 mph (40 m/s) **OR** 100 mph (44 m/s) **OR** 110 mph (49 m/s), **as directed**.
 - 2) Importance Factor: **<Insert factor>**.
 - 3) Exposure Category: **A OR B OR C OR D, as directed**.
 - b. Deflection Limits: Design overhead coiling doors to withstand design wind load without evidencing permanent deformation or disengagement of door components.
3. Operability under Wind Load: Design overhead coiling doors to remain operable under design **OR** uniform pressure (velocity pressure) of 20 lbf/sq. ft. (960 Pa), **as directed**, wind load, acting inward and outward.
4. Windborne-Debris-Impact-Resistance Performance: Provide glazed and impact-protective overhead coiling doors that pass missile-impact and cyclic-pressure tests when tested according to ASTM E 1886 and ASTM E 1996.
 - a. Large Missile Test: For overhead coiling doors located within 30 feet (9.144 m) of grade.
 - b. Small Missile Test: For overhead coiling doors located more than 30 feet (9.144 m) above grade.
5. Seismic Performance: Overhead coiling doors shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
6. Operation Cycles: Provide overhead coiling door components and operators capable of operating for not less than number of cycles indicated for each door. One operation cycle is complete when a door is opened from the closed position to the fully open position and returned to the closed position.

D. Submittals

1. Product Data: For each type and size of overhead coiling door and accessory.



2. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Show locations of replaceable fusible links.
 - c. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each exposed product and for each color and texture specified.
4. Delegated-Design Submittal: For overhead coiling doors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Qualification Data: For qualified Installer.
6. Seismic Qualification Certificates: For overhead coiling doors, accessories, and components, from manufacturer.
7. Oversize Construction Certification: For door assemblies required to be fire-rated and that exceed size limitations of labeled assemblies.
8. Maintenance Data.

E. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for both installation and maintenance of units required for this Project.
2. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** IBC Standard 716.5 **OR** UL 10B, **as directed**.
 - a. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
 - b. Temperature-Rise Limit: Where indicated **OR** At vertical exit enclosures and exit passageways, **as directed**, provide doors that have a maximum transmitted temperature end point of not more than 450 deg F (250 deg C) above ambient after 30 minutes of standard fire-test exposure.
 - c. Smoke Control: Where indicated **OR** In corridors and smoke barriers, **as directed**, provide doors that are listed and labeled with the letter "S" on the fire-rating label by a qualified testing agency for smoke- and draft-control based on testing according to IBC Standard 716.5 **OR** UL 1784, **as directed**; with maximum air-leakage rate of 3.0 cfm/sq. ft. (0.01524 cu. m/s x sq. m) of door opening at 0.10 inch wg (24.9 Pa) for both ambient and elevated temperature tests.
3. Sound-Control Doors: Assemblies that have been fabricated and tested to control the passage of sound and have minimum certified STC rating according to ASTM E 413.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines **OR** ICC/ANSI A117.1, **as directed**.

1.2 PRODUCTS

A. Door Curtain Materials And Construction

1. Door Curtains: Fabricate overhead coiling-door curtain of interlocking metal slats, designed to withstand wind loading indicated, in a continuous length for width of door without splices. Unless otherwise indicated, provide slats of thickness and mechanical properties recommended by door manufacturer for performance, size, and type of door indicated, and as follows:



- a. Steel Door Curtain Slats: Zinc-coated (galvanized), cold-rolled structural steel sheet; complying with ASTM A 653/A 653M, with G90 (Z275) zinc coating; nominal sheet thickness (coated) of 0.028 inch (0.71 mm) and as required to meet requirements.
 - b. Stainless-Steel Door Curtain Slats: ASTM A 666, Type 304; sheet thickness of 0.025 inch (0.64 mm) and as required to meet requirements.
 - c. Aluminum Door Curtain Slats: ASTM B 209 (ASTM B 209M) sheet or ASTM B 221 (ASTM B 221M) extrusions, alloy and temper standard with manufacturer for type of use and finish indicated; thickness of 0.050 inch (1.27 mm) and as required to meet requirements.
 - d. Vision-Panel Glazing: Manufacturer's standard clear glazing, fabricated from transparent acrylic sheet or fire-protection rated glass as required for type of door; set in glazing channel secured to curtain slats.
 - e. Insulation: Fill slats for insulated doors with manufacturer's standard thermal insulation complying with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E 84. Enclose insulation completely within slat faces.
 - f. Metal Interior Curtain-Slat Facing: Match metal of exterior curtain-slat face.
 - g. Plastic Interior Curtain-Slat Facing: Extruded PVC plastic with maximum flame-spread index of 25 **OR** 75 **OR** 200, **as directed**, and smoke-developed index of 450, according to ASTM E 84.
 - h. Gasket Seal: Provide insulated slats with manufacturer's standard interior-to-exterior thermal break or with continuous gaskets between slats.
2. Endlocks and Windlocks for Service Doors: Malleable-iron casings galvanized after fabrication, secured to curtain slats with galvanized rivets or high-strength nylon. Provide locks on not less than alternate curtain slats for curtain alignment and resistance against lateral movement.
 3. Endlocks for Counter Doors: Manufacturer's standard locks on not less than alternate curtain slats for curtain alignment and resistance against lateral movement.
 4. Bottom Bar for Service Doors: Consisting of two angles, each not less than 1-1/2 by 1-1/2 by 1/8 inch (38 by 38 by 3 mm) thick; fabricated from manufacturer's standard hot-dip galvanized steel, stainless steel, or aluminum extrusions to match curtain slats and finish.
 5. Bottom Bar for Counter Doors: Manufacturer's standard continuous channel or tubular shape, fabricated from manufacturer's standard hot-dip galvanized steel, stainless steel, or aluminum extrusions to match curtain slats and finish.
 6. Astragal for Interior Doors: Equip each door bottom bar with a replaceable, adjustable, continuous, compressible gasket of flexible vinyl, rubber, or neoprene as a cushion bumper.
 7. Curtain Jamb Guides: Manufacturer's standard angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading. Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent overtravel of curtain, and a continuous bar for holding windlocks.
 - a. Removable Posts and Jamb Guides for Counter Doors: Manufacturer's standard.
 8. Pass Door(s): Door and frame assembly constructed integrally with the coiling-door assembly and bearing the same fire rating. Complying with egress and accessibility requirements of authorities having jurisdiction.
 - a. Door Frame and Integral Jamb Guide: Fabricate of angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading.
 - b. Hinged Frame: Hinged pass door and frame that swings out of the way, as a unit, to allow use of the full coiling-door opening width. One jamb of the pass-door frame is hinged and the other jamb includes a guide for the lower, narrower part of the coiling-door curtain.
 - c. Rigid Frame: Rigid pass door and frame that are built into the rigid, lower part of the door curtain and that raise with the curtain.
 - d. Locking Hardware:
 - 1) Lockset **OR** Exit Hardware: As specified in Division 08 Section "Door Hardware" **OR** As selected from manufacturer's full range, **as directed**.



- 2) Lock Cylinders: Provide cylinders specified in Division 08 Section "Door Hardware" **OR** standard with manufacturer, **as directed**, and keyed to building keying system, **as directed**.
- 3) Keys: Two **OR** Three, **as directed**, for each cylinder.
- e. Thresholds: Equip pass doors with integral thresholds that comply with egress and accessibility requirements of authorities having jurisdiction.

B. Hood

1. General: Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.
 - a. Galvanized Steel: Nominal 0.028-inch- (0.71-mm-) thick, hot-dip galvanized steel sheet with G90 (Z275) zinc coating, complying with ASTM A 653/A 653M.
 - b. Stainless Steel: 0.025-inch- (0.64-mm-) thick stainless-steel sheet, Type 304, complying with ASTM A 666.
 - c. Aluminum: 0.040-inch- (1.02-mm-) thick aluminum sheet complying with ASTM B 209 (ASTM B 209M), of alloy and temper recommended by manufacturer and finisher for type of use and finish indicated.
 - d. Include automatic drop baffle on fire-rated doors to guard against passage of smoke or flame.
 - e. Exterior-Mounted Doors: Fabricate hood to act as weather protection and with a perimeter sealant-joint-bead profile for applying joint sealant.

C. Counter Doors

1. Integral Frame, Hood, and Fascia for Counter Door: Welded sheet metal assembly of the following sheet metal:
 - a. Galvanized Steel: Nominal 0.064-inch- (1.63-mm-) thick, hot-dip galvanized steel sheet with G90 (Z275) zinc coating, complying with ASTM A 653/A 653M.
 - b. Stainless Steel: 0.062-inch- (1.59-mm-) thick stainless-steel sheet, Type 304, complying with ASTM A 666.
2. Integral Metal Sill for Counter Door: Fabricate sills as integral part of frame assembly of Type 304 stainless steel in manufacturer's standard thickness with No. 4 finish.
3. Fire-Rated, Laminate Counter: Fire-door manufacturer's high-pressure decorative laminate-covered countertop, UL or ITS tested and labeled for 1-1/2-hour fire rating for approved use with fire-door assembly.

D. Locking Devices

1. Slide Bolt: Fabricate with side-locking bolts to engage through slots in tracks for locking by padlock, located on both left and right jamb sides, operable from coil side.
2. Locking Device Assembly: Fabricate with cylinder lock, spring-loaded dead bolt, operating handle, cam plate, and adjustable locking bars to engage through slots in tracks.
 - a. Lock Cylinders: Provide cylinders specified in Division 08 Section "Door Hardware" **OR** standard with manufacturer, **as directed**, and keyed to building keying system, **as directed**.
 - b. Keys: Provide Two **OR** Three, **as directed**, for each cylinder.
3. Chain Lock Keeper: Suitable for padlock.
4. Safety Interlock Switch: Equip power-operated doors with safety interlock switch to disengage power supply when door is locked.

E. Curtain Accessories

1. Smoke Seals: Equip each fire-rated door with smoke-seal perimeter gaskets for smoke and draft control as required for door listing and labeling by a qualified testing agency.



2. Weatherseals: Equip each exterior door with weather-stripping gaskets fitted to entire perimeter of door for a weathertight installation, unless otherwise indicated.
 - a. At door head, use 1/8-inch- (3-mm-) thick, replaceable, continuous sheet secured to inside of hood.
 - b. At door jambs, use replaceable, adjustable, continuous, flexible, 1/8-inch- (3-mm-) thick seals of flexible vinyl, rubber, or neoprene.
3. Push/Pull Handles: Equip each push-up-operated or emergency-operated door with lifting handles on each side of door, finished to match door.
 - a. Provide pull-down straps or pole hooks for doors more than 84 inches (2130 mm) high.
4. Automatic-Closing Device for Fire-Rated Doors: Equip each fire-rated door with an automatic-closing device that is inoperative during normal door operations and that has a governor unit complying with NFPA 80 and an easily tested and reset release mechanism designed to be activated by the following:
 - a. Replaceable fusible links with temperature rise and melting point of 165 deg F (74 deg C) interconnected and mounted on both sides of door opening.
 - b. Manufacturer's standard UL-labeled smoke detector and door-holder-release devices.
 - c. Manufacturer's standard UL-labeled heat detector and door-holder-release devices.
 - d. Building fire-detection and -alarm systems and manufacturer's standard door-holder-release devices.

F. Counterbalancing Mechanism

1. General: Counterbalance doors by means of manufacturer's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.
2. Counterbalance Barrel: Fabricate spring barrel of manufacturer's standard hot-formed, structural-quality, welded or seamless carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of slats and to limit barrel deflection to not more than 0.03 in./ft. (2.5 mm/m) of span under full load.
3. Spring Balance: One or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Secure ends of springs to barrel and shaft with cast-steel barrel plugs.
4. Torsion Rod for Counterbalance Shaft: Fabricate of manufacturer's standard cold-rolled steel, sized to hold fixed spring ends and carry torsional load.
5. Brackets: Manufacturer's standard mounting brackets of either cast iron or cold-rolled steel plate.

G. Manual Door Operators

1. Equip door with manufacturer's recommended manual door operator unless another type of door operator is indicated.
2. Push-up Door Operation: Design counterbalance mechanism so required lift or pull for door operation does not exceed 25 lbf (111 N).
3. Chain-Hoist Operator: Consisting of endless steel hand chain, chain-pocket wheel and guard, and gear-reduction unit with a maximum 25 lbf (111 N) **OR** 30 lbf (133 N), **as directed**, force for door operation. Provide alloy-steel hand chain with chain holder secured to operator guide.
4. Crank Operator: Consisting of crank and crank gearbox, steel crank drive shaft, and gear-reduction unit, of type indicated. Size gears to require not more than 25 lbf (111 N) **OR** 30 lbf (133 N), **as directed**, force to turn crank. Fabricate gearbox to be oil tight and to completely enclose operating mechanism. Provide manufacturer's standard crank-locking device.

H. Electric Door Operators

1. General: Electric door operator assembly of size and capacity recommended and provided by door manufacturer for door and operation-cycles requirement specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, remote-control stations, control devices, integral gearing for locking door, and accessories required for proper operation.
 - a. Comply with NFPA 70.



- b. Provide control equipment complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6, with NFPA 70 Class 2 control circuit, maximum 24 V, ac or dc.
 2. Usage Classification: Electric operator and components capable of operating for not less than number of cycles per hour indicated for each door.
 3. Door Operator Location(s): Operator location indicated for each door.
 - a. Top-of-Hood Mounted: Operator is mounted to the right or left door head plate with the operator on top of the door-hood assembly and connected to the door drive shaft with drive chain and sprockets. Headroom is required for this type of mounting.
 - b. Front-of-Hood Mounted: Operator is mounted to the right or left door head plate with the operator on coil side of the door-hood assembly and connected to the door drive shaft with drive chain and sprockets. Front clearance is required for this type of mounting.
 - c. Wall Mounted: Operator is mounted to the inside front wall on the left or right side of door and connected to door drive shaft with drive chain and sprockets. Side room is required for this type of mounting. Wall mounted operator can also be mounted above or below shaft; if above shaft, headroom is required.
 - d. Bench Mounted: Operator is mounted to the right or left door head plate and connected to the door drive shaft with drive chain and sprockets. Side room is required for this type of mounting.
 - e. Through-Wall Mounted: Operator is mounted on other side of wall from coil side of door.
 4. Electric Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 11 Section "Common Motor Requirements For Equipment", unless otherwise indicated.
 - a. Electrical Characteristics:
 - 1) Phase: Single phase **OR** Polyphase, **as directed**.
 - 2) Volts: 115 **OR** 208 **OR** 230 **OR** 460, **as directed**, V.
 - 3) Hertz: 60.
 - b. Motor Type and Controller: Reversible motor and controller (disconnect switch) for motor exposure indicated.
 - c. Motor Size: Minimum size as indicated. If not indicated, large enough to start, accelerate, and operate door in either direction from any position, at a speed not less than 8 in./sec. (203 mm/s) and not more than 12 in./sec. (305 mm/s), without exceeding nameplate ratings or service factor.
 - d. Operating Controls, Controllers (Disconnect Switches), Wiring Devices, and Wiring: Manufacturer's standard unless otherwise indicated.
 - e. Coordinate wiring requirements and electrical characteristics of motors and other electrical devices with building electrical system and each location where installed.
 5. Limit Switches: Equip each motorized door with adjustable switches interlocked with motor controls and set to automatically stop door at fully opened and fully closed positions.
 6. Obstruction Detection Device: Equip motorized door with indicated external automatic safety sensor capable of protecting full width of door opening. For non-fire-rated doors, activation of device immediately stops and reverses downward door travel. For fire-rated doors, activation delays closing.
 - a. Photoelectric Sensor: Manufacturer's standard system designed to detect an obstruction in door opening without contact between door and obstruction.
 - 1) Self-Monitoring Type: Designed to interface with door operator control circuit to detect damage to or disconnection of sensing device. When self-monitoring feature is activated, door closes only with sustained pressure on close button.
 - b. Sensor Edge: Automatic safety sensor edge, located within astragal or weather stripping mounted to bottom bar. Contact with sensor activates device. Connect to control circuit using manufacturer's standard take-up reel or self-coiling cable.
 - 1) Self-Monitoring Type: Four-wire configured device designed to interface with door operator control circuit to detect damage to or disconnection of sensor edge.
 7. Remote-Control Station: Momentary-contact, three-button control station with push-button controls labeled "Open," "Close," and "Stop."



- a. Interior units, full-guarded, surface-mounted, heavy-duty type, with general-purpose NEMA ICS 6, Type 1 enclosure.
 - b. Exterior units, full-guarded, standard-duty, surface-mounted, weatherproof type, NEMA ICS 6, Type 4 enclosure, key operated.
 8. Emergency Manual Operation: Equip each electrically powered door with capability for emergency manual operation. Design manual mechanism so required force for door operation does not exceed 25 lbf (111 N) **OR** 30 lbf (133 N), **as directed**.
 9. Emergency Operation Disconnect Device: Equip operator with hand-operated disconnect mechanism for automatically engaging manual operator and releasing brake for emergency manual operation while disconnecting motor without affecting timing of limit switch. Mount mechanism so it is accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.
 10. Motor Removal: Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency manual operation.
 11. Audible and Visual Signals: Audible alarm and visual indicator lights in compliance with regulatory requirements for accessibility.
 12. Radio-Control System: Consisting of the following:
 - a. Three-channel universal coaxial receiver to open, close, and stop door; one **OR** two, **as directed**, per operator.
 - b. Multifunction remote control.
 - c. Remote-antenna mounting kit.
- I. Door Assembly
1. Service **OR** Insulated Service **OR** Counter, **as directed**, Door: Overhead coiling door formed with curtain of interlocking metal slats.
 2. Operation Cycles: Not less than 10,000 **OR** 20,000 **OR** 50,000 **OR** 100,000, **as directed**.
 - a. Include tamperproof cycle counter.
 3. STC Rating: 26.
 4. Curtain R-Value: 4.5 deg F x h x sq. ft./Btu (0.792 K x sq. m/W) **OR** 5.0 deg F x h x sq. ft./Btu (0.881 K x sq. m/W) **OR** 6.0 deg F x h x sq. ft./Btu (1.057 K x sq. m/W), **as directed**.
 5. Door Curtain Material: Galvanized steel **OR** Stainless steel **OR** Aluminum, **as directed**.
 6. Door Curtain Slats: Curved **OR** Flat, **as directed**, profile slats of 1-1/4-inch (32-mm) **OR** 1-1/2-inch (38-mm) **OR** 1-7/8-inch (48-mm) **OR** 2-5/8-inch (67-mm) **OR** 3-1/4-inch (83-mm), **as directed**, center-to-center height.
 - a. Perforated Slats: Approximately 1/16-inch (1.6-mm) pinholes **OR** 3/32-inch (2.4-mm) pinholes **OR** 7/8-inch- (22-mm-) wide by 3/8-inch- (10-mm-) high slots, **as directed**.
 - b. Fenestrated Slats: Approximately 3- by 5/8-inch (76- by 16-mm) **OR** 4- by 5/8-inch (102- by 16-mm) **OR** 10- by 1-5/8-inch (254- by 41-mm), **as directed**, openings spaced approximately 1-1/2 inches (38 mm) apart and beginning 12 inches (305 mm) from jamb guides.
 - c. Vision Panels: Approximately 10- by 1-5/8-inch (254- by 41-mm) openings spaced approximately 2 inches (51 mm) apart and beginning 12 inches (305 mm) from end guides; in two **OR** three, **as directed**, rows of slats at height indicated on Drawings; installed with insulated, **as directed**, vision-panel glazing.
 - d. Insulated-Slat Interior Facing: Metal **OR** Plastic, **as directed**.
 7. Curtain Jamb Guides: Galvanized steel **OR** Stainless steel **OR** Aluminum, **as directed**, with exposed finish matching curtain slats. Provide continuous integral wear strips to prevent metal-to-metal contact and to minimize operational noise. Provide removable post(s) and jamb guides where shown on Drawings.
 8. Pass Door(s): Hinged **OR** Rigid, **as directed**, frame with lockset **OR** exit hardware, **as directed**.
 9. Hood: Match curtain material and finish **OR** Galvanized steel **OR** Stainless steel **OR** Aluminum, **as directed**.
 - a. Shape: Round **OR** Square **OR** As shown on Drawings, **as directed**.
 - b. Mounting: Face of wall **OR** Between jambs **OR** As shown on Drawings, **as directed**.
 10. Integral Frame, Hood, and Fascia for Counter Door: Galvanized steel **OR** Stainless steel, **as directed**.



- a. Mounting: Face of wall **OR** Between jambs **OR** As shown on Drawings, **as directed**.
 11. Sill Configuration for Counter Door: No sill **OR** Integral metal sill, **as directed**.
 12. Locking Devices: Equip door with slide bolt for padlock **OR** locking device assembly, **as directed**, and chain lock keeper, **as directed**.
 - a. Locking Device Assembly: Single-jamb side **OR** Cremone type, both jamb sides, **as directed**, locking bars, operable from inside with thumb turn **OR** outside with cylinder **OR** outside only, with cylinder **OR** inside and outside with cylinders, **as directed**.
 13. Manual Door Operator: Push-up operation **OR** Chain-hoist operator **OR** Manufacturer's standard crank operator **OR** Awning-crank operator **OR** Wall-crank operator, **as directed**.
 - a. Provide operator with through-wall shaft operation.
 - b. Provide operator with manufacturer's standard removable operating arm.
 14. Electric Door Operator:
 - a. Usage Classification: Heavy duty, 60 to 90 cycles per hour **OR** Standard duty, up to 60 cycles per hour **OR** Medium duty, up to 15 cycles per hour **OR** Light duty, up to 10 cycles per hour, **as directed**.
 - b. Operator Location: Top of hood **OR** Front of hood **OR** Wall **OR** Bench **OR** Through wall **OR** As shown on Drawings, **as directed**.
 - c. Motor Exposure: Interior **OR** Exterior, wet, and humid, **as directed**.
 - d. Emergency Manual Operation: Push-up **OR** Chain **OR** Crank, **as directed**, type.
 - e. Obstruction-Detection Device: Automatic photoelectric sensor **OR** electric sensor edge on bottom bar **OR** pneumatic sensor edge on bottom bar, **as directed**; self-monitoring type, **as directed**.
 - 1) Sensor Edge Bulb Color: Black **OR** As selected from manufacturer's full range, **as directed**.
 - f. Remote-Control Station: Interior **OR** Exterior **OR** Where shown on Drawings, **as directed**.
 - g. Other Equipment: Audible and visual signals **OR** Radio-control system, **as directed**.
 15. Door Finish:
 - a. Aluminum Finish: Mill **OR** Clear anodized **OR** Light bronze anodized **OR** Medium bronze anodized **OR** Dark bronze anodized **OR** Black anodized **OR** Anodized color matching sample **OR** Anodized color as selected from full range of industry colors and color densities, **as directed**.
 - b. Baked-Enamel or Powder-Coated Finish: Color as indicated by manufacturer's designations **OR** Color matching sample **OR** Color as selected from manufacturer's full range, **as directed**.
 - c. Factory Prime Finish: Manufacturer's standard color.
 - d. Stainless-Steel Finish: No. 2B (bright, cold rolled) **OR** No. 4 (polished directional satin), **as directed**.
 - e. Interior Curtain-Slat Facing: Match finish of exterior curtain-slat face **OR** PVC plastic, **as directed**.
- J. Fire-Rated Door Assembly
1. Fire-Rated Service **OR** Insulated Service **OR** Counter, **as directed**, Door: Overhead fire-rated coiling door formed with curtain of interlocking metal slats.
 2. Operation Cycles: Not less than 10,000 **OR** 20,000 **OR** 50,000 **OR** 100,000, **as directed**.
 - a. Include tamperproof cycle counter.
 3. Fire Rating: 3/4 hour **OR** 1 hour **OR** 1-1/2 hours **OR** 3 hours **OR** 4 hours, **as directed**, with temperature-rise limit, **as directed**, and with smoke control, **as directed**.
 4. STC Rating: 27.
 5. Curtain R-Value: 4.5 deg F x h x sq. ft./Btu (0.792 K x sq. m/W) **OR** 5.0 deg F x h x sq. ft./Btu (0.881 K x sq. m/W) **OR** 6.0 deg F x h x sq. ft./Btu (1.057 K x sq. m/W), **as directed**.
 6. Door Curtain Material: Galvanized steel **OR** Stainless steel, **as directed**.
 7. Door Curtain Slats: Curved **OR** Flat, **as directed**, profile slats of 1-1/4-inch (32-mm) **OR** 1-1/2-inch (38-mm) **OR** 1-7/8-inch (48-mm) **OR** 2-5/8-inch (67-mm) **OR** 3-1/4-inch (83-mm), **as directed**, center-to-center height.



- a. Vision Panels: Approximately 10- by 1-5/8-inch (254- by 41-mm) openings spaced approximately 2 inches (51 mm) apart and beginning 12 inches (305 mm) from end guides; in two **OR** three, **as directed**, rows of slats at height indicated on Drawings; installed with fire-rated vision-panel glazing.
- b. Insulated-Slat Interior Facing: Metal.
8. Curtain Jamb Guides: Galvanized steel **OR** Stainless steel, **as directed**, with exposed finish matching curtain slats.
9. Pass Door(s): Hinged **OR** Rigid, **as directed**, frame with lockset **OR** exit hardware, **as directed**.
10. Hood: Match curtain material and finish **OR** Galvanized steel **OR** Stainless steel, **as directed**.
 - a. Shape: Round **OR** Square **OR** As shown on Drawings, **as directed**.
 - b. Mounting: Face of wall **OR** Between jambs **OR** As shown on Drawings, **as directed**.
11. Integral Frame, Hood, and Fascia for Counter Door: Galvanized steel **OR** Stainless steel, **as directed**.
 - a. Mounting: Face of wall **OR** Between jambs **OR** As shown on Drawings, **as directed**.
12. Sill Configuration for Fire-Rated Counter Door: No sill **OR** Integral metal sill **OR** Fire-rated, laminate counter, **as directed**.
 - a. High-Pressure Decorative Laminate: Match color, pattern, and finish as indicated by manufacturer's designations **OR** of sample **OR** as selected from manufacturer's full range, **as directed**.
13. Locking Devices: Equip door with slide bolt for padlock **OR** locking device assembly, **as directed**, and chain lock keeper, **as directed**.
 - a. Locking Device Assembly: Single-jamb side **OR** Cremone type, both jamb sides, **as directed**, locking bars, operable from inside with thumbturn **OR** outside with cylinder **OR** outside only, with cylinder **OR** inside and outside with cylinders, **as directed**.
14. Manual Door Operator: Push-up operation **OR** Chain-hoist operator **OR** Manufacturer's standard crank operator **OR** Awning-crank operator **OR** Wall-crank operator, **as directed**.
 - a. Provide operator with through-wall shaft operation.
 - b. Provide operator with manufacturer's standard removable operating arm.
15. Electric Door Operator:
 - a. Usage Classification: Heavy duty, 60 to 90 cycles per hour **OR** Standard duty, up to 60 cycles per hour **OR** Medium duty, up to 15 cycles per hour **OR** Light duty, up to 10 cycles per hour, **as directed**.
 - b. Operator Location: Top of hood **OR** Front of hood **OR** Wall **OR** Bench **OR** Through wall **OR** As shown on Drawings, **as directed**.
 - c. Motor Exposure: Interior **OR** Exterior, wet, and humid, **as directed**.
 - d. Emergency Manual Operation: Push-up **OR** Chain **OR** Crank, **as directed**, type.
 - e. Obstruction Detection Device: Automatic photoelectric sensor **OR** electric sensor edge on bottom bar **OR** pneumatic sensor edge on bottom bar, **as directed**; self-monitoring type, **as directed**.
 - 1) Sensor Edge Bulb Color: Black **OR** As selected from manufacturer's full range, **as directed**.
 - f. Remote-Control Station: Interior **OR** Exterior **OR** Where shown on Drawings, **as directed**.
 - g. Other Equipment: Audible and visual signals **OR** Radio-control system, **as directed**.
16. Door Finish:
 - a. Baked-Enamel or Powder-Coated Finish: Color as indicated by manufacturer's designations **OR** Color matching sample **OR** Color as selected from manufacturer's full range, **as directed**.
 - b. Factory Prime Finish: Manufacturer's standard color.
 - c. Stainless-Steel Finish: No. 2B (bright, cold rolled) **OR** No. 4 (polished directional satin), **as directed**.
 - d. Interior Curtain-Slat Facing: Match finish of exterior curtain-slat face.

K. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.



2. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

L. Aluminum Finishes

1. Mill Finish: Manufacturer's standard.
2. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
3. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
4. Baked-Enamel or Powder-Coat Finish: AAMA 2603. Comply with coating manufacturer's written instructions for cleaning, conversion coating, application, and baking.

M. Steel And Galvanized-Steel Finishes

1. Factory Prime Finish: Manufacturer's standard primer, compatible with field-applied finish. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.
2. Baked-Enamel or Powder-Coat Finish: Manufacturer's standard baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.

N. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - c. Directional Satin Finish: No. 4.
3. Bright, Cold-Rolled, Unpolished Finish: No. 2B.

1.3 EXECUTION

A. Installation

1. Install overhead coiling doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.
2. Install overhead coiling doors, hoods, and operators at the mounting locations indicated for each door.
3. Accessibility: Install overhead coiling doors, switches, and controls along accessible routes in compliance with regulatory requirements for accessibility.
4. Fire-Rated Doors: Install according to NFPA 80.
5. Smoke-Control Doors: Install according to NFPA 80 and NFPA 105.

B. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
 - a. Perform installation and startup checks according to manufacturer's written instructions.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - c. Test door closing when activated by detector or alarm-connected fire-release system. Reset door-closing mechanism after successful test.

C. Adjusting

1. Adjust hardware and moving parts to function smoothly so that doors operate easily, free of warp, twist, or distortion.



2. Lubricate bearings and sliding parts as recommended by manufacturer.
3. Adjust seals to provide weathertight fit around entire perimeter.

END OF SECTION 08 33 13 00



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Task	Specification	Specification Description
08 33 23 00	08 33 13 00	Overhead Coiling Doors



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SECTION 08 33 26 00 - OVERHEAD COILING GRILLES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for overhead coiling grilles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Open-curtain overhead coiling grilles.
 - b. Closed-curtain overhead coiling grilles.

C. Performance Requirements

1. Delegated Design: Design overhead coiling grilles, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Overhead coiling grilles shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. Seismic Component Importance Factor: 1.5 **OR** 1.0, **as directed**.
3. Operation Cycles: Provide overhead coiling grille components and operators capable of operating for not less than number of cycles indicated for each grille. One operation cycle is complete when a grille is opened from the closed position to the fully open position and returned to the closed position.

D. Submittals

1. Product Data: For each type and size of overhead coiling grille and accessory. Include the following:
 - a. Construction details, material descriptions, dimensions of individual components, profiles for curtain components, and finishes.
 - b. Rated capacities, operating characteristics, electrical characteristics, and furnished accessories.
2. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each type of exposed finish required, prepared on Samples of size indicated below.
 - a. Open-Curtain Grille: 18-inch- (457-mm-) square assembly with full-size components consisting of rods, spacers, and links as required to illustrate each assembly, including glazed inserts, **as directed**.
 - b. Closed-Curtain Grille: 18-inch- (457-mm-) square assembly with full-size components consisting of ribs and infill as required to illustrate each assembly.
 - c. Bottom Bar: 6 inches (150 mm) long with sensor edge, **as directed**.
 - d. Guides: 6 inches (150 mm) long.
 - e. Mounting Frame: 6 inches (150 mm) long.
 - f. Brackets: 6 inches (150 mm) square.
 - g. Hood: 6 inches (150 mm) square.



4. Delegated-Design Submittal: For overhead coiling grilles indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of seismic restraints.
 - b. Summary of forces and loads on walls and jambs.
5. Qualification Data: For qualified Installer.
6. Seismic Qualification Certificates: For overhead coiling grilles, accessories, and components, from manufacturer.
7. Maintenance Data: For overhead coiling grilles to include in maintenance manuals.

E. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for both installation and maintenance of units required for this Project.
2. Source Limitations: Obtain overhead coiling grilles from single source from single manufacturer.
 - a. Obtain operators and controls from overhead coiling grille manufacturer.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1.

1.2 PRODUCTS

A. Grille Curtain Materials And Construction

1. Open-Curtain Grilles: Fabricate metal grille curtain as an open network of horizontal rods, spaced at regular intervals, that are interconnected with vertical links, which are formed and spaced as indicated and are free to rotate on the rods.
 - a. Aluminum Grille Curtain: ASTM B 221 (ASTM B 221M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
 - b. Stainless-Steel Grille Curtain: ASTM A 666, Type 300 series.
 - c. Steel Grille Curtain: Hot-dip zinc-coated (galvanized) complying with ASTM A 123/A 123M, or electrogalvanized complying with ASTM 653/A 653M, and phosphatized before fabrication.
 - d. Glazing Insert: Manufacturer's standard glazing of clear polycarbonate sheet secured by the curtain links.
2. Closed-Curtain Grilles: Fabricate curtain as a series of horizontal double-C ribs, spaced at regular intervals, that alternate with continuous horizontal infill panels secured by the ribs.
 - a. Aluminum Horizontal Ribs: ASTM B 221 (ASTM B 221M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
 - b. Glass Panels: Uncoated, clear, heat-treated, fully tempered float glass; complying with ASTM C 1048, Condition A, Type I, Class I, Quality q3, Kind FT; manufacturer's standard panel dimensions and thickness.
 - c. Plastic Panels: Fire-retardant polycarbonate sheet manufactured by the extrusion process; UV resistant; manufacturer's standard panel dimensions and thickness.
 - d. Aluminum Panels: ASTM B 209 (ASTM B 209M), alloy and temper standard with manufacturer for type of use and finish indicated; manufacturer's standard panel dimensions and thickness; finished to match ribs.
 - 1) Perforations: Manufacturer's standard pinholes.
3. Endlocks: Continuous end links, chains, or other devices at ends of rods; locking and retaining grille curtain in guides against excessive pressures, maintaining grille curtain alignment, and preventing lateral movement.
4. Bottom Bar: Manufacturer's standard continuous channel or tubular shape, finished to match grille.



- a. Astragal: Equip each grille bottom bar with a replaceable, adjustable, continuous, compressible gasket of flexible vinyl, rubber, or neoprene as a cushion bumper.
 - b. Provide motor-operated grilles with combination bottom astragal and sensor edge.
 5. Grille Curtain Jamb Guides: Manufacturer's standard shape having curtain groove with return lips or bars to retain curtain. Provide continuous integral wear strips to prevent metal-to-metal contact and to minimize operational noise; with removable stops on guides to prevent overtravel of curtain.
 - a. Removable Posts and Jamb Guides: Manufacturer's standard.
- B. Hoods And Accessories
 1. General: Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.
 - a. Galvanized Steel: Nominal 0.028-inch- (0.71-mm-) thick, hot-dip galvanized steel sheet with G90 (Z275) zinc coating, complying with ASTM A 653/A 653M.
 - b. Stainless Steel: 0.025-inch- (0.64-mm-) thick stainless-steel sheet, Type 304, complying with ASTM A 666.
 - c. Aluminum: 0.040-inch- (1.02-mm-) thick aluminum sheet complying with ASTM B 209 (ASTM B 209M), of alloy and temper recommended by manufacturer and finisher for type of use and finish indicated.
 2. Removable Metal Soffit: Formed or extruded from same metal and with same finish as curtain if hood is mounted above ceiling, unless otherwise indicated.
 3. Mounting Frame: Manufacturer's standard mounting frame designed to support grille; factory fabricated from ASTM A 36/A 36M structural-steel tubes or shapes, hot-dip galvanized per ASTM A 123/A 123M; fastened to floor and structure above grille; to be built into wall construction; and complete with anchors, connections, and fasteners.
 4. Push/Pull Handles: Equip each push-up-operated or emergency-operated grille with lifting handles on each side of grille, finished to match grille.
 - a. Provide pull-down straps or pole hooks for grilles more than 84 inches (2130 mm) high.
- C. Locking Devices
 1. Slide Bolt: Fabricate with side-locking bolts to engage through slots in tracks for locking by padlock, located on both left and right jamb sides, operable from coil side.
 2. Locking Device Assembly: Fabricate with cylinder lock, spring-loaded dead bolt, operating handle, cam plate, and adjustable locking bars to engage through slots in tracks.
 - a. Lock Cylinders: Provide cylinders specified in Division 08 Section "Door Hardware" **OR** standard with manufacturer, **as directed**, and keyed to building keying system, **as directed**.
 - b. Keys: Two **OR** Three, **as directed**, for each cylinder.
 3. Chain Lock Keeper: Suitable for padlock.
 4. Safety Interlock Switch: Equip power-operated grilles with safety interlock switch to disengage power supply when grille is locked.
- D. Counterbalancing Mechanism
 1. General: Counterbalance grilles by means of manufacturer's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.
 2. Counterbalance Barrel: Fabricate spring barrel of manufacturer's standard hot-formed, structural-quality, welded or seamless carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of parts and to limit barrel deflection to not more than 0.03 in./ft. (2.5 mm/m) of span under full load.



3. Spring Balance: One or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Secure ends of springs to barrel and shaft with cast-steel barrel plugs.
4. Torsion Rod for Counterbalance Shaft: Fabricate of manufacturer's standard cold-rolled steel, sized to hold fixed spring ends and carry torsional load.
5. Brackets: Manufacturer's standard mounting brackets of either cast iron or cold-rolled steel plate.

E. Manual Grille Operators

1. Equip grille with manufacturer's recommended manual grille operator unless another type of grille operator is indicated.
2. Push-up Grille Operation: Design counterbalance mechanism so required lift or pull for grille operation does not exceed 25 lbf (111 N).
3. Chain-Hoist Operator: Consisting of endless steel hand chain, chain-pocket wheel and guard, and gear-reduction unit with a maximum 25 lbf (111 N) **OR** 30 lbf (133 N), **as directed**, force for grille operation. Provide alloy-steel hand chain with chain holder secured to operator guide.
4. Crank Operator: Consisting of crank and crank gearbox, steel crank drive shaft, and gear-reduction unit, of type indicated. Size gears to require not more than 25 lbf (111 N) **OR** 30 lbf (133 N), **as directed**, force to turn crank. Fabricate gearbox to be oil tight and to completely enclose operating mechanism. Provide manufacturer's standard crank-locking device.

F. Electric Grille Operators

1. General: Electric grille operator assembly of size and capacity recommended and provided by grille manufacturer for grille and operation-cycles requirement specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, remote-control stations, control devices, integral gearing for locking grille, and accessories required for proper operation.
 - a. Comply with NFPA 70.
 - b. Provide control equipment complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6, with NFPA 70 Class 2 control circuit, maximum 24 V, ac or dc.
2. Usage Classification: Electric operator and components capable of operating for not less than number of cycles per hour indicated for each grille.
3. Grille Operator Location(s): Operator location indicated for each grille.
 - a. Top-of-Hood Mounted: Operator is mounted to the right or left grille head plate with the operator on top of the grille-hood assembly and connected to the grille drive shaft with drive chain and sprockets. Headroom is required for this type of mounting.
 - b. Front-of-Hood Mounted: Operator is mounted to the right or left grille head plate with the operator on coil side of the grille-hood assembly and connected to the grille drive shaft with drive chain and sprockets. Front clearance is required for this type of mounting.
 - c. Wall Mounted: Operator is mounted to the inside front wall on the left or right side of grille and connected to grille drive shaft with drive chain and sprockets. Side room is required for this type of mounting. Wall mounted operator can also be mounted above or below shaft; if above shaft, headroom is required.
 - d. Bench Mounted: Operator is mounted to the right or left grille head plate and connected to the grille drive shaft with drive chain and sprockets. Side room is required for this type of mounting.
 - e. Through-Wall Mounted: Operator is mounted on other side of wall from coil-side of grille.
4. Electric Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 11 Section "Common Motor Requirements For Equipment" unless otherwise indicated.
 - a. Electrical Characteristics:
 - 1) Phase: Single phase **OR** Polyphase, **as directed**.
 - 2) Volts: 115 **OR** 208 **OR** 230 **OR** 460, **as directed**, V.
 - 3) Hertz: 60.
 - b. Motor Type and Controller: Reversible motor and controller (disconnect switch) for motor exposure indicated.



- c. Motor Size: Minimum size as indicated. If not indicated, large enough to start, accelerate, and operate grille in either direction from any position, at a speed not less than 8 in./sec. (203 mm/s) and not more than 12 in./sec. (305 mm/s), without exceeding nameplate ratings or service factor.
 - d. Operating Controls, Controllers (Disconnect Switches), Wiring Devices, and Wiring: Manufacturer's standard unless otherwise indicated.
 - e. Coordinate wiring requirements and electrical characteristics of motors and other electrical devices with building electrical system and each location where installed.
 5. Limit Switches: Equip each motorized grille with adjustable switches interlocked with motor controls and set to automatically stop grille at fully opened and fully closed positions.
 6. Obstruction Detection Device: Equip motorized grille with indicated external automatic safety sensor capable of protecting full width of grille opening. Activation of sensor immediately stops and reverses downward grille travel.
 - a. Photoelectric Sensor: Manufacturer's standard system designed to detect an obstruction in grille opening without contact between grille and obstruction.
 - 1) Self-Monitoring Type: Designed to interface with grille operator control circuit to detect damage to or disconnection of sensing device. When self-monitoring feature is activated, grille closes only with sustained pressure on close button.
 - b. Sensor Edge: Automatic safety sensor edge, located within astragal or weather stripping mounted to bottom bar. Contact with sensor activates device. Connect to control circuit using manufacturer's standard take-up reel or self-coiling cable.
 - 1) Self-Monitoring Type: Four-wire configured device designed to interface with grille operator control circuit to detect damage to or disconnection of sensing device.
 7. Remote-Control Station: Momentary-contact, three-button control station with push-button controls labeled "Open," "Close," and "Stop."
 - a. Interior units, full-guarded, surface-mounted, heavy-duty type, with general-purpose NEMA ICS 6, Type 1 enclosure.
 - b. Exterior units, full-guarded, standard-duty, surface-mounted, weatherproof type; NEMA ICS 6, Type 4 enclosure, key operated.
 8. Emergency Manual Operation: Equip each electrically powered grille with capability for emergency manual operation. Design manual mechanism so required force for grille operation does not exceed 25 lbf (111 N) **OR** 30 lbf (133 N), **as directed**.
 9. Emergency Operation Disconnect Device: Equip operator with hand-operated disconnect mechanism for automatically engaging manual operator and releasing brake for emergency manual operation while disconnecting motor without affecting timing of limit switch. Mount mechanism so it is accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.
 10. Motor Removal: Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency manual operation.
 11. Audible and Visual Signals: Audible alarm and visual indicator lights in compliance with regulatory requirements for accessibility.
 12. Emergency-Egress Release: Flush, wall-mounted handle mechanism, for ADA-ABA-compliant egress feature, not dependent on electric power. The release allows an unlocked grille to partially open without affecting limit switches to permit passage, and it automatically resets motor drive upon return of handle to original position.
 13. Self-Opening Mechanism: Automatic release mechanism triggered by smoke detector, **OR** emergency push-button station, **as directed**, fire alarm or power failure. When activated, the grille self opens by means of a fail-safe operator to the fully open position without the need of power operation or battery backup systems. When the alarm is cleared **OR** emergency push-button is reset, and the alarm is cleared, **as directed**, and power is restored, the grille will operate normally.
- G. Open-Curtain Grille Assembly
1. Open-Curtain Grille: Overhead coiling grille with a curtain having a network of horizontal rods that interconnect with vertical links.
 2. Operation Cycles: Not less than 10,000 **OR** 20,000 **OR** 50,000 **OR** 100,000, **as directed**.



- a. Include tamperproof cycle counter.
3. Grille Curtain Material: Aluminum **OR** Stainless steel **OR** Galvanized steel, **as directed**.
 - a. Space rods at approximately 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm), **as directed**, o.c.
 - b. Space links approximately 3 inches (76 mm) **OR** 6 inches (152 mm) **OR** 9 inches (228 mm), **as directed**, apart in a straight in-line **OR** brick (staggered), **as directed**, pattern.
 - c. Glazing Inserts: Manufacturer's standard.
 - d. Spacers: Metal tubes matching curtain material **OR** PVC, **as directed**.
4. Curtain Jamb Guides: Aluminum **OR** Stainless steel **OR** Galvanized steel, **as directed**, with exposed finish matching curtain slats. Provide continuous integral wear strips to prevent metal-to-metal contact and to minimize operational noise. Provide removable post(s) and jamb guides where shown on Drawings, **as directed**.
5. Hood: Match curtain material and finish **OR** Aluminum **OR** Stainless steel **OR** Galvanized steel, **as directed**.
 - a. Shape: Round **OR** Square **OR** As shown on Drawings, **as directed**.
 - b. Mounting: Face of wall **OR** Between jambs **OR** On mounting frame **OR** As shown on Drawings, **as directed**.
6. Locking Devices: Equip grille with slide bolt for padlock **OR** locking device assembly, **as directed**, and chain lock keeper, **as directed**.
 - a. Locking Device Assembly: Single-jamb side **OR** Cremone type, both jamb sides, **as directed**, locking bars, operable from inside with thumb turn **OR** outside with cylinder **OR** outside only, with cylinder **OR** inside and outside with cylinders, **as directed**.
7. Manual Grille Operator: Push-up operation **OR** Chain-hoist operator **OR** Manufacturer's standard crank operator **OR** Awning-crank operator **OR** Wall-crank operator, **as directed**.
 - a. Provide operator with through-wall shaft operation.
 - b. Provide operator with manufacturer's standard removable operating arm.
8. Electric Grille Operator:
 - a. Usage Classification: Heavy duty, 60 to 90 cycles per hour **OR** Standard duty, up to 60 cycles per hour **OR** Medium duty, up to 15 cycles per hour **OR** Light duty, up to 10 cycles per hour, **as directed**.
 - b. Operator Location: Top of hood **OR** Front of hood **OR** Wall **OR** Bench **OR** Through wall **OR** As shown on Drawings, **as directed**.
 - c. Motor Exposure: Interior **OR** Exterior, wet, and humid, **as directed**.
 - d. Emergency Manual Operation: Push-up **OR** Chain **OR** Crank, **as directed**, type.
 - e. Obstruction-Detection Device: Automatic photoelectric sensor **OR** electric sensor edge on bottom bar **OR** pneumatic sensor edge on bottom bar, **as directed**; self-monitoring type, **as directed**.
 - 1) Sensor Edge Bulb Color: Black **OR** As selected from manufacturer's full range, **as directed**.
 - f. Remote-Control Station: Interior **OR** Exterior **OR** Where shown on Drawings, **as directed**.
 - g. Other Equipment: Audible and visual signals **OR** Emergency-egress release **OR** Self-opening mechanism, **as directed**.
9. Grille Finish:
 - a. Aluminum Finish: Mill **OR** Clear anodized **OR** Light bronze anodized **OR** Medium bronze anodized **OR** Dark bronze anodized **OR** Black anodized **OR** Anodized color matching sample **OR** Anodized color as selected from full range of industry colors and color densities, **as directed**.
 - b. Baked-Enamel or Powder-Coated Finish: Color as indicated by manufacturer's designations **OR** Color matching sample **OR** Color as selected from manufacturer's full range, **as directed**.
 - c. Factory Prime Finish: Manufacturer's standard color.
 - d. Stainless-Steel Finish: No. 2B (bright, cold rolled) **OR** No. 4 (polished directional satin), **as directed**.
 - e. PVC Spacers: Color as indicated by manufacturer's designations **OR** Color as selected from manufacturer's full range, **as directed**.



- H. Closed-Curtain Grille Assembly
1. Closed-Curtain Grille: Overhead coiling grille with a curtain having a series of horizontal ribs alternating with continuous horizontal infill panels secured by the ribs.
 2. Operation Cycles: Not less than 10,000 **OR** 20,000 **OR** 50,000 **OR** 100,000, **as directed**.
 - a. Include tamperproof cycle counter.
 3. Grille Curtain Material: Aluminum ribs with continuous inserts indicated.
 - a. Space ribs at approximately 3 inches (76 mm), **as directed**, o.c.
 - b. Inserts: Glass panels.
 - c. Inserts: Clear, transparent **OR** Translucent, **as directed**, plastic panels.
 - d. Inserts: Solid **OR** Perforated, **as directed**, aluminum panels.
 4. Curtain Jamb Guides: Aluminum with exposed finish matching curtain slats. Provide continuous integral wear strips to prevent metal-to-metal contact and to minimize operational noise. Provide removable post(s) and jamb guides where shown on Drawings, **as directed**.
 5. Hood: Match curtain material and finish **OR** Aluminum **OR** Stainless steel **OR** Galvanized steel, **as directed**.
 - a. Shape: Round **OR** Square **OR** As shown on Drawings, **as directed**.
 - b. Mounting: Face of wall **OR** Between jambs **OR** On mounting frame **OR** As shown on Drawings, **as directed**.
 6. Locking Devices: Equip grille with slide bolt for padlock **OR** locking device assembly, **as directed**, and chain lock keeper, **as directed**.
 - a. Locking Device Assembly: Single-jamb side **OR** Cremone type, both jamb sides, **as directed**, locking bars, operable from inside with thumbturn **OR** outside with cylinder **OR** outside only, with cylinder **OR** inside and outside with cylinders, **as directed**.
 7. Manual Grille Operator: Push-up operation **OR** Chain-hoist operator **OR** Manufacturer's standard crank operator **OR** Awning-crank operator **OR** Wall-crank operator, **as directed**.
 - a. Provide operator with through-wall shaft operation.
 - b. Provide operator with manufacturer's standard removable operating arm.
 8. Electric Grille Operator:
 - a. Usage Classification: Heavy duty, 60 to 90 cycles per hour **OR** Standard duty, up to 60 cycles per hour **OR** Medium duty, up to 15 cycles per hour **OR** Light duty, up to 10 cycles per hour, **as directed**.
 - b. Operator Location: Top of hood **OR** Front of hood **OR** Wall **OR** Bench **OR** Through wall **OR** As shown on Drawings, **as directed**.
 - c. Motor Exposure: Interior **OR** Exterior, wet, and humid, **as directed**.
 - d. Emergency Manual Operation: Push-up **OR** Chain **OR** Crank, **as directed**, type.
 - e. Obstruction-Detection Device: Automatic photoelectric sensor **OR** electric sensor edge on bottom bar **OR** pneumatic sensor edge on bottom bar, **as directed**; self-monitoring type, **as directed**.
 - 1) Sensor Edge Bulb Color: Black **OR** As selected from manufacturer's full range, **as directed**.
 - f. Remote-Control Station: Interior **OR** Exterior **OR** Where shown on Drawings, **as directed**.
 - g. Other Equipment: Audible and visual signals **OR** Emergency-egress release **OR** Self-opening mechanism, **as directed**.
 9. Grille Finish:
 - a. Aluminum Finish: Mill **OR** Clear anodized **OR** Light bronze anodized **OR** Medium bronze anodized **OR** Dark bronze anodized **OR** Black anodized **OR** Anodized color matching sample **OR** Anodized color as selected from full range of industry colors and color densities, **as directed**.
 - b. Baked-Enamel or Powder-Coated Finish: Color as indicated by manufacturer's designations **OR** Color matching sample **OR** Color as selected from manufacturer's full range, **as directed**.
 - c. Factory Prime Finish: Manufacturer's standard color.
 - d. Stainless-Steel Finish: No. 2B (bright, cold rolled) **OR** No. 4 (polished directional satin), **as directed**.

I. General Finish Requirements



1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

J. Aluminum Finishes

1. Mill Finish: Manufacturer's standard.
2. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
3. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
4. Baked-Enamel or Powder-Coat Finish: AAMA 2603. Comply with coating manufacturer's written instructions for cleaning, conversion coating, application, and baking.

K. Steel And Galvanized-Steel Finishes

1. Factory Prime Finish: Manufacturer's standard primer, compatible with field-applied finish. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.
2. Baked-Enamel or Powder-Coat Finish: Manufacturer's standard baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.

L. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - c. Directional Satin Finish: No. 4.
3. Bright, Cold-Rolled, Unpolished Finish: No. 2B.

1.3 EXECUTION

A. Examination

1. Examine substrates areas and conditions, with Installer present, for compliance with requirements for substrate construction and other conditions affecting performance of the Work.
2. Examine locations of electrical connections.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Install overhead coiling grilles and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.
2. Install overhead coiling grilles, hoods, and operators at the mounting locations indicated for each grille.
3. Accessibility: Install overhead coiling grilles, switches, and controls along accessible routes in compliance with regulatory requirements for accessibility.

C. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
 - a. Perform installation and startup checks according to manufacturer's written instructions.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.



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- c. Test grille opening when activated by detector, fire-alarm system, emergency-egress release, or self-opening mechanism as required. Reset grille-opening mechanism after successful test.

 - D. Adjusting
 - 1. Adjust hardware and moving parts to function smoothly so that grilles operate easily, free of warp, twist, or distortion.
 - 2. Lubricate bearings and sliding parts as recommended by manufacturer.

 - E. Demonstration
 - 1. Train Owner's maintenance personnel to adjust, operate, and maintain overhead coiling grilles.

END OF SECTION 08 33 26 00



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SECTION 08 33 36 00 - SIDE COILING GRILLES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for side coiling grilles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Performance Requirements

1. Operation-Cycle Requirements: Provide side coiling grille components and operators capable of operating for not less than 10,000 **OR** 20,000, **as directed**, cycles and for 10 cycles per day.

C. Submittals

1. Product Data: For each type and size of side coiling grille and accessory.
2. Shop Drawings: Include plans, elevations, sections, details, and attachment to other work.
3. Samples: For each exposed finish.

D. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for both installation and maintenance of units required for this Project.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100.

1.2 PRODUCTS

A. Grille Curtain Materials And Construction

1. Grille Curtain: Network of 1/4-inch- (6-mm-) **OR** 5/16-inch- (8-mm-), **as directed**, minimum diameter horizontal rods, or rods covered with tube spacers. Interconnect rods by vertical links approximately 5/8 inch (16 mm) wide and rotating on rods.
 - a. Space rods at approximately 1-1/2 inches (38 mm) o.c.
 - b. Space links approximately 3 inches (76 mm) apart in a straight in-line **OR** staggered, **as directed**, pattern.
 - c. Steel Grille Curtain: Hot-dip zinc-coated (galvanized), complying with ASTM A 123/A 123M, or electrogalvanized complying with ASTM 653/A 653M, and phosphatized before fabrication.
 - d. Stainless-Steel Grille Curtain: ASTM A 666, Type 300 series.
 - e. Aluminum Grille Curtain: ASTM B 221 (ASTM B 221M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
2. Top Track: Extruded aluminum channel mechanically attached to a support angle with provisions for take-up bolts to compensate for a maximum deflection of 1/2-inch.
3. Bottom Track: Manufacturer's standard, finished to match grille.
4. Coil Box: Entirely enclose coiled grille, operating mechanism, supporting disk and the drum around which the grille will coil.
5. Power Operated Grille: Safety interlock switch to disengage power supply when grille is locked.
6. Manual Grille Operator: Crank or Push-Pull.
7. Electric Grille Operator: Manufacturer's standard type, size, and capacity for grille and operation-cycle requirements specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, remote-control stations, control devices, integral gearing for locking grille, and accessories. Comply with NFPA 70.
 - a. Disconnect Device: Hand-operated for automatically engaging chain and sprocket operator and releasing brake for emergency manual operation while disconnecting motor,



without affecting timing of limit switch. Mount to be accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.

- b. Grille-Operator Type: Wall- or bracket-mounted unit with electric motor, gear-reduction drive, and chain and sprocket secondary drive.
8. Electric Motors: High-starting torque, reversible, continuous-duty, polyphase, Class A insulated, electric motors complying with NEMA MG 1; with overload protection; sized to start, accelerate, and operate grille in either direction from any position, at not less than 2/3 fps (0.2 m/s) and not more than 1 fps (0.3 m/s), without exceeding nameplate ratings or service factor. Coordinate wiring requirements and electrical characteristics of motors with building electrical system.
 - a. Open dripproof-type motor, and controller with NEMA ICS 6, Type 1 enclosure.
 - b. Totally enclosed, nonventilated or fan-cooled motor, fitted with plugged drain, and controller with NEMA ICS 6, Type 4 enclosure where indicated.
9. Remote-Control Station: Momentary-contact **OR** Sustained-pressure, **as directed**, three-button control station; fully guarded, weatherproof (if for exterior location), key operated.
10. Obstruction Detection Device: External automatic safety sensor capable of protecting full width of grille opening. Activation of sensor immediately stops and reverses grille travel.
11. Provide electric operators with ADA-compliant audible alarm and visual indicator lights.

B. Finishes

1. Aluminum Anodic Finish: Mill finish **OR** Class II, clear anodic coating complying with AAMA 611, **as directed**.
2. Galvanized Steel Finish: Manufacturer's standard primer **OR** Powder-coat finish, **as directed**.
 - a. Color and Gloss: As selected from manufacturer's full range.
 - b. Painting is specified in Division 09 Section(s) "Interior Painting" **OR** "Staining And Transparent Finishing".
3. Stainless-Steel Finish: Bright, cold-rolled, unpolished finish: No. 2B finish **OR** Bright, directional polish: No. 4 finish, **as directed**.

1.3 EXECUTION

A. Installation

1. General: Install side coiling grilles and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports.
2. Lubricate bearings and sliding parts; adjust grilles to operate easily, free of warp, twist, or distortion.

END OF SECTION 08 33 36 00



Task	Specification	Specification Description
08 33 39 00	01 22 16 00	No Specification Required
08 34 13 00	01 22 16 00	No Specification Required
08 34 16 00	01 22 16 00	No Specification Required
08 34 23 00	08 31 13 00	Access Doors And Frames



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SECTION 08 34 49 13 - RADIATION PROTECTION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for radiation protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Lead sheet, strip, and plate.
 - b. Lead bricks.
 - c. Lead glass.
 - d. Lead glazing plastic.
 - e. Lead-lined building materials and products including the following:
 - 1) Concrete masonry units.
 - 2) Gypsum lath.
 - 3) Gypsum base for gypsum veneer plaster and board.
 - 4) Steel hollow-metal doors and door frames.
 - 5) Wood doors.
 - 6) Observation-window frames.
 - 7) Modular shielding partitions.
 - 8) Film transfer cabinets.
 - 9) Neutron-shielding doors, frames, and hardware.
 - f. Informational signs.

C. Definitions

1. Lead Equivalence: The thickness of lead that provides the same attenuation (reduction of radiation passing through) as the material in question under the specified conditions.
 - a. Lead equivalence specified for materials used in diagnostic x-ray rooms is as measured at 100 kV unless otherwise indicated.

D. Performance Requirements

1. Provide materials and workmanship, including joints and fasteners, that maintain continuity of radiation protection at all points and in all directions equivalent to materials specified in thicknesses and locations indicated.
 - a. Materials, thicknesses, and configurations indicated are based on radiation protection design prepared by Owner's radiation health physicist. This design is available to Contractor on request.
2. Lead-Lined Assemblies: Unless otherwise indicated, provide lead thickness in doors, door frames, window frames, penetration shielding, joint strips, film transfer cabinets, and other items located in lead-lined assemblies not less than that indicated for assemblies in which they are installed.
3. Lead Glazing: Unless otherwise indicated, provide lead equivalence not less than that indicated for assembly in which glazing is installed.

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Certificates for Credit MR 7: Chain-of-custody certificates certifying that wood veneer on doors complies with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.



- 1) Include statement indicating costs for certified wood veneer doors.
3. Shop Drawings: Show layout of radiation-protected areas. Indicate lead thickness or lead equivalence of components. Show components and installation conditions not fully dimensioned or detailed in product data.
 - a. Show ducts, pipes, conduit, and other objects that penetrate radiation protection; include details of penetrations.
 - b. Show details of neutron-shielding doors and frames, including anchorage to and coordination with other work. Show locations of electrical conduit and boxes for connecting door operators, door operator switches, and door interlock switches.
 - 1) Wiring Diagrams: For power, signal, and control wiring.
4. Samples: For each exposed product and for each color and texture specified.
5. Field quality-control reports.
6. Operation and maintenance data.
7. Warranty: Sample of special warranty.

F. Quality Assurance

1. Forest Certification: Provide wood veneers for doors produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
2. Fire-Rated and Smoke-Control, **as applicable**, Door and Frame Assemblies: Comply with Division 08 Section(s) "Hollow Metal Doors And Frames" OR "Flush Wood Doors", **as applicable**.
3. Glazing: Comply with requirements in Division 08 Section "Glazing".
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Preinstallation Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Lead-Lined Gypsum Panels: Neatly stack panels flat to prevent deformation.
2. Lead-Lined Steel Doors and Frames: Comply with requirements in Division 08 Section "Hollow Metal Doors And Frames" for delivery, storage, and handling.
OR
Lead-Lined Steel Doors and Frames: Deliver doors and frames cardboard wrapped or crated to provide protection during delivery and storage. Inspect for damage on delivery. Minor damage may be repaired provided the refinished repair matches new work and is approved by the Owner; otherwise, remove and replace damaged items as directed.
3. Lead-Lined Wood Doors: Comply with requirements in Division 08 Section "Flush Wood Doors" for delivery, storage, and handling.
OR
Lead-Lined Wood Doors: Comply with manufacturer's written instructions and requirements in WDMA I.S.1-A.
4. Package doors individually in plastic bags or cardboard cartons **OR** cardboard cartons and wrap bundles of doors in plastic sheeting, **as directed**.
5. Mark each door on bottom **OR** top and bottom, **as directed**, rail with opening number used on Shop Drawings.

H. Warranty

1. Comply with requirements in Division 08 Section "Flush Wood Doors".

1.2 PRODUCTS

A. Materials

1. Lead Sheet, Strip, and Plate: ASTM B 749, alloy UNS No. L51121 (chemical-copper lead).



2. Lead Bricks: Interlocking cast- or extruded-lead bricks made from pig lead, complying with ASTM B 29 with 1/2 percent antimony added, with tongues and grooves on adjoining edges.
3. Borated Polyethylene: Manufactured specifically for neutron shielding and containing not less than 5 percent boron.
4. Lead Glass: Lead-barium, polished float glass containing not less than 60 percent heavy metal oxides, including not less than 48 percent lead oxide by weight.
 - a. Safety Glass: Fully tempered **OR** Laminated, **as directed**, float glass.
 - 1) Outer Lite: Clear float glass; thickness as indicated **OR as directed**.
 - 2) Interlayer: Clear polyvinyl butyral or cured resin of manufacturer's standard thickness indicated with a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after laminating glass lites and installation.
 - 3) Inner Lite: Lead-barium, polished float glass; thickness as indicated **OR as directed**.
5. Lead Glazing Plastic: Transparent acrylic sheet impregnated with an organolead compound and containing 30 percent lead by weight.
6. Lead-Lined Concrete Masonry Units: Fabricated from two solid concrete units, complying with ASTM C 90 or ASTM C 129, separated vertically by a single sheet of lead permanently bonded or anchored between the two halves. Size lead sheets to provide a 1-inch (25-mm) overlap with adjacent units or provide supplemental lead to ensure uninterrupted protection.
 - a. Provide special shapes as needed to maintain bond without cutting units.
 - b. Provide lead wool for filling voids or joints.
7. Masonry Mortar: Comply with Division 04 Section "Unit Masonry".
OR
Masonry Mortar: Comply with ASTM C 270, Type N, Proportion Specification.
 - a. Limit cementitious materials to portland cement and hydrated lime, **as directed**.
8. Grout: ASTM C 476, with a slump of 8 to 11 inches (200 to 280 mm) as measured according to ASTM C 143/C 143M.
 - a. For grouting frames of neutron-shielding doors, use coarse grout made from aggregate having a density not less than that used for concrete walls in which frames are installed.
9. Lead-Lined Gypsum Lath: 3/8-inch- (9.5-mm-) **OR** 1/2-inch- (12.7-mm-), **as directed**, thick gypsum lath complying with Division 09 Section "Gypsum Plastering" with a single sheet of lead, 1 inch (25 mm) longer and wider than lath, laminated to the back of lath so lead extends 1 inch (25 mm) beyond one side and one end.
 - a. For metal or wood furring and framing, provide 5/8-inch- (16-mm-) diameter lead disks or 5/8-by-1-1/4-inch (16-by-32-mm) lead tabs for covering screw heads.
 - b. For wood, provide lead-headed nails for fastening lead-lined gypsum lath, accessories, and trim to wood members.
10. Lead-Lined Gypsum Base for Gypsum Veneer Plaster **OR** Board, **as directed**: 1/2-inch- (12.7-mm-) **OR** 5/8-inch- (16-mm-), **as directed**, thick gypsum board complying with Division 09 Section(s) "Gypsum Veneer Plastering" **OR** "Gypsum Board", **as directed**, of width and length required for support spacing and to prevent cracking during handling, and with a single sheet of lead laminated to the back of the board.
 - a. Provide lead sheet lining the full width and length of board **OR** of board and length necessary to extend from floor to 84 inches (2133 mm) above floor **OR** of board and height as indicated on Drawings, **as directed**.
 - b. Provide 3-inch- (75-mm-) wide lead strips for wrapping metal stud flanges.
 - c. Provide 2-inch- (50-mm-) wide lead strips for backing joints.
 - d. Provide 5/16-inch (8-mm) **OR** 5/8-inch (16-mm), **as directed**, lead disks for covering screw heads.
 - e. Provide lead-headed nails for fastening gypsum board, accessories, and trim to wood members.
11. Accessories and Fasteners: Provide manufacturer's standard fasteners and accessories as required for installation, maintaining same lead equivalence as rest of system.
12. Asphalt Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.
13. Asphalt Felt: ASTM D 226.



B. Lead-Lined Steel Hollow-Metal Doors

1. General: Steel doors complying with ANSI/NAAMM-HMMA 861, except with a single continuous sheet of lead of thickness not less than that required for partition in which door is installed **OR** as indicated on Drawings, **as directed**, and extending from top to bottom and edge to edge, installed either between back-to-back stiffeners or between stiffeners and stop face of door.
 - a. Line inverted channels at top and bottom of doors with lead sheet of same thickness used in door and close with filler channels to provide flush top and bottom edges.
 - b. Shield cutouts for locksets with lead sheet of same thickness used in door. Lap lining of cutouts with door lining 1 inch (25 mm).
 - c. Prepare doors to receive observation windows **OR** louvers **OR** windows and louvers, **as directed**; cut and trim openings through doors in factory. Provide removable stops for glazed openings.
 - d. Provide lead-lined astragals for pairs of doors.
 - e. Factory fit doors to suit frame-opening sizes indicated with 1/16-inch (1.5-mm) clearance at heads and jambs and minimum clearance at bottom.
 - f. Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating **OR** factory-applied paint, **as directed**.
 - 1) Color and Gloss: As selected from manufacturer's full range.
2. Lead Door Louvers: Provide louvers with 20 **OR** 30, **as directed**, percent free area, of sizes and types indicated. Fabricate from formed-lead sheet or lead extrusions of not less than lead thickness required for door in which louver is installed. Fabricate louvers to be lightproof with fixed maze-type blades that maintain required lead equivalence at all points and in all directions. Factory fit and assemble louvers in doors before shipping to Project site.

C. Lead-Lined Steel Hollow-Metal Door Frames

1. General: Steel door frames complying with ANSI/NAAMM-HMMA 861, except 0.0667 inch (1.7 mm) thick, and lined with lead sheet of thickness not less than that required for doors and walls where frames are used.
 - a. Provide additional reinforcements and internal supports to adequately carry the weight of lead-lined doors. Install reinforcements and supports before installing lead lining.
 - b. Form lead sheet to match frame contour, continuous in each jamb and across the head, lapping the stops. Form lead shields around areas prepared to receive hardware. Fabricate lead lining wide enough to maintain an effective lap with lead of adjacent shielding.
 - c. Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating **OR** factory-applied paint, **as directed**.
 - 1) Color and Gloss: As selected from manufacturer's full range.

D. Lead-Lined Wood Doors

1. General: Flush solid-core wood doors with lead lining, thickness not less than that required for partition in which door is installed **OR** as indicated on Drawings, **as directed**.
 - a. Door Construction: Veneer face, five **OR** seven, **as directed**, ply, bonded mineral **OR** particleboard **OR** structural composite lumber **OR** glued-wood-stave, **as directed**, core.

OR

 Door Construction: Plastic-laminate face, three **OR** five, **as directed**, ply, bonded particleboard core.
 - b. Lead Lining: One or more continuous sheets of lead extending from top to bottom and edge to edge, constructed either in the core or between the core and faces, at manufacturer's option.

OR

 Lead Lining: One continuous sheet of lead extending from top to bottom and edge to edge, constructed in the core. Assemble lead lining and core with poured lead fasteners or steel bolts. Space fasteners not more than 1-1/2 inches (38 mm) from door edge and about 8 inches (200 mm) o.c. Countersink bolt heads and cover with lead.



- c. Comply with Division 08 Section "Flush Wood Doors" for grade, faces, veneer matching, fabrication, finishing, and other requirements unless otherwise indicated.
 - d. Quality Standard: AWI's "Architectural Woodwork Quality Standards Illustrated" **OR** WDMA I.S.1-A, "Architectural Wood Flush Doors" **OR** WI's "Manual of Millwork", **as directed**.
 - e. Grade: Premium **OR** Custom **OR** Economy, **as directed**.
 - f. Face Veneer Species and Cut: White oak, rift cut **OR** Red oak, plain sliced **OR** White birch, plain sliced **OR** White birch, rotary cut **OR** Match wood doors that are not lead lined, **as directed**.
 - 1) Veneer Matching: Slip **OR** Book, **as directed**, and running **OR** balance, **as directed**, match.
 - 2) Factory finish with stain and, **as directed**, transparent catalyzed lacquer or conversion varnish.
 - g. Faces: Any closed-grain hardwood of mill option, for opaque finish.
 - h. Faces: Plastic laminate complying with NEMA LD 3, Grade HGS.
 - 1) Color, Patterns, and Finishes: As selected from manufacturer's full range.
 - i. Shield cutouts for locksets with lead sheet of same thickness used in door. Lap lining of cutouts with door lining.
 - j. Prepare doors to receive observation windows **OR** louvers **OR** observation windows and louvers, **as directed**; cut and trim openings through doors in factory. Provide removable wood stops for glazed openings.
 - k. Provide lead-lined astragals for pairs of doors.
 - l. Factory fit doors to suit frame openings indicated with 1/16-inch (1.5-mm) clearance at heads and jambs and minimum clearance at bottom. Factory machine doors for hardware not surface applied.
2. Lead Door Louvers: Provide louvers with 20 **OR** 30, **as directed**, percent free area, of sizes and types indicated. Fabricate from formed-lead sheet or lead extrusions of not less than lead thickness required for door in which louver is installed. Fabricate louvers to be lightproof with fixed maze-type blades that maintain required lead equivalence at all points and in all directions. Factory fit and assemble louvers in doors before shipping to Project site.
- E. Lead-Lined Observation-Window Frames
- 1. General: Fabricate from 0.043-inch- (1.1-mm-) thick, formed-steel sheet or 0.064-inch- (1.6-mm-) thick aluminum extrusions with mitered corners, welded or bolted with concealed fasteners.
 - a. Line with lead sheet formed to match frame contour, continuous in each jamb and across head and sill, lapping the stops, and fabricated wide enough to maintain an effective lap with lead of adjoining assemblies.
 - b. Construct so lead lining overlaps glazing material perimeter by at least 3/8 inch (9.5 mm) and provide removable stops.
 - c. Form sill with an opening for sound transmission. Offset sound passage to make opening lightproof and to maintain required lead equivalence at all points and in all directions.
- F. Lead-Lined Modular Shielding Partitions
- 1. General: Partial-height modular partitions assembled from factory-finished standard components consisting of lead-lined enameled-steel framing members, lead-lined opaque panels, lead glazing plastic vision panels, and hardware necessary for assembly and for securing to other construction. Fabricate opaque panels from honeycomb-core metal panels with polyurethane paint finish.
 - a. Lead Equivalence for Opaque Panels: 1.5 mm.
 - b. Lead Equivalence for Framing Members: 1.5 mm.
 - c. Lead Equivalence for Vision Panels: 1.5 **OR** 1.0 **OR** 0.8 **OR** 0.5, **as directed**, mm.
- G. Lead-Lined Film Transfer Cabinets
- 1. General: Factory-fabricated, double-wall construction, of 0.0428-inch- (1.1-mm-) thick, cold-rolled, stretcher-leveled, commercial-quality steel sheet free of scale, buckle, pits, and other



defects. Line entire interior and doors with lead sheet thickness not less than that required for partition in which cabinet is installed **OR** as indicated on Drawings, **as directed**.

- a. Configuration and Size: Two-compartment, four-door type with compartments 8 inches wide by 19 inches high by 18-3/4 inches deep (203 mm wide by 483 mm high by 476 mm deep) **OR** 10-1/4 inches wide by 21 inches high by 20 inches deep (260 mm wide by 533 mm high by 508 mm deep), **as directed**, inside.

OR

Configuration and Size: As indicated on Drawings **OR as directed**.

- b. Provide an integral flange with lead lining extending beyond rough opening at least 3/4 inch (19 mm).
- c. Provide a sound passage in cabinet frame. Offset sound passage to make opening lightproof and to maintain required lead equivalence at all points and in all directions.
- d. Doors: Mount doors on full-height, concealed-leaf hinges. Label doors to one compartment "EXPOSED" and to other "UNEXPOSED." Provide a manual interlocking device to prevent doors on opposite sides of compartments from being opened at same time.
- e. Exterior Finish: Baked-on gray enamel primer.
- f. Cabinet Interior: Provide each compartment with a black rubber floor. Finish interior of doors, sides, and top in a nonreflective black finish.
- g. Trim: Provide face flange or separate trim on each side of wall.
- h. Hardware: Provide bright, polished, chrome-plated brass hardware.
- i. Rough-in Frame: Provide adjustable telescoping rough-in frame fabricated from 0.064-inch- (1.6-mm-) thick, zinc-coated steel. Design frame to allow adjustment for wall thicknesses from approximately 4 to 8 inches (100 to 200 mm).
- j. Support Brackets: Provide two support brackets for each cabinet. Provide brackets manufactured from 1-inch (25-mm) OD, 0.065-inch (1.65-mm) wall thickness, anodized aluminum or stainless-steel tubing with satin finish. Provide with fixed- or swivel-type mounting flanges on both ends.

OR

Support Brackets: Provide two triangular support brackets for each cabinet. Brackets shall be manufactured from 0.0428-inch- (1.1-mm-) thick steel sheet with flanges for fastening to wall and to cabinet. Finish with baked-on primer.

H. Neutron-Shielding Doors And Frames

1. General: Steel plate doors lined with lead and borated polyethylene and hung from structural-steel door frames.
 - a. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
 - b. Door Construction: Fabricate from 1/4-inch- (6-mm-) thick steel plate faces, reinforced at hinge locations, and 1/2-inch- (13-mm-) thick, steel flat-bar edges fully welded together. Continuously weld exposed joints and finish smooth, matching adjacent surfaces.
 - 1) Apply filler to interior of door faces to provide smooth, even surfaces for applying lead and polyethylene. Bond lead to interior of door face with permanent adhesive.
 - 2) Install lead in one piece and polyethylene in single or multiple sheets, all full height and width of door interior.
 - c. Door Frame Construction: Fabricate from 1/4-inch- (6-mm-) thick steel plate to dimensions indicated, fully welded together. Continuously weld exposed joints and finish smooth, matching adjacent surfaces.
 - 1) Fabricate frames with depth equal to thickness of shielding wall in which door is installed. Rabbet frame to receive door and to provide a 4-inch (100-mm) overlap between door edges and remaining frame depth. Make frame faces 4 inches (100 mm) wide with 3/4-inch- (19-mm-) deep backbends.
 - 2) Reinforce frames and drill and tap as needed to accept finish hardware.
 - 3) Provide steel strap anchors using 1/8-by-2-inch- (3-by-50-mm-) wide straps of length required for a minimum 8-inch (200-mm) embedment. Weld anchors to frame



- members not more than 8 inches (200 mm) from both bottom and top of jambs and from ends of head, and space anchors not more than 24 inches (600 mm) apart.
- 4) Provide channel-shaped sill fabricated from 1/4-inch- (6-mm-) thick steel plate lined with lead. Make sill 1-1/2 inches (38 mm) deep by same width as jambs and weld to door jambs.
- d. Shop-Primed Finish: Prepare ferrous-metal surfaces to comply with SSPC-SP 3 (Power Tool Cleaning) and apply an alkyd primer complying with MPI#79.
 - 1) Stripe paint corners, crevices, bolts, welds, and sharp edges.
 - e. Hardware: Provide the following hardware for each door:
 - 1) Hinges: BHMA A156.1, Type A8391; weld- or bolt-on type at manufacturer's option; sized for door weight; two or three per door at manufacturer's option.
 - 2) Pulls: BHMA A156.6, Type J401, two per door.
 - 3) Operator: Power-opening and spring- or power-closing unit; with automatic hold-open; complying with BHMA A156.10; sized for door weight and width; and adjustable for opening, closing, and checking speeds. Unit shall have an emergency release to allow door to be opened manually and a disconnect switch to prevent power operation when door is in emergency-release mode.
 - 4) Controls: Provide two wall-mounted, recessed, push-plate switches for opening door and one push-button switch for closing door. Provide motion or presence sensors to detect persons or objects in path of door and, if these are detected, to stop and reverse action of door operator.
 - f. Door Interlock Switch: Provide electric switch in frame jamb to prevent operation of radiation therapy equipment when door is open and to shut off power to equipment if door is opened while equipment is in use.
 - 1) Provide rough box for installing switch, fabricated from 1/4-inch- (6-mm-) thick steel plate welded to frame and lined on all sides with 1/4-inch- (6-mm-) thick lead plate.
- I. Informational Signs
1. Informational Signs, General: Fabricate signs by engraving lettering in high-pressure-laminate engraving stock with contrasting face and core. Machine engrave copy using high-speed cutters mechanically positioned by master templates for accurately formed letters, numbers, and symbols.
 - a. Color: As selected from manufacturer's full range of colors.
 - b. Provide copy indicated or as directed. Provide signs of sufficient size to contain required information.
 - c. Indicate lead equivalence in millimeters and heights of radiation protection in inches (millimeters).
 2. Rooms Where the Level of Protection Is Uniform Throughout: Provide one sign for each room indicating lead equivalence of partitions, ceilings, floors, doors, and other portions of radiation protection enclosure. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height.
 3. Rooms Where the Level of Protection Is Not Uniform Throughout: Provide one sign for each room with different lead equivalences in different locations. Indicate, in tabular form, lead equivalence of each wall, partition, ceiling, floor, door, and window. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height. Indicate where lead equivalence changes or is not continuous.
 4. Rooms Where Some Partitions Are without Radiation Protection: Provide one sign for each partition that contains radiation protection and indicate its lead equivalence. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height.
 5. Rooms Where Only the Door Has Radiation Protection: Provide one sign for each door indicating its lead equivalence.
- J. Door And Door Frame Fabrication
1. Hardware Preparation: Factory prepare doors and frames to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to the Door Hardware Schedule and templates furnished as specified in Division 08 Section "Door Hardware".



1.3 EXECUTION

A. Installation Of Lead Sheets In Concrete Floor Slabs

1. Apply a coat of asphalt mastic or paint to concrete surfaces before installing lead sheet.
2. Before installing floor lead sheet, place lead strips not less than 7 inches (175 mm) wide under the base of vertical wall protection. Extend lead strips approximately 3 inches (75 mm) into the shielded room area.
3. Lead Sheet, 1/8 Inch (3 mm) Thick or Less: Install in a single layer with a 2-inch (50-mm) minimum lap at joints.
4. Lead Sheet More Than 1/8 Inch (3 mm) Thick: Install in two or more layers with a 2-inch (50-mm) minimum lap at joints, or in a single layer with joints butted and covered with a 4-inch- (100-mm-) wide lead strip of same thickness.
5. Extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls of room.

OR

In floor slabs above shielded rooms where lead sheet is indicated, extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls of room below.

6. At door openings, extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls and at least 12 inches (300 mm) beyond door opening on both sides except where lead-lined thresholds are provided.
7. After installation, apply a coat **OR** two coats, **as directed**, of asphalt coating on top surface of lead sheet and protect from damage until concrete topping is placed.

B. Installation Of Lead Bricks

1. Remove projections from concrete surfaces to receive lead bricks and apply one layer of asphalt felt to prevent contact between lead bricks and concrete.
 - a. At recesses in concrete floors to receive lead bricks, turn up asphalt felt at perimeter of recess.
2. Install lead bricks to dimensions indicated, tightly fitted together, with joints offset in succeeding courses. Cut bricks neatly at joints with adjacent materials for a snug fit, with edges straight and true and at right angles.
 - a. Calk joints between lead bricks and support framing with lead wool.
 - b. Install lead strips as indicated at joints between lead bricks and support framing.
 - c. Secure lead bricks to walls as indicated with steel flat bars fastened with steel lag bolts driven into lead plugs.
3. After installation, apply a coat of asphalt coating on surfaces of lead bricks that will receive concrete.

C. Installation Of Lead-Lined Concrete Masonry Units

1. Lay units in running bond, using methods recommended in writing by concrete masonry unit manufacturer.
2. Cut units, as needed, without disturbing bond between lead and concrete, and without reducing required lapping margin or shielding qualities.
3. Blocks Designed to Have Lead Laps at Joints: Lay units with tight lead laps without soldering or burning.
4. Blocks Designed to Have Lead Bars in Joints: Lay units with lead bars, of thickness not less than that required in block, in each horizontal and vertical joint. Position bars directly adjacent to lead lining with bars overlapping lead lining at least twice the thickness of lead lining, but not less than 1/2 inch (13 mm).
5. Mortar Joints: Lay units with 1/2-inch (13-mm) solidly filled mortar joints. Keep lead laps free of intervening mortar. Cut joints flush with face of units.
6. Wraparound Metal Frames: Extend units into frame openings with lead lining projecting into rabbets of frames to effectively lap with lead frames or frame linings at least 1 inch (25 mm).
7. Pipe and Conduit Chases: Where pipe and conduit chases occur within blocks, faces can be removed from one side to permit installation. Where necessary to remove lead lining for pipe and conduit installation, install continuous lead sheet and overlap adjoining lead protection at least 1



inch (25 mm). Fill voids around pipe and conduit chases with mortar, finished flush with face of partition. Do not locate pipe and conduit chases directly opposite each other in same partition.

D. Installation Of Lead-Lined Gypsum Lath

1. Install lath with long edges at right angles to supports with lead lining facing supports. Place end joints over supports and stagger joints in alternate courses. Overlap lead extensions on adjacent lath to provide an effective lead lap.
 - a. Install so joints in walls do not align with adjacent ceiling joints.
2. Fastening to Metal and Wood Supports: Use screws spaced as recommended in writing by gypsum lath manufacturer. Drive screws through lead tabs and fold tabs over screw heads or apply lead disks over screw heads.
 - a. Fasten accessories and trim to supports with screws, using lead tabs or lead disks as specified above for fastening lath.
3. Fastening to Wood Supports: Use lead-headed nails spaced as recommended in writing by gypsum lath manufacturer. Drill pilot holes to prevent deforming nails or distorting lath. Set nail heads flush with lath surface.
 - a. Fasten accessories and trim to supports with lead-headed nails as specified above for fastening lath.
4. Openings: Extend lead-lined gypsum lath into frames of openings, lapping lead lining with lead frames or frame linings at least 1 inch (25 mm). Arrange lath around openings so neither horizontal nor vertical joints occur at corners of openings.
5. Control and Expansion Joints: Install lead strip on face of framing, extending across joint, and lap with lead lining of lath.

E. Installation Of Lead-Lined Gypsum Base For Gypsum Veneer Plaster **OR** Board, **as directed**

1. Install with long edge parallel to supports and lead lining facing supports. Provide blocking at end joints. Install using construction adhesive and supplementary fasteners.
2. Fastening to Metal Supports: Use steel drill screws spaced as recommended in writing by gypsum board manufacturer. Install lead strips covering face of framing and wrap around flange to cover points of screws.
 - a. Where possible, install lead-lined gypsum board before installing gypsum board on other side of partition, and do not fold lead strips back over inside of flange until after lead-lined gypsum board is applied.
 - b. Apply lead disks recessed flush with surface of board over heads of screws securing trim.
3. Fastening to Metal and Wood Supports: Use steel drill screws spaced as recommended in writing by gypsum board manufacturer. Apply lead disks over screw heads and recess flush with surface of board.
 - a. Install lead strips, 1-1/2 inches (38 mm) wide minimum and same thickness as lead lining, to face of supports and blocking where joints occur. Secure lead strips with construction adhesive. Provide shims at intermediate supports.
 - b. Apply lead disks recessed flush with surface of board over heads of screws securing trim.
4. Fastening to Wood Supports: Use lead-headed nails spaced as recommended in writing by gypsum board manufacturer. Drill pilot holes to prevent deforming nails or distorting board. Drive nail heads slightly below exposed surface.
 - a. Install lead strips, 1-1/2 inches (38 mm) wide minimum and same thickness as lead lining, to face of supports and blocking where joints occur. Secure lead strips with construction adhesive. Provide shims at intermediate supports.
 - b. Fasten accessories and trim to wood supports with lead-headed nails as specified above for fastening gypsum board.
5. Two-Layer System: Apply a facing sheet of gypsum board vertically over base sheet using laminating adhesive recommended in writing by gypsum board manufacturer. Offset joints in finish layer from joints in base layer and fasten at top and bottom of sheet to support finish panel until adhesive has set.
 - a. Locate fasteners above ceiling or behind wall base and cover fasteners with lead disks recessed flush with surface of board.



6. Openings: Extend lead-lined gypsum board into frames of openings, lapping lead lining with lead frames or frame linings at least 1 inch (25 mm). Arrange board around openings so neither horizontal nor vertical joints occur at corners of openings.
7. Install control and expansion joints where indicated, with appropriate trim accessories. Install lead strip on face of framing, extending across joint, and lap with lead lining of gypsum board.

F. Installation Of Lead-Lined Doors And Door Frames

1. Install lead-lined steel doors and door frames according to Division 08 Section "Hollow Metal Doors And Frames".
 - a. Apply a coat of asphalt mastic or paint to lead lining in door frames where lead will come in contact with masonry or grout.
2. Install lead-lined wood doors according to Division 08 Section "Flush Wood Doors".
3. Glazing: Comply with installation requirements in Division 08 Section "Glazing" and with door manufacturer's written instructions.
4. Frames: Comply with HMMA 840 unless otherwise indicated. Except for frames located in existing walls or partitions, place frames before constructing walls. Set frames accurately in position, plumb, and brace securely until permanent anchors are set.
 - a. Provide three anchors per jamb, located adjacent to hinge on hinge jamb and at corresponding heights on strike jamb.
 - b. In masonry construction, use wire or T-strap anchors and apply a coat of asphalt mastic or paint to lead lining where lead will come in contact with masonry or grout.
 - c. In metal stud construction, use wall anchors attached to studs with screws.
 - d. In wood stud construction, use strap anchors attached to studs with screws.
5. If frames are factory-lined, lap lead lining of frames over lining in walls at least 1 inch (25 mm).
6. Lead Lining of Frames: Line inside of frames with lead of thickness not less than that required in doors and walls where frames are used. Form lead to match frame contour, continuous in each jamb and across the head, lapping the stops. Form lead shields around areas prepared to receive hardware. Lap lining over lining in walls at least 1 inch (25 mm).
7. Install doors in frames level and plumb, aligned with frames and with uniform clearance at each edge.
8. Line astragals with lead sheet.
9. Hardware: Line covers, escutcheons, and plates to provide effective shielding at cutouts and penetrations of frames and doors. See Division 08 Section "Door Hardware" for other installation requirements.
10. Touch up damaged finishes with compatible coating after sanding smooth.
11. Operation: Rehang or replace doors that do not swing or operate freely. Check and readjust operating hardware items, leaving doors and frames undamaged and in proper operating condition.

G. Installation Of Lead-Lined Observation Windows

1. Install observation windows according to manufacturer's written installation instructions.
 - a. Apply a coat of asphalt mastic or paint to lead lining in frames where lead will come in contact with masonry or grout.
2. Install windows level, plumb, square, true to line, and anchored securely in place to structural support.
3. Install leaded side of frame on radiation side of wall. Lap lead lining of frames over lining in walls at least 1 inch (25 mm).
4. Glazing: Comply with installation requirements in Division 08 Section "Glazing" and with manufacturer's written instructions.

H. Installation Of Lead-Lined Modular Shielding Partitions

1. Install partitions after finishes are complete in spaces where partitions are located. Install according to manufacturer's written instructions and Shop Drawings.
2. Cut and remove wall base where modular shielding partitions meet other walls so partition will fit tightly to wall.



3. Secure partition framing to floor with 1/4-inch (6-mm) expansion anchors 16 inches (400 mm) o.c. and fasten to walls and ceilings as indicated. Brace partitions with tie rods fastened to walls or ceilings as indicated.
- I. Installation Of Penetrating Items
 1. At penetrations of lead linings, provide lead shields to maintain continuity of protection.
 2. Provide lead linings, sleeves, shields, and other protection in thickness not less than that required in assembly being penetrated.
 3. Secure shields at penetrations using adhesive or wire ties but not penetrating fasteners unless indicated on Drawings.
 4. Film Transfer Cabinets: Where film transfer cabinets occur in lead-lined partitions, line wall flange with lead sheet of same thickness as required for partition where it is located.
 5. Outlet Boxes and Conduit: Cover or line with lead sheet lapped over adjacent lead lining at least 1 inch (25 mm). Wrap conduit with lead sheet for a distance of not less than 10 inches (250 mm) from box.
 6. Duct Openings: Unless otherwise indicated, line or wrap ducts with lead sheet for distance from partition/ceiling equal to three times the largest opening dimension. Lap lead sheet with adjacent lead lining at least 1 inch (25 mm).
 7. Piping: Unless otherwise indicated, wrap piping with lead sheet for a distance of not less than 10 inches (250 mm) from point of penetration.
 - J. Installation Of Neutron-Shielding Doors And Frames
 1. Install frames in concrete forms before concrete is placed. Adjust frames as needed so they are square and within 1/16 inch (1.5 mm) of plumb. Secure frames to forms and brace to resist forces resulting from concrete placement.
 2. Install frames in concrete openings and adjust as needed so they are square and within 1/16 inch (1.5 mm) of plumb. Secure frames to concrete and brace to resist forces resulting from weight and movement of shielding door. Grout frames, consolidating grout to solidly fill spaces between frame and opening.
 3. Install doors in frames and install door operators, door controls, interlock switches, and other components according to manufacturer's written instructions and Shop Drawings.
 4. Touch up damaged primer with compatible coating after sanding smooth.
 5. Operation: Rehang or replace doors that do not swing or operate freely. Check and readjust operators and controls for opening, closing, latching, and back-checking speeds and for open- and closed-door positions.
 - K. Field Quality Control
 1. Testing Agency: Engage a qualified testing agency to perform tests and inspections after radiology equipment has been installed and placed in operating condition.
 2. Correct deficiencies in or remove and replace radiation protection that inspection reports indicate does not comply with specified requirements.
 - L. Protection
 1. Lock radiation-protected rooms once doors and locks are installed and limit access to only those persons performing work in the rooms.

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SECTION 08 34 53 00 - DETENTION DOORS AND FRAMES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for detention doors and frames. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Swinging detention doors.
 - b. Sliding detention doors.
 - c. Detention panels.
 - d. Detention frames.

C. Definitions

1. Minimum-Thickness Steel: Indicated as the specified minimum thicknesses for base metal without coatings, according to HMMA 803.
2. Nominal-Thickness Stainless Steel: Indicated as the specified thicknesses for which over- and under-thickness tolerances apply, according to ASTM A 480/A 480M.
3. Nominal Surface of Floor Covering: Top surface of floor; for resilient tile and carpet, nominal surface of floor covering is defined as top of concrete slab.

D. Performance Requirements

1. Detention Doors and Frame Assemblies: Provide detention doors and frames that comply with the following, based on testing manufacturer's standard units in assemblies similar to those indicated for this Project:
 - a. Security Grade: Comply with Grade 1 **OR** Grade 2 **OR** Grade 3 **OR** Grade 4, **as directed**, according to ASTM F 1450.
 - b. Bullet Resistance: Comply with Level 3 rating when tested according to UL 752.
 - 1) Listed and labeled, by a testing agency acceptable to authorities having jurisdiction, as bullet resisting.
 - c. Tool-Attack Resistance: Comply with small-tool-attack-resistance rating when tested according to UL 437 and UL 1034.
2. Detention Frames: Provide sidelight and borrowed-light detention frames that comply with ASTM F 1592 and removable stop test according to HMMA 863, based on testing manufacturer's standard units in assemblies similar to those indicated for this Project.

E. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, core descriptions, label compliance, fire-resistance rating, and temperature-rise ratings, and finishes for each type of detention doors and frames specified.
2. Shop Drawings: In addition to requirements below, provide a schedule using same reference numbers for details and openings as those on Drawings:
 - a. Elevations of each door design.
 - b. Direction of swing **OR** slide, **as directed**.
 - c. Inmate and non-inmate sides.
 - d. Details of doors, including vertical and horizontal edge details, and metal thicknesses.
 - e. Details of frames, including dimensioned profiles, and metal thicknesses.
 - f. Locations of reinforcement and preparations for hardware.
 - g. Details of each different wall opening condition.
 - h. Details of anchorages, joints, field splices, and connections.



- i. Details of food-pass openings, louvers, speaking apertures, and gun ports.
 - j. Details of moldings, removable stops, and glazing.
 - k. Details of conduit, junction boxes, and preparations for electrified and pneumatic door hardware.
3. Samples:
- a. For each type of exposed finish required.
 - b. For the following items to demonstrate compliance with requirements for quality of materials and construction:
 - 1) Detention Doors: Show vertical-edge, top, and bottom construction; insulation; face stiffeners; and hinge and other applied hardware reinforcement. Include separate section showing glazing if applicable.
 - 2) Detention Frames: Show profile, welded corner joint, welded hinge reinforcement, grout-cover boxes, floor and wall anchors, and silencers. Include separate section showing fixed steel panels and glazing if applicable.
4. Coordination Drawings: Drawings of each detention door and frame, drawn to scale, on which connections and interface with electrified and pneumatic control systems are shown.
5. Oversize Construction Certification: For assemblies required to be fire rated and exceeding limitations of labeled assemblies.
6. Welding certificates.
7. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency for detention doors and frames. Indicate metal thickness of each component of tested assembly and describe construction methods.
8. Field quality-control reports documenting inspections of installed products.

F. Quality Assurance

- 1. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - c. AWS D1.6, "Structural Welding Code - Stainless Steel."
- 2. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure **OR** as close to neutral pressure as possible, **as directed**, according to NFPA 252 **OR** IBC Standard 716.5 **OR** UL 10B **OR** UL 10C, **as directed**.
 - a. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
 - b. Temperature-Rise Limit: Where indicated **OR** At vertical exit enclosures and exit passageways, **as directed**, provide doors that have a maximum transmitted temperature end point of not more than 450 deg F (250 deg C) above ambient after 30 minutes of standard fire-test exposure.
- 3. Fire-Rated Detention Sidelight and Borrow-Light Frames: Assemblies complying with NFPA 80 that are listed and labeled, by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to NFPA 257.
- 4. Smoke-Control Detention Door Assemblies: Comply with NFPA 105.

G. Delivery, Storage, And Handling

- 1. Deliver detention doors and frames palleted, wrapped, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
- 2. Deliver detention frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.
- 3. Inspect units, on delivery, for damage. Minor damage may be repaired provided refinished items match new work and are approved by Architect; otherwise, remove and replace damaged items as directed.



4. Store detention doors and frames under cover at building site. Place units in a vertical position with heads up, spaced by blocking, on minimum 4-inch- (102-mm-) high wood blocking. Avoid using nonvented plastic or canvas shelters that could create a humidity chamber.
 - a. Provide minimum 1/4-inch (6-mm) space between each stacked unit to permit air circulation.

H. Maintenance Tools

1. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.

1.2 PRODUCTS

A. Materials

1. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, CS (Commercial Steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.
2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, CS (Commercial Steel), Type B.
3. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, CS (Commercial Steel), Type B; with G60 (Z180) zinc (galvanized) or A60 (ZF180) zinc-iron-alloy (galvannealed) coating designation.
4. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, Type 304.
5. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
6. Concealed Bolts: ASTM A 307, Grade A unless otherwise indicated.
7. Masonry Anchors: Fabricated from same steel sheet as door face.
8. Embedded Anchors: Fabricated from mild steel shapes and plates, hot-dip galvanized according to ASTM A 153/A 153M.
9. Postinstalled Expansion Anchors: With capability to sustain, without failure, a load equal to 4 times the load imposed, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
 - a. Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition (mild).
 - b. Corrosion Protection: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2 (ASTM F 738M and ASTM F 836M, Alloy Group 1 or 4) for bolts and nuts; ASTM A 276 or ASTM A 666, Type 304 or 316, for anchors.
 - c. Corrosion Protection: Components fabricated from nickel-copper-alloy rods complying with ASTM B 164 for UNS No. N04400 alloy.
10. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
11. Glazing: Comply with Division 08 Section "Security Glazing".
12. Grout: Comply with ASTM C 476, with a slump of not more than 4 inches (102 mm) as measured according to ASTM C 143/C 143M.
13. Insulation: Slag-wool-fiber/rock-wool-fiber or glass-fiber blanket insulation. ASTM C 665, Type I (unfaced); with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics. Minimum 1.5-lb/cu. ft. (24-kg/cu. m) density.
14. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil (0.4-mm) dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

B. Detention Doors

1. General: Provide flush-design detention doors of seamless hollow construction, 2 inches (51 mm) thick unless otherwise indicated. Construct detention doors with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges.
 - a. For single-acting swinging detention doors, bevel both vertical edges 1/8 inch in 2 inches (3 mm in 51 mm).
 - b. For sliding detention doors, square both vertical edges.
2. Core Construction: Provide the following core construction of same material as detention door face sheets, welded to both detention door faces:



- a. Steel-Stiffened Core: 0.042-inch- (1.0-mm-) thick, steel vertical stiffeners extending full-door height, with vertical webs spaced not more than 4 inches (102 mm) apart, spot welded to face sheets a maximum of 3 inches (76 mm) o.c. Fill spaces between stiffeners with insulation.
- b. Truss-Stiffened Core: 0.013-inch- (0.3-mm-) thick, steel, truncated triangular stiffeners extending between face sheets and for full height and width of door; with stiffeners welded to face sheets not more than 3 inches (76 mm) o.c. vertically and 2-3/4 inches (70 mm) horizontally. Fill spaces between stiffeners with insulation.
3. Vertical Edge Channels: 0.123-inch- (3.1-mm-) thick, continuous channel of same material as detention door face sheets, extending full-door height at each vertical edge; welded to top and bottom channels to create a fully welded perimeter channel. Noncontiguous channel is permitted to accommodate lock-edge hardware only if lock reinforcement is welded to and made integral with channel.
4. Top and Bottom Channels: 0.123-inch- (3.1-mm-) thick metal channel of same material as detention door face sheets, spot welded, not more than 4 inches (102 mm) o.c., to face sheets.
 - a. Reinforce top edge of detention door with 0.053-inch- (1.3-mm-) thick closing channel, inverted and nesting in top channel; welded so channel web is flush with top door edges.
5. Hardware Reinforcement: Fabricate reinforcing plates from same material as detention door face sheets to comply with the following minimum thicknesses:
 - a. Full-Mortise Hinges and Pivots: 0.187 inch (4.7 mm) thick.
 - b. Maximum-Security Surface Hinges: 0.250 inch (6.3 mm) thick.
 - c. Strike Reinforcements: 0.187 inch (4.7 mm) thick.
 - d. Slide-Device Hanger Attachments: As recommended by device manufacturer.
 - e. Lock Fronts, Concealed Holders, and Surface-Mounted Closers: 0.093 inch (2.3 mm) thick.
 - f. All Other Surface-Mounted Hardware: 0.093 inch (2.3 mm) thick.
 - g. Lock Pockets: 0.123 inch (3.1 mm) thick at non-inmate side, welded to face sheet.
6. Hardware Enclosures: Provide enclosures and junction boxes for electrically operated detention door hardware of same material as detention door face sheets, interconnected with UL-approved, 1/2-inch- (13-mm-) diameter conduit and connectors.
 - a. Where indicated for installation of wiring, provide access plates to junction boxes, fabricated from same material and thickness as face sheet and fastened with at least 4 security fasteners spaced not more than 6 inches (152 mm) o.c.
7. Interior Detention Door Face Sheets: Fabricated from cold-rolled steel sheets **OR** metallic-coated steel sheets **OR** stainless-steel sheets, **as directed**.
 - a. Security Grade 1: 0.093-inch- (2.3-mm-) minimum-thickness steel **OR** 0.109-inch (2.8-mm) nominal-thickness stainless steel, **as directed**.
 - b. Security Grade 2: 0.093-inch- (2.3-mm-) minimum-thickness steel **OR** 0.109-inch (2.8-mm) nominal-thickness stainless steel, **as directed**.
 - c. Security Grade 3: 0.067-inch- (1.7-mm-) minimum-thickness steel **OR** 0.078-inch (2.0-mm) nominal-thickness stainless steel, **as directed**.
 - d. Security Grade 4: 0.067-inch- (1.7-mm-) minimum-thickness steel **OR** 0.078-inch (2.0-mm) nominal-thickness stainless steel, **as directed**.
8. Exterior Detention Door Face Sheets: Fabricated from metallic-coated steel sheets **OR** stainless-steel sheets, **as directed**.
 - a. Security Grade 1: 0.093-inch- (2.3-mm-) minimum-thickness steel **OR** 0.109-inch (2.8-mm) nominal-thickness stainless steel, **as directed**.
 - b. Security Grade 2: 0.093-inch- (2.3-mm-) minimum-thickness steel **OR** 0.109-inch (2.8-mm) nominal-thickness stainless steel, **as directed**.
 - c. Security Grade 3: 0.067-inch- (1.7-mm-) minimum-thickness steel **OR** 0.078-inch (2.0-mm) nominal-thickness stainless steel, **as directed**.
 - d. Security Grade 4: 0.067-inch- (1.7-mm-) minimum-thickness steel **OR** 0.078-inch (2.0-mm) nominal-thickness stainless steel, **as directed**.

C. Detention Panels



1. Provide fixed detention panels of same materials, construction, and finish as specified for adjoining detention frame.

D. Detention Frames

1. General: Provide fully welded detention frames with integral stops, of seamless construction without visible joints or seams. Fabricate detention frames with contact edges closed tight and corners mitered, reinforced, and continuously welded full depth and width of detention frame.
2. Provide two temporary steel spreaders spot welded to bottom of jambs to act as bracing during shipping and storage. Remove prior to installation.
3. Stop Height: Provide minimum stop height of 0.625 inch (16 mm) **OR** 0.750 inch (19 mm), **as directed**, for detention door openings and minimum stop height of 1-1/4 inches (32 mm) in security glazing or detention panel openings unless otherwise indicated.
4. Interior Detention Frames: Fabricated from cold-rolled steel sheets **OR** metallic-coated steel sheets where indicated **OR** stainless-steel sheets for stainless-steel detention doors, **as directed**.
 - a. Security Grade 1: 0.093-inch- (2.3-mm-) minimum-thickness steel **OR** 0.109-inch (2.8-mm) nominal-thickness stainless steel, **as directed**.
 - b. Security Grade 2: 0.093-inch- (2.3-mm-) minimum-thickness steel **OR** 0.109-inch (2.8-mm) nominal-thickness stainless steel, **as directed**.
 - c. Security Grade 3: 0.067-inch- (1.7-mm-) minimum-thickness steel **OR** 0.078-inch (2.0-mm) nominal-thickness stainless steel, **as directed**.
 - d. Security Grade 4: 0.067-inch- (1.7-mm-) minimum-thickness steel **OR** 0.078-inch (2.0-mm) nominal-thickness stainless steel, **as directed**.
5. Exterior Detention Frames: Fabricated from metallic-coated steel sheets **OR** stainless-steel sheets for stainless-steel detention doors, **as directed**.
 - a. Security Grade 1: 0.093-inch- (2.3-mm-) minimum-thickness steel **OR** 0.109-inch (2.8-mm) nominal-thickness stainless steel, **as directed**.
 - b. Security Grade 2: 0.093-inch- (2.3-mm-) minimum-thickness steel **OR** 0.109-inch (2.8-mm) nominal-thickness stainless steel, **as directed**.
 - c. Security Grade 3: 0.067-inch- (1.7-mm-) minimum-thickness steel **OR** 0.078-inch (2.0-mm) nominal-thickness stainless steel, **as directed**.
 - d. Security Grade 4: 0.067-inch- (1.7-mm-) minimum-thickness steel **OR** 0.078-inch (2.0-mm) nominal-thickness stainless steel, **as directed**.
6. Hardware Reinforcement: Fabricate reinforcing plates from same material as detention frame to comply with the following minimum thicknesses:
 - a. Hinges and Pivots: 0.187 inch (4.7 mm) thick by 1-1/2 inches (38 mm) wide by 10 inches (254 mm) long.
 - b. Strikes, Flush Bolts, and Closers: 0.187 inch (4.7 mm) thick.
 - c. Surface-Mounted Hardware: 0.093 inch (2.3 mm) thick.
 - d. Lock Pockets: 0.123 inch (3.1 mm) thick at non-inmate side, welded to face sheet. Provide 0.123-inch- (3.1-mm-) thick, lock protection plate for attachment to lock pocket with security fasteners.
7. Hardware Enclosures: Provide enclosures and junction boxes for electrically operated detention door hardware, interconnected with UL-approved, 1/2-inch- (13-mm-) diameter conduit and connectors.
 - a. Where indicated for installation of wiring, provide access plates to junction boxes, fabricated from same material and thickness as face sheet and fastened with at least 4 security fasteners spaced not more than 6 inches (152 mm) o.c.
8. Mullions and Transom Bars: Provide closed or tubular mullions and transom bars where indicated. Fasten mullions and transom bars at crossings and to jambs by butt welding. Reinforce joints between detention frame members with concealed clip angles or sleeves of same metal and thickness as detention frame.
9. Jamb Anchors: Weld jamb anchors to detention frames near hinges and directly opposite on strike jamb or as required to secure detention frames to adjacent construction.
 - a. Number of Anchors: Provide two anchors per jamb plus the following:
 - 1) Detention Door Frames: One additional anchor for each 18 inches (457 mm), or fraction thereof, above 54 inches (1372 mm) in height.



- 2) Detention Frames with Security Glazing or Detention Panels: One additional anchor for each 18 inches (457 mm), or fraction thereof, above 36 inches (914 mm) in height.
 - b. Masonry Anchors: Adjustable, corrugated or perforated, strap-and-stirrup anchors to suit detention frame size; formed of same material and thickness as detention frame; with strap not less than 2 inches (51 mm) wide by 10 inches (254 mm) long.
 - c. Embedded Anchors: Provide detention frames with removable faces at jambs where embedded anchors are indicated. Anchors consist of three parts:
 - 1) Embedded Plates: Steel plates, 0.188 inch thick by 4 inches wide by 6 inches (4.7 mm thick by 102 mm wide by 152 mm) long. Continuously weld 2 steel bars, 1/2 inch (13 mm) in diameter and 10 inches (254 mm) long with 2-inch (51-mm) 90-degree turndown on ends, to the embedded end of each plate. Weld steel angles, 0.188 inch thick by 2 by 2 by 4 inches (4.7 mm thick by 51 by 51 by 102 mm) long, to the exposed end of each plate. Embed at locations to match frame angles.
 - 2) Frame Angles: Steel angles, 0.188 inch thick by 2 by 2 by 4 inches (4.7 mm thick by 51 by 51 by 102 mm) long, welded to detention frames with 1-inch- (25-mm-) long welds at each end of angle.
 - 3) Connector Angles: Steel angles, of size required, to connect frame angles and embedded plates.
 - d. Postinstalled Expansion Anchors: Minimum 1/2-inch- (13-mm-) diameter concealed bolts with expansion shields or inserts. Provide conduit spacer from detention frame to wall, welded to detention frame. Reinforce detention frames at anchor locations.
10. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, formed of same material and thickness as detention frame, and as follows:
 - a. Monolithic Concrete Slabs: Clip anchors, with two holes to receive fasteners, welded to bottom of jambs and mullions with at least four spot welds per anchor.
 - b. Separate Topping Concrete Slabs: Adjustable anchors with extension clips, allowing not less than 2-inch (51-mm) height adjustment, welded to jambs and mullions with at least 4 spot welds per anchor. Terminate bottom of detention frames at finish floor surface.
 11. Rubber Door Silencers: Except on weather-stripped detention doors, drill stops in strike jambs to receive three silencers on single-detention-door frames and drill head jamb stop to receive two silencers on double-detention-door frames. Keep holes clear during construction.
 12. Grout Guards: Provide factory-installed grout guards of same material as detention frame, welded to detention frame at back of hardware cutouts, silencers, and glazing-stop screw preparations to close off interior of openings and prevent mortar or other materials from obstructing hardware operation or installation.

E. Moldings And Stops

1. Provide fixed moldings on inmate side of glazed openings and removable stops on non-inmate side.
 - a. Height: As required to provide minimum 1-inch (25-mm) glass engagement, but not less than 1-1/4 inches (32 mm).
 - b. Fixed Moldings: Formed from same material as detention door and frame face sheets, but not less than 0.093-inch- (2.3-mm-) thick, spot welded to face sheets a maximum of 5 inches (127 mm) o.c.
 - c. Removable Stops: Formed from 0.123-inch- (3.1-mm-) thick angle, of same material as detention door face sheets. Secure with button head security fasteners spaced uniformly not more than 9 inches (229 mm) **OR** 6 inches (152 mm), **as directed**, o.c. and not more than 2 inches (51 mm) from each corner, and as necessary to satisfy performance requirements. Form corners with notched or mitered hairline joints.
2. Coordinate rabbet width between fixed and removable stops with type of glass or panel and type of installation indicated.

F. Accessories



1. Pass-Through Openings: Fabricate flush openings using 0.093-inch- (2.3-mm-) thick interior channels of same material as detention door faces, inverted to be flush with openings, welded to inside of both face sheets and with corners fully welded. Mount shutters on non-inmate side of detention doors. Reinforce for locks and food-pass hinges.
 - a. Inset Shutters: Fabricate from 2 steel plates, 0.123 inch (3.1 mm) thick, of same material as detention door face sheets, spot welded together and sized to inset inside opening and to prevent inmate tampering of lock and hinges.
 - b. Overlapping Shutters: For surface application on non-inmate side of door. Fabricate from a single steel plate, of same material as detention door face sheets, 0.187 inch (4.7 mm) thick, sized to overlap food-pass openings 1/2 inch (13 mm).
 2. Detention Door Louvers: Fabricate flush louver openings using 0.093-inch- (2.3-mm-) thick, interior steel channels of same material as detention door faces, welded to inside of both detention door face sheets and with corners fully welded. Provide welded, inverted V- or Y-shaped vanes allowing specified airflow, fabricated from same material as detention door face sheets, 0.093 inch (2.3 mm) thick, and spaced so no rigid flat instrument can pass through.
 - a. Reinforcement: Reinforce louvers that exceed 18 inches (457 mm) in height at louver midpoint with 1/4-by-1-1/2-inch- (6.3-by-38-mm-) square, vertical rectangular steel bar or 3/4-inch- (19-mm-) diameter, vertical steel bar.
 - b. Airflow: Airflow and static-pressure loss **as directed**.
 - c. Exterior Detention Door Insect Screens: Fabricated from 12-by-12 (2.1-by-2.1-mm) mesh of 0.028-inch- (0.71-mm-) diameter, stainless-steel wire or from perforated metal of same material and thickness as detention door face sheet with 1/8-inch- (3-mm-) diameter holes spaced 1 inch (25 mm) o.c.; where indicated.
 3. Speaking Apertures: Consisting of a rectangular pattern of holes, minimum 1 inch high by 4 inches wide (25 mm high by 102 mm wide), with holes 1/4 inch (6 mm) in diameter. Locate holes in both face sheets directly across from each other and spaced not more than 1 inch (25 mm) o.c. vertically and horizontally. Provide 0.067-inch- (1.7-mm-) thick, pressed-steel baffles in interior of detention door between hole patterns to prevent passage of objects.
 4. Gun Ports: Fabricate units to comply with UL 752 and to resist same security level as detention doors in which they are installed.
- G. Security Fasteners
1. Security Fasteners: Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator.
 2. Drive-System Type, Head Style, Material, and Protective Coating: Provide as required for assembly, installation, and strength, and as follows:
 - a. Drive-System Types: Pinned Torx-Plus **OR** Pinned Torx, **as directed**.
 - b. Fastener Strength: Grade 8 (Class 10.9).
 - c. Socket Button Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - d. Socket Flat Countersunk Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - e. Socket Head Cap Fasteners:
 - 1) Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
 - 2) Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
 - f. Protective Coatings for Heat-Treated Alloy Steel:
 - 1) Zinc and clear trivalent chromium, for exterior applications and interior applications where indicated.
 - 2) Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.
- H. Fabrication
1. Fabricate detention doors and frames rigid, neat in appearance, and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of



metal. Weld exposed joints continuously; grind, fill, dress, and make smooth, flush, and invisible. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.

2. Tolerances: Fabricate detention doors and frames to comply with manufacturing tolerances indicated in HMMA 863.
3. Fabricate multiple-opening detention frames with mullions that have closed tubular shapes and with no visible seams or joints.
4. Exterior Detention Doors: Provide weep-hole openings in bottom of detention doors to permit entrapped moisture to escape. Seal joints in top edges of detention doors against water penetration.
5. Hardware Preparation: Factory prepare detention doors and frames to receive mortised hardware, including cutouts, reinforcement, mortising, drilling, and tapping, according to final door hardware schedule and templates provided by detention door hardware supplier.
 - a. Reinforce detention doors and frames to receive surface-mounted door hardware. Drilling and tapping may be done at Project site.
 - b. Locate door hardware as indicated or, if not indicated, according to HMMA 831.
6. Factory cut openings in detention doors.
7. Weld components to comply with referenced AWS standard. Weld before finishing components to greatest extent possible. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

I. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Finish detention doors and frames after assembly.

J. Metallic-Coated Steel Sheet Finishes

1. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and apply galvanizing repair paint, complying with SPPC-Paint 20, to comply with ASTM A 780.
2. Factory Priming for Field-Painted Finish: Apply shop primer specified below immediately after surface preparation and pretreatment. Apply a smooth coat of even consistency to provide a uniform dry film thickness of not less than 0.7 mils (0.02 mm).
 - a. Shop Primer: Manufacturer's or fabricator's standard, fast-curing, lead- and chromate-free primer complying with ANSI A250.10 acceptance criteria; recommended by primer manufacturer for zinc-coated steel; compatible with substrate and field-applied finish paint system indicated; and providing a sound foundation for field-applied topcoats despite prolonged exposure.

K. Steel Sheet Finishes

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning"; remove dirt, oil, grease, or other contaminants that could impair paint bond. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 3, "Power Tool Cleaning," or SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
2. Factory Priming for Field-Painted Finish: Apply shop primer specified below immediately after surface preparation and pretreatment. Apply a smooth coat of even consistency to provide a uniform dry film thickness of not less than 0.7 mils (0.02 mm).
 - a. Shop Primer: Manufacturer's or fabricator's standard, fast-curing, corrosion-inhibiting, lead- and chromate-free, universal primer complying with ANSI A250.10 acceptance criteria; compatible with substrate and field-applied finish paint system indicated; and providing a sound foundation for field-applied topcoats despite prolonged exposure.

L. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.



2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - c. Directional Satin Finish: No. 4.

1.3 EXECUTION

A. Preparation

1. Remove welded-in shipping spreaders installed at factory.
2. Prior to installation and with shipping spreaders removed, adjust detention frames for squareness, alignment, twist, and plumbness to the following tolerances:
 - a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb and perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of face.
 - c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of door rabbet.
 - d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a perpendicular line from head to floor.

B. Installation

1. General: Install detention doors and frames plumb, rigid, properly aligned, and securely fastened in place, complying with Drawings, schedules, and manufacturer's written recommendations.
2. Anchorage: Set detention frame anchorage devices according to details on Shop Drawings and per anchorage device manufacturer's written instructions.
 - a. Masonry Anchors: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout.
 - b. Embedded Anchors: Install embedded plates in wall surrounding frame openings to match frame angle locations.
 - c. Postinstalled Expansion Anchors: Drill holes in existing construction at locations to match bolt locations and install bolt expansion shields or inserts.
3. Assemble detention frames fabricated in sections. Install angle splices at each corner, of same material and thickness as detention frame, and extend at least 4 inches (102 mm) on both sides of joint.
 - a. Field splice only at approved locations. Weld, grind, and finish as required to conceal evidence of splicing on exposed faces.
 - b. Continuously weld and finish smooth joints between faces of abutted, multiple-opening, detention frame members.
 - c. Field Welding: Comply with the following requirements:
 - 1) Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2) Obtain fusion without undercut or overlap.
 - 3) Remove welding flux immediately.
 - 4) At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
4. Apply bituminous coating to backs of frames prior to filling with grout.
5. Placing Detention Frames: Install detention frames of sizes and profiles indicated. Set detention frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces and spreaders, leaving surfaces smooth and undamaged.
 - a. Embedded Anchors: Remove jamb faces from detention frames and set detention frames into opening. Weld steel connector angle to frame angle and to embedded plate with 1-



inch- (25-mm-) long welds at each end of connector angle to form a rigid frame assembly solidly anchored. Reinstall jamb faces using security fasteners.

- b. Postinstalled Expansion Anchors: Install bolt. After bolt is tightened, weld bolt head to provide nonremovable condition. Grind, dress, and finish smooth welded bolt head.
 - c. At fire-rated openings, install detention frames according to NFPA 80.
 - d. Install detention frames with removable stops located on non-inmate side of opening.
6. Grout: Fully grout detention frame jambs and heads. Completely fill space between frames and adjacent substrates. Hand trowel grout and take other precautions, including bracing detention frames, to ensure that frames are not deformed or damaged by grout forces.
 7. Swinging Detention Doors: Fit non-fire-rated detention doors accurately in their frames, with the following clearances:
 - a. Between Doors and Frames at Jambs and Head: 1/8 inch (3.2 mm).
 - b. Between Edges of Pairs of Doors: 1/8 inch (3.2 mm).
 - c. At Door Sills with Threshold: 3/8 inch (9.5 mm).
 - d. At Door Sills without Threshold: 3/4 inch (19.1 mm).
 - e. Between Door Bottom and Nominal Surface of Floor Covering: 1/2 inch (12.7 mm).
 8. Sliding Detention Doors: Fit sliding detention doors in their frames according to manufacturer's written instructions and as required to allow doors to slide without binding.
 9. Fire-Rated Detention Doors: Install with clearances as specified in NFPA 80.
 10. Smoke-Control Detention Doors: Install according to NFPA 105.
 11. Installation Tolerances: Comply with installation tolerances indicated in HMMA 863.
 12. Glazing: Comply with installation requirements in Division 08 Section "Security Glazing", unless otherwise indicated.

C. Field Quality Control

1. Inspect installed products to verify compliance with requirements. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents.
2. Remove and replace detention work where inspections indicate that work does not comply with specified requirements.
3. Perform additional inspections to determine compliance of replaced or additional work. Prepare inspection reports.
4. Prepare field quality-control certification that states installed products and their installation comply with requirements in the Contract Documents.
5. Select one detention door at random from detention doors delivered to Project and have it cut in half or otherwise taken apart for verification that construction complies with requirements.
6. Test Method: Verify weld strength by prying or chiseling door apart at edge seams, end channels, or stiffeners. Not more than five percent of welds may fail test.
 - a. If tested door fails, replace or rework all detention doors to bring them into compliance at Contractor's expense.
 - b. If tested door passes, replace tested door at Contractor's expense.

D. Adjusting And Cleaning

1. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including detention doors and frames that are warped, bowed, or otherwise unacceptable.
2. Clean grout and other bonding material off detention doors and frames immediately after installation.
3. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying primer.
 - a. After finishing smooth field welds, apply air-drying primer.
4. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.
5. Stainless-Steel Surfaces: Clean surfaces according to manufacturer's written instructions.



END OF SECTION 08 34 53 00



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**SECTION 08 34 53 00a - SECURITY GRILLES**

DESCRIPTION OF WORK

This specification covers the furnishing and installation of materials for security grilles. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

GENERAL

System Description

1. Performance Requirements: Comply with following:
 - a. Performance Tests: Conducted by accredited independent testing laboratory in accordance with specified requirements in this Section.
 - 1) Source Quality Control Performance Tests: Conducted in shop or laboratory by accredited independent laboratory.
 - 2) Field Quality Performance Tests: Conducted in field.
 - b. Test Grilles: Completely assembled grille, including hardware, mounted vertically in accordance with manufacturer's recommendations.
 - 1) Test Grille Size: 914 mm (36 inches) wide by 1 219 mm (48 inches) high.
2. Bar Type Security Grilles:
 - a. Impact Test: Test Grille: Withstand impact force of 111 N (25 foot-pounds) with no breaking of welds or bar separation exceeding 127 mm (5 inches).
 - b. Bar Separation Test: Test Grille: Withstand bar separation test force of 227 kg (500 pounds) with no breaking of welds or bar separation exceeding 127 mm (5 inches).
 - c. Sag Test: If grille is equipped with side (jamb) hinges, Test Grille in Fully Extended Position: Withstand sag load of 34 kg (75 pounds) with permanent set after load removal not exceeding 1.6 mm (0.063 inch).
 - d. Forced Entry Resistance Test: If grille is equipped with side (jamb) hinges, test in closed position. Grille shall withstand forced entry loads and shall not be rendered openable throughout test.
3. Window Type Security Grilles:
 - a. Operating Force: Operating Panels: Operate with force exceeding 16 kg (35 pounds) after panel is in motion.
 - b. Impact Test: Test Grille: Withstand impact force of 111 N (25 foot-pounds). Sheet of double strength glass placed 76 mm (3 inches) behind grille material shall remain uncracked or unbroken after impact. No damage occurs that would allow entry through grille.
 - c. Forced Entry Resistance Test: If grille is operable, test grille in closed position. Grille shall withstand forced entry loads and shall not be rendered openable throughout test.
4. Child Guard Security Grilles:
 - a. Impact Test: Test Grille: Withstand impact force of 67 N (15 foot-pounds) with no weld or fastener breakage or bar separation exceeding 127 mm (5 inches).
 - b. Bar Separation Test: Withstand bar separation test force of 23 kg (50 pounds) with no weld or fastener breakage or bar separation exceeding 127 mm (5 inches).
5. Security Guard Security Grilles:
 - a. Impact Test: Test Grille in Fully Extended Position: Withstand impact force of 111 N (25 foot-pounds) with no weld or fastener breakage or bar separation exceeding 127 mm (5 inches).
 - b. Bar Separation Test: Withstand bar separation test force of 23 kg (50 pounds) with no breaking of welds or bar separation exceeding 127 mm (5 inches).
 - c. Sag Test: If grille is operable and equipped with side (jamb) hinges, test grille in fully extended position. Grille shall withstand sag load of 34 kg (75 pounds) with permanent set after load removal not exceeding 1.6 mm (0.063 inch).



- d. Forced Entry Resistance Test: If grille is operable, test grille in closed position. Grille shall withstand forced entry loads and shall not be rendered openable throughout test.

Submittals

6. Product Data:
7. Shop Drawings:
 - a. Include standard details showing recommendations for installation.
 - b. Include size of fasteners, maximum spacing from each end, center-to-center spacing on all four sides, minimum penetration of fasteners into load-bearing material and maximum clearance between frame and rough opening.
8. Samples: Submit full set of finish color samples for color selection.
9. Quality Assurance/Control Submittals:
 - a. Test Reports: Results of testing by accredited independent laboratory demonstrating compliance of security grilles with specified performance requirements.
 - b. Certificates: Manufacturer's written certification that security grilles meet or exceed specified performance requirements.
10. Closeout Submittals:
 - a. Special warranty.

Quality Assurance

11. Certifications: Comply with ANSI Z34.2.
12. Regulatory Requirements:
 - a. Egress Requirements and Fireman Access: Comply with applicable codes and regulations.
 - 1) Accessibility: Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
 - a) Uniform Federal Accessibility Standards (UFAS).
 - 2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
 - 3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
 - 4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
13. Mock-ups: For Supply and Install Contract: Install one full size mock-up of each type of security grille with specified finish for acceptance.
 - a. Locations: As directed.
 - b. Approved Mock-ups: Standard for rest of work.
 - c. Approved Mock-ups: May remain part of completed project.

Delivery, Storage, And Handling

14. Packing, Shipping, Handling, and Unloading: Pack materials at manufacturing plant to prevent damage during shipping.
15. Acceptance at Site: Inspect security grilles upon delivery. Replace damaged or defective materials before installation.
16. Storage and Protection: Store security grilles in manner to protect from weather and other damage.

Project Conditions

17. Field Measurements: Field measure openings for security grilles before start of fabrication.

Scheduling And Sequencing

18. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.

Warranty

19. Special Warranty: Provide one year written covering materials and installation for security grilles.
 - a. Warranty: Include coverage of hardware.
 - b. Contractor: Agrees to supply and install, free of charge, any required replacement parts or complete replacement security grille.



PRODUCTS

Security Grilles: KANE Screens, or approved equivalent.

20. General: Type(s) and size(s) indicated, specified, or scheduled with necessary hardware, anchors and equipment.
 - a. Egress Requirements and Fireman Access: Comply with applicable codes and regulations.
21. Materials:
 - a. Aluminum: ASTM B 221 commercial quality and of proper alloy for grille construction, free from defects impairing strength and/or durability.
 - 1) Zinc Limit: 3.0 percent in order to assure that cladding is anodic to core.
 - 2) Aluminum Extrusions: Minimum ultimate tensile strength of 151 600 kPa (22,000 PSI) and maximum yield strength of 110 300 kPa (16,000 PSI).
 - b. Steel :
 - 1) Shapes, Plates and Bars: ASTM A 36 or ASTM A 569.
 - 2) Steel Pipe: ASTM A 53.

Accessories

22. Hardware: Designed to perform functions for which it is intended and securely attached to grille.
 - a. Operable Grilles: Equipped with locks capable of meeting specified forced-entry requirements.
 - b. Locks: Releasable from interior but properly guarded to prevent access from exterior when window is open.
23. Anchoring Devices Used in Erection of Grilles: Nonmagnetic stainless steel or other noncorrosive material compatible with grille.
 - a. Anchors Exposed when Grille is Closed and Locked: Non-removable security type.
24. Fasteners:
 - a. Screws, Nuts, Washers, Bolts, Rivets, and Other Miscellaneous Fastening Devices Incorporated in Grilles: Nonmagnetic stainless steel or other corrosion resistant materials compatible with security grille and of sufficient strength to perform functions for which they are used.
 - b. Fasteners Concealed when Grille is installed and Closed: Magnetic stainless steel having chromium content of not less than 16 percent.
 - c. Fasteners Concealed when Grille is installed and Open: ASTM B 766 cadmium plated steel, ASTM B 633 zinc plated steel, or ASTM B 456 nickel or chrome plated steel.

Fabrication

25. Security Grilles: Fabricated of aluminum or steel and assembled in secure and workmanlike manner to perform as specified and to assure neat construction.
 - a. Welding or Brazing Flux: Completely removed immediately upon completion of welding or brazing operation.
 - b. Grilles: Constructed to reject passage of 102 mm (4 inch) diameter sphere at every space and interval when installed.
 - c. Grille Swing Width for Side Mounting: Maximum of 900 mm (3 feet). For opening in excess of 900 mm (3 feet), provide combination of fixed and operable grilles.
 - d. Grilles: Meet or exceed specified performance requirements in this Section.
 - e. Grilles: Comply with applicable fire codes.
26. Bar Type Security Grilles: Constructed of rigid aluminum or steel bars and of construction to meet or exceed specified performance requirements in this Section.
 - a. Fixed and Operable Bar Type Security Grilles: May be jamb or side hinged for egress.
27. Window Type Security Grilles: Constructed of aluminum or steel frame with two movable vent frames.
 - a. Vent Frames: Glazed with vinyl coated expanded carbon steel, No. 9 - 38 mm (1-1/2 inch) diamond pattern or equal.
 - b. Grilles: Constructed in manner to meet or exceed specified performance requirements in this Section.
28. Child Guard Security Grilles: Constructed of aluminum or steel bar or tubes and constructed to adjust and mount to exterior track of existing double or single hung windows.



- a. Grilles: Constructed in manner to meet or exceed specified performance requirements in this Section.
- 29. Security Guard Security Grilles: Constructed of aluminum or steel bars or tubes and constructed to adjust and mount to exterior of existing double or single hung window.
 - a. Fixed and Operable Window Guard Security Grilles: May be jamb or side hinged, or top hinged, for egress.
 - b. Grilles: Constructed in manner to meet or exceed specified performance requirements in this Section.

Finishes

- 30. Grilles: Factory applied baked on enamel painted finish.
 - a. Exposed Surfaces: Clean and free from serious surface blemishes.
 - b. Dress and finish exposed welded joints.
 - c. Steel: Rust resistive primer under baked on enamel.
 - d. Color: As selected from manufacturer's standard colors.

Source Quality Control

- 31. Testing: Performed by accredited independent testing laboratory. Use following HUD test procedures to determine if security grilles comply with specified performance requirements in this Section:
- 32. Sag Test for Side Mounted Grilles: Mount test grille into rigid frame to prevent movement of grille frame during loading.
 - a. Fully Assembled Grille: Opened to 90 degrees or to its open stop.
 - b. Test Load: Applied vertically at point 760mm (30 inches) from face of frame on operating portion of grille.
 - c. Load: Maintained for period of 3 minutes.
 - d. After removal of load, measure permanent sag at point of load application.
- 33. Impact Test: Mount test grille into rigid frame per manufacturer's recommendations.
 - a. One Impact: Made at center of grille or point deemed most susceptible to impact by testing agency.
 - b. Application of Impact Load: Made using 275 mm (11 inch) diameter sphere on free-swinging pendulum.
 - c. Impact: Made at bottom of pendulum arc.
 - d. Impact for Window Type Grille: Made at center of interior sash.
- 34. Bar Separation Test: Subject test grille to separation test at its weakest point of resistance.
 - a. Separation Load: Applied by means of pneumatic or hydraulic cylinder with adequate controls to apply load slowly to avoid quick impact.
 - b. Load: Maintained for period of 10 seconds before release.
- 35. Forced Entry Resistance Test: Mount test grille into rigid frame to prevent movement of grille during test.
 - a. Test Loads: Applied at point within 150 mm (6 inches) of locking mechanism in direction tending to open grille.
 - b. Load A of 34 kg (75 pounds) and Load B of 68 kg (150 pounds): Applied simultaneously, held for 10 seconds and released.
 - c. Load A of 34 kg (75 pounds): Applied vertically upward.
 - d. Load B of 68 kg (150 pounds): Applied perpendicular to face of grille in opening direction.
 - e. Load C of 34 kg (75 pounds): Applied horizontally from load point toward jamb opposite load.

EXECUTION

Examination

- 36. Site Verification of Conditions:
 - a. Field Measurements: Verify field measurements are as indicated on Shop Drawings.



- b. Existing Conditions: Examine openings before beginning installation.
- c. Do not proceed with installation until conditions are satisfactory.

Preparation

- 37. Protection: Protect adjacent elements from damage and disfiguration in accordance with Detailed Scope of Work.
 - a. Contractor: Responsible for damage to grounds, plantings, buildings and any other facilities or property caused by construction operations.
 - b. Repair or replace damaged elements in accordance with Detailed Scope of Work.
- 38. Existing Security Grilles: Remove existing grilles and debris from site in accordance with Detailed Scope of Work.
- 39. Preparation: Prepare openings and existing frames as required to comply with Performance Requirements.

Installation

- 40. General: Install in accordance with manufacturer's recommendations, Reference Standards, and approved Shop Drawings to comply with Performance Requirements.
 - a. Security Grilles: Securely anchor in place to straight, plumb and level condition, without distortion.
 - b. Egress Requirements and Fireman Access: Comply with applicable codes and regulations.
- 41. Dissimilar Materials: Isolate materials from incompatible materials as necessary to prevent deterioration.
 - a. Separate dissimilar metals with bituminous paint, suitable sealant, non-absorptive plastic or elastomeric tape, or gasket between surfaces.
 - 1) Coat aluminum in direct contact with concrete, masonry, steel, or other non-compatible materials with bituminous paint, zinc chromate primer, or other suitable insulating material.

Field Quality Control

- 42. Field Testing: Contractor shall have field testing of installed security grilles conducted by a testing agency in accordance with performance test described under Performance Requirements in this Section and Source Quality Control in this Section. Tests will be modified as required for field conditions.
 - a. Contractor: Provide incidental labor facilities necessary to facilitate inspections and tests.
 - b. Costs of Testing:
 - 1) By Contractor: Initial tests with failures and subsequent tests as required because of test failures. Costs shall include costs of Architect/Engineer and other consultants for observations of tests and corrective work.
 - c. Corrective Measures: Meet standards of quality of specified security grille and subject to acceptance of the Owner.

Adjusting And Cleaning

- 43. Adjusting: At completion of job, check, adjust, and lubricate hardware as required and leave security grilles and hardware in proper operating condition.
- 44. Cleaning: Comply with requirements of Detailed Scope of Work.
 - a. Clean security grilles after installation is completed to remove foreign matter and surface blemishes.
 - b. Scratched or Abraded Surfaces: Touch-up with rust inhibitor primer and enamel paint compatible with factory finish.

Protection

- 45. Installed Work: Protect security grilles from damage after installation.

END OF SECTION 08 34 53 00a



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Task	Specification	Specification Description
08 34 53 00	08 11 63 13a	Security Window Screens and Doors
08 34 56 00	08 11 63 13a	Security Window Screens and Doors
08 34 56 00	08 34 53 00	Detention Doors And Frames
08 34 56 00	08 34 53 00a	Security Grilles
08 34 73 13	08 12 13 13	Steel Doors And Frames
08 34 73 13	08 12 13 13a	Steel Entry Doors
08 34 73 13	08 12 13 13b	Stainless Steel Doors And Frames



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SECTION 08 34 73 16 - SOUND CONTROL DOORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for sound-control door assemblies. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Steel sound-control doors.
 - b. Wood sound-control doors.
 - c. Steel frames and sound-control seals.

C. Submittals

1. Product Data: For each type of product indicated. Include sound ratings, construction details, material descriptions, core descriptions, fire-resistance rating, temperature-rise ratings, and finishes.
2. LEED Submittals:
 - a. Certificates for Credit MR 7: Chain-of-custody certificates certifying that wood doors comply with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body, **as directed**.
 - b. Product Data for Credit EQ 4.4: For adhesives and composite wood products, indicating that product contains no urea formaldehyde.
3. Shop Drawings: Include the following:
 - a. Elevations of each door design.
 - b. Details of sound-control seals, door bottoms, and thresholds.
 - c. Details of doors, including vertical and horizontal edge details and metal thicknesses.
 - d. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
 - e. Locations of reinforcement and preparations for hardware.
 - f. Details of each different wall opening condition.
 - g. Details of anchorages, joints, field splices, and connections.
 - h. Details of accessories.
 - i. Details of moldings, removable stops, and glazing.
 - j. Details of conduit and preparations for power, signal, and control systems.
4. Samples:
 - a. Finishes: For each type of exposed finish required, prepared on Samples of not less than 3 by 5 inches (75 by 125 mm).
 - b. Doors: Include section of vertical-edge, top, and bottom construction; automatic door bottom or gasket; core construction; glazing; and hinge and other applied hardware reinforcement.
 - c. Frames: Include profile, corner joint, floor and wall anchors, and seals. Include separate section showing fixed sound panels if applicable.
5. Schedule: Provide a schedule of sound-control door assemblies prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with the Door Hardware Schedule.
6. Qualification Data: For qualified Installer, manufacturer, and acoustical testing agency.
7. Product Certificates: For each type of sound-control door assembly, from manufacturer.
8. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each type of sound-control door assembly.
9. Field quality-control reports.
10. Maintenance Data: For sound-control door assemblies to include in maintenance manuals.



11. Warranty: Samples of special warranty.

D. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer that is certified for chain of custody by an FSC-accredited certification body.
2. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
3. Acoustical Testing Agency Qualifications: An independent agency accredited as an acoustical laboratory according to the National Voluntary Laboratory Accreditation Program of NIST.
4. Source Limitations: Obtain sound-control door assemblies, including doors, frames, sound-control seals, hinges (when integral for sound control), thresholds, and other items essential for sound control, from single source from single manufacturer.
5. Sound Rating: Provide sound-control door assemblies identical to those of assemblies tested as sound-retardant units by an acoustical testing agency, and have the following minimum rating:
 - a. STC Rating: As indicated on Drawings **OR** As indicated in the Door Schedule, **as directed**, as determined by ASTM E 413 when tested in an operable condition according to ASTM E 90 and ASTM E 1408.
6. Forest Certification: Provide doors made with cores **OR** veneers **OR** not less than 70 percent of wood products **OR** all wood products, **as directed**, obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
7. Fire-Rated Door Assemblies: Assemblies listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C.
 - a. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
8. Smoke- and Draft-Control Door Assemblies: Where indicated **OR** At corridors, smoke barriers, and smoke partitions, **as directed**, provide assemblies tested according to UL 1784.
 - a. Air-Leakage Rate: Maximum air leakage of 0.3 cfm/sq. ft. (3 cu. m/m x sq. m) at the tested pressure differential of 0.3-inch wg (75 Pa) of water.
9. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling

1. Deliver doors and frames palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
 - a. Provide additional protection to prevent damage to finish of factory-finished wood doors.
2. Shipping Spreaders: Deliver welded frames with two removable spreader bars across bottom of frames, tack welded or mechanically attached to jambs and mullions.
3. Store doors and frames under cover at Project site. Place units in a vertical position with heads up, spaced by blocking, on minimum 4-inch- (100-mm-) high, wood blocking. Avoid using nonvented plastic or canvas shelters that could create a humidity chamber.
 - a. If wrappers on doors become wet, remove cartons immediately. Provide a minimum of 1/4-inch (6-mm) space between each stacked door to permit air circulation.

F. Project Conditions

1. Environmental Limitations: Do not deliver or install wood sound-control wood doors until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
2. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

G. Coordination



1. Coordinate installation of anchorages for sound-control door assemblies. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of sound-control door assemblies that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Failure to meet sound rating requirements.
 - 2) Faulty operation of sound seals.
 - 3) Deterioration of metals, metal finishes, and other materials beyond normal use or weathering.
 - 4) Wood doors that are warped (bow, cup, or twist) more than 1/4 inch (6 mm) in a 42-by-84-inch (1067-by-2134-mm) section, or show telegraphing of core construction in face veneers exceeding 0.01 inch in a 3-inch (0.25 mm in a 75-mm) span.
 - b. Warranty Period for Steel Doors: Five years from date of Final Completion.
 - c. Warranty Period for Wood Doors: Two years from date of Final Completion.

1.2 PRODUCTS

A. Steel Sound-Control Doors

1. Description: Provide flush-design sound-control doors, 1-3/4 inches (44 mm) thick, of seamless construction; with manufacturer's standard sound-retardant core as required to provide STC **OR** STC and fire, **as directed**, rating indicated. Construct doors with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges. Fabricate according to ANSI/NAAMM-HMMA 865.
 - a. Exterior Doors: Fabricate from metallic-coated steel sheet 0.052-inch (1.32-mm) nominal thickness, or thicker as required to provide STC rating indicated.
 - b. Interior Doors: Fabricate from cold-rolled steel sheet unless otherwise indicated, 0.048-inch (1.21-mm) nominal thickness, or thicker as required to achieve STC rating indicated.
 - c. Loose Stops for Glazed Lites in Doors: Same material as face sheets.
 - d. Top and Bottom Channels: Closed with continuous channels of same material as face sheets, spot welded to face sheets not more than 6 inches (150 mm) o.c.
 - e. Hardware Reinforcement: Same material as face sheets.
2. Materials:
 - a. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.
 - b. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.
 - c. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B, with G60 (Z180) zinc (galvanized) or A40 (ZF120) zinc-iron-alloy (galvannealed) coating designation.
 - d. Glazing: As required by sound-control door assembly manufacturer to comply with sound-control **OR** sound-control and fire-rated-door labeling, **as directed**, requirements.
3. Finishes:
 - a. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
 - 1) Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.
 - b. Factory-Applied Paint Finish: Manufacturer's standard primer and finish coats, complying with ANSI/SDI A250.3 for performance and acceptance criteria.



- 1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

B. Wood Sound-Control Doors

1. Description: Provide flush-design sound-control doors, 1-3/4 inches (44 mm) thick; with manufacturer's standard sound-retardant core as required to provide STC **OR** STC and fire, **as directed**, rating indicated. Fabricate according to WDMA 1.S.1-A.
2. Materials: Comply with Division 08 Section(s) "Flush Wood Doors" OR "Stile And Rail Wood Doors", **as directed**, for grade, faces, veneer matching, fabrication, finishing, and other requirements unless otherwise indicated.
 - a. Glazing: As required by sound-control door assembly manufacturer to comply with sound-control **OR** sound-control and fire-rated-door labeling, **as directed**, requirements.
3. Finishes:
 - a. Factory finish sound-control wood doors to match doors specified in Division 08 Section(s) "Flush Wood Doors" OR "Stile And Rail Wood Doors", **as directed**.

C. Sound-Control Panels

1. Provide sound-control panels of same materials, construction, sound rating, and finish as specified for adjoining sound-control steel **OR** wood, **as directed**, doors.

D. Sound-Control Frames

1. Description: Fabricate sound-control door frames with corners mitered, reinforced, and continuously welded full depth and width of frame. Fabricate according to ANSI/NAAMM-HMMA 865.
 - a. Weld frames according to NAAMM-HMMA 820.
 - b. Exterior Frames: Fabricate from metallic-coated steel sheet 0.079-inch (2.01-mm) nominal thickness, or thicker as required to provide STC rating indicated.
 - c. Interior Frames: Fabricate from cold-rolled steel sheet unless otherwise indicated, 0.075-inch (1.90-mm) nominal thickness, or thicker as required to provide STC rating indicated.
 - d. Sound-Control Panel Stops: Formed integral with frames, a minimum of 5/8 inch (16 mm) high, unless otherwise indicated.
 - e. Hardware Reinforcement: Fabricate according to ANSI/NAAMM-HMMA 865 of same material as face sheets.
 - f. Head Reinforcement: Reinforce frames with metallic-coated steel channel or angle stiffener, 0.108-inch (2.74-mm) nominal thickness, welded to head.
 - g. Jamb Anchors:
 - 1) Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.064-inch (1.63-mm) nominal thickness metallic-coated steel with corrugated or perforated straps not less than 2 inches (50 mm) wide by 10 inches (250 mm) long; or wire anchors not less than 0.156 inch (4.0 mm) thick.
 - 2) Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.048-inch (1.21-mm) nominal thickness uncoated steel unless otherwise indicated.
 - 3) Postinstalled Expansion Type for In-Place Concrete or Masonry: Minimum 3/8-inch- (9.5-mm-) diameter, metallic-coated steel bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.
 - h. Floor Anchors: Not less than 0.079-inch (2.01-mm) nominal thickness metallic-coated steel, and as follows:
 - 1) Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
 - 2) Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2-inch (50-mm) height adjustment. Terminate bottom of frames at finish floor surface.
 - i. Ceiling Struts: Minimum 3/8-inch-thick by 2-inch- (9.5-mm-thick by 50-mm-) wide uncoated steel unless otherwise indicated.
 - j. Plaster Guards: Metallic-coated steel sheet, not less than 0.026 inch (0.6 mm) thick.



2. Materials:
 - a. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.
 - b. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.
 - c. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B, with G60 (Z180) zinc (galvanized) or A40 (ZF120) zinc-iron-alloy (galvannealed) coating designation.
 - d. Supports and Anchors: After fabricating, galvanize units to be built into exterior walls according to ASTM A 153/A 153M, Class B.
 - e. Inserts, Bolts, and Fasteners: Provide items to be built into exterior walls, hot-dip galvanized according to ASTM A 153/A 153M or ASTM F 2329.
 - f. Powder-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching sound-control door frames of type indicated.
 - g. Mineral-Fiber Insulation: Insulation composed of rock-wool fibers, slag-wool fibers, or glass fibers.
3. Finishes:
 - a. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
 - 1) Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.
 - b. Factory-Applied Paint Finish: Manufacturer's standard primer and finish coats, complying with ANSI/SDI A250.3 for performance and acceptance criteria.
 - 1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

E. Sound-Control Hardware

1. Description: Provide manufacturer's standard sound-control system, including head and jamb seals, door bottoms, cam-lift hinges, and thresholds, as required by testing to achieve STC **OR** STC and fire, **as directed**, rating indicated.
 - a. Compression Seals: One-piece units; consisting of closed-cell sponge neoprene seal held in place by metal retainer; with retainer cover of same material as door frame; attached to door frame with concealed screws.
OR
Magnetic Seals: One-piece units; consisting of closed-cell sponge neoprene seal and resiliently mounted magnet held in place by metal retainer; with retainer cover of same material as door frame; attached to door frame with concealed screws.
 - b. Automatic Door Bottoms: Neoprene or silicone gasket, held in place by metal housing, that automatically drops to form seal when door is closed; mounted to bottom edge of door with screws.
 - 1) Mounting: Mortised or semimortised into bottom of door or surface mounted on face of door as required by testing to achieve STC rating indicated.
OR
Door Bottoms: Neoprene or silicone gasket held in place by metal housing; mortised into bottom edge of door.
 - c. Cam-Lift Hinges: Full-mortise template type that raises door 1/2 inch (13 mm) when door is fully open; with hardened pin; fabricated from stainless steel.
 - d. Thresholds: Flat, smooth, unfluted type as recommended by manufacturer; fabricated from aluminum **OR** stainless steel **OR** solid wood matching wood door faces, **as directed**.
 - 1) Finish: Clear **OR** Color, **as directed**, anodic finish.
 - 2) Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from full range of industry colors and color densities, **as directed**.
2. Other Hardware: Comply with requirements in Division 08 Section "Door Hardware".



F. Sound-Control Accessories

1. Glazing: Comply with requirements in Division 08 Section "Glazing"
2. Grout: Comply with ASTM C 476, with a slump of not more than 4 inches (102 mm) as measured according to ASTM C 143/C 143M.
3. Corrosion-Resistant Coating: Cold-applied asphalt mastic, compounded for 15-mil (0.4-mm) dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

G. Fabrication

1. Sound-Control Steel Door Fabrication: Sound-control doors to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal.
 - a. Seamless Edge Construction: Fabricate doors with faces joined at vertical edges by welding; welds shall be ground, filled, and dressed to make them invisible and to provide a smooth, flush surface.
 - b. Exterior Doors: Close top edges flush and seal joints against water penetration. Provide weep-hole openings in bottom of exterior doors to permit moisture to escape.
 - c. Glazed Lites: Factory install glazed lites according to requirements of tested assembly to achieve STC rating indicated. Provide fixed stops and moldings welded on secure side of door.
 - d. Hardware Preparation: Factory prepare sound-control doors to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping, according to the Door Hardware Schedule and templates furnished as specified in "Door Hardware".
 - 1) Reinforce doors to receive nontemplated mortised and surface-mounted door hardware.
 - 2) Locate door hardware as indicated, or if not indicated, according to NAAMM-HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."
 - e. Tolerances: Fabricate doors to tolerances indicated in ANSI/NAAMM-HMMA 865.
2. Sound-Control Wood Door Fabrication: Factory fit doors to suit frame-opening sizes indicated, with uniform clearances and bevels according to referenced quality standard, unless otherwise indicated. Comply with final door hardware schedules and hardware templates.
 - a. Comply with clearance requirements in NFPA 80 for fire-rated doors.
 - b. Locate door hardware as indicated, or if not indicated, according to DHI WDHS.3, "Recommended Locations for Architectural Hardware for Wood Flush Doors."
 - 1) Coordinate measurements of hardware mortises in steel frames to verify dimensions and alignment before factory machining.
3. Sound-Control Frame Fabrication: Fabricate sound-control frames to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.
 - a. Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible. Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated from same thickness metal as frames.
 - b. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 - c. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
 - d. Jamb Anchors: Provide number and spacing of anchors as follows:
 - 1) Masonry Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
 - a) Two anchors per jamb up to 60 inches (1524 mm) in height.
 - b) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) in height.



- c) Four anchors per jamb from 90 to 96 inches (2286 to 2438 mm) in height.
- d) Four anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof more than 96 inches (2438 mm) in height.
- 2) Stud Wall Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
 - a) Three anchors per jamb up to 60 inches (1524 mm) in height.
 - b) Four anchors per jamb from 60 to 90 inches (1524 to 2286 mm) in height.
 - c) Five anchors per jamb from 90 to 96 inches (2286 to 2438 mm) in height.
 - d) Five anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof more than 96 inches (2438 mm) in height.
 - e) Two anchors per head for frames more than 42 inches (1066 mm) wide and mounted in metal stud partitions.
- 3) Postinstalled Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.
- e. Head Reinforcement: For frames more than 48 inches (1219 mm) wide, provide continuous head reinforcement for full width of opening, welded to back of frame at head.
- f. Hardware Preparation: Factory prepare sound-control frames to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping, according to the Door Hardware Schedule and templates furnished as specified in Division 08 Section "Door Hardware".
 - 1) Reinforce frames to receive nontemplated mortised and surface-mounted door hardware.
 - 2) Locate hardware as indicated, or if not indicated, according to NAAMM-HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."
- g. Plaster Guards: Weld guards to frame at back of hardware cutouts and glazing-stop screw and sound-control seal preparations to close off interior of openings in frames to be grouted.
- h. Tolerances: Fabricate frames to tolerances indicated in ANSI/NAAMM-HMMA 865.

1.3 EXECUTION

A. Examination

- 1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of sound-control door assemblies.
- 2. Examine roughing-in for embedded and built-in anchors to verify actual locations of sound-control door frame connections before frame installation.
- 3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

- 1. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.
- 2. Prior to installation and with installation spreaders in place, adjust and securely brace sound-control door frames to the following tolerances:
 - a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a perpendicular line from head to floor.



3. Drill and tap doors and frames to receive nontemplated mortised and surface-mounted door hardware.

C. Installation

1. General: Install sound-control door assemblies plumb, rigid, properly aligned, and securely fastened in place; comply with manufacturer's written instructions.
2. Frames: Install sound-control door frames in sizes and profiles indicated.
 - a. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
 - 1) At fire-rated openings, install frames according to NFPA 80.
 - 2) At openings requiring smoke and draft control, install frames according to NFPA 105.
 - 3) Where frames are fabricated in sections due to shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, and dress; make splice smooth, flush, and invisible on exposed faces.
 - 4) Install sound-control frames with removable glazing stops located on secure side of opening.
 - 5) Remove temporary braces only after frames or bucks have been properly set and secured.
 - 6) Check squareness, twist, and plumbness of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
 - 7) Apply corrosion-resistant coatings coating to backs of frames to be filled with mortar, grout, and plaster containing antifreezing agents.
 - b. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor and secure with postinstalled expansion anchors.
 - 1) Floor anchors may be set with powder-actuated fasteners instead of postinstalled expansion anchors, if so indicated and approved on Shop Drawings.
 - c. Metal-Stud Partitions: Solidly pack mineral-fiber insulation behind frames.
 - d. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
 - e. In-Place Gypsum Board Partitions: Secure frames in place with postinstalled expansion anchors through floor anchors at each jamb. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
 - f. Ceiling Struts: Extend struts vertically from top of frame at each jamb to supporting construction above, unless frame is anchored to masonry or to other structural support at each jamb. Bend top of struts to provide flush contact for securing to supporting construction above. Provide adjustable wedged or bolted anchorage to frame jamb members.
 - g. Grouted Frames: Solidly fill space between frames and substrate with grout. Take precautions, including bracing frames, to ensure that frames are not deformed or damaged by grout forces.
 - h. Installation Tolerances: Adjust sound-control door frames for squareness, alignment, twist, and plumbness to the following tolerances:
 - 1) Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - 2) Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - 3) Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - 4) Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a perpendicular line from head to floor.
3. Doors: Fit sound-control doors accurately in frames, within clearances indicated below. Shim as necessary.



- a. Non-Fire-Rated Doors: Fit non-fire-rated doors accurately in frames with the following clearances:
 - 1) Jamb: 1/8 inch (3 mm).
 - 2) Head with Butt Hinges: 1/8 inch (3 mm).
 - 3) Head with Cam-Lift Hinges: As required by manufacturer, but not more than 3/8 inch (9.5 mm).
 - 4) Sill: Manufacturer's standard.
 - 5) Between Edges of Pairs of Doors: 1/8 inch (3 mm).
 - b. Fire-Rated Doors: Install fire-rated doors with clearances according to NFPA 80.
 4. Sound-Control Seals: Where seals have been prefit and preinstalled in the factory and subsequently removed for shipping, reinstall seals and adjust according to manufacturer's written instructions.
 5. Cam-Lift Hinges: Install hinges according to manufacturer's written instructions.
 6. Thresholds: Set thresholds in full bed of sealant complying with requirements in Division 7 Section "Joint Sealants."
 7. Glazing: Comply with installation requirements in Division 08 Section "Glazing" and with sound-control door assembly manufacturer's written instructions.
 - a. Secure stops with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c., and not more than 2 inches (50 mm) o.c. from each corner.
- D. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 2. Testing Services: Acoustical testing and inspecting agency shall select one sound-control door at random from sound-control door assemblies that are completely installed and perform testing for verification that assembly complies with STC rating requirements.
 - a. Field tests shall be conducted according to ASTM E 336, with results calculated according to ASTM E 413. Acceptable field STC values shall be within 5 dB of laboratory STC values.
 - b. Inspection Report: Acoustical testing agency shall submit report in writing to the Owner and Contractor within 24 hours after testing.
 - c. If tested door fails, replace or rework all sound-control door assemblies to bring them into compliance at Contractor's expense.
 - 1) Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 3. Prepare test and inspection reports.
- E. Adjusting And Cleaning
1. Final Adjustments: Check and adjust seals, door bottoms, and other sound-control hardware items right before final inspection. Leave work in complete and proper operating condition.
 2. Remove and replace defective work, including defective or damaged sound seals and doors and frames that are warped, bowed, or otherwise unacceptable.
 - a. Adjust gaskets, gasket retainers, and retainer covers to provide contact required to achieve STC rating.
 3. Clean grout off sound-control door frames immediately after installation.
 4. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying primer.
 5. Metallic-Coated Surfaces: Clean abraded areas of doors and repair with galvanizing repair paint according to manufacturer's written instructions.

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SECTION 08 62 00 00 - ROOF WINDOWS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for roof windows. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Fixed (nonoperable) roof windows for exterior locations with aluminum-clad, copper-clad and fiberglass-clad exterior exposed surfaces and wood interior exposed surfaces.
 - b. Venting (with operable sash) roof windows for exterior locations with aluminum-clad, copper-clad and fiberglass-clad exterior exposed surfaces and wood interior exposed surfaces.

C. Performance Requirements

1. Structural Performance: Provide roof windows capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - a. Wind Loads: Compliance is based on testing units representative of those indicated for Project that pass AAMA/WDMA/CSA 101/I.S.2/A440, Uniform Load Structural Test.
 - 1) Basic Wind Speed: 85 mph (38 m/s) **OR** 90 mph (40 m/s), **as directed**.
 - 2) Importance Factor.
 - 3) Exposure Category: **B OR C OR D, as directed**.
 - b. Deflection Limits: Design glass framing system to limit lateral deflections of glass edges to less than 1/175 of glass-edge length or 3/4 inch (19 mm), whichever is less, at design pressure based on testing performed according to AAMA/WDMA/CSA 101/I.S.2/A440, Uniform Load Deflection Test, or structural computations.
 - c. Snow Loads.
2. Windborne-Debris Resistance: Provide glazed roof windows capable of resisting impact from windborne debris, based on the pass/fail criteria as determined from testing glazed roof windows identical to those specified, according to ASTM E 1886 and testing information in ASTM E 1996 **OR** AAMA 506, **as directed**, and requirements of authorities having jurisdiction.

D. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, fabrication methods, dimensions of individual components and profiles, hardware, finishes, and operating instructions.
 - a. Motors: Show nameplate data, ratings, characteristics, and mounting arrangements.
2. LEED Submittal:
 - a. Certificates for Credit MR 7: Chain-of-custody certificates certifying that roof windows comply with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body. Include statement indicating costs for each certified wood product.
3. Shop Drawings: Include plans, elevations, sections, details, hardware, attachments to other work, operational clearances, installation details, and the following:
 - a. Mullion details, including reinforcement and stiffeners.
 - b. Joinery details.
 - c. Expansion provisions.
 - d. Flashing and drainage details.
 - e. Weather-stripping details.



- f. Glazing details.
- g. Accessories.
- h. Window cleaning provisions.
- i. Window System Operators: Show locations, mounting, and details for installing operator components and controls.
- j. Window System Operators: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
- k. Wiring Diagrams: Power, signal, and control wiring.
4. Samples: For roof windows and components required, prepared on Samples of size indicated below.
 - a. Main Framing Member: 12-inch- (300-mm-) long section with weather stripping, **as directed**, glazing bead and factory-applied color finish.
 - b. Hardware: Full-size units with factory-applied finish.
5. Delegated-Design Submittal: For roof windows indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation and used to determine the following:
 - a. Structural test pressures and design pressures from loads indicated.
 - b. Deflection limitations of glass framing systems.
6. Qualification Data: For qualified Installer, manufacturer and professional engineer.
7. Product Test Reports: Based on evaluation of comprehensive tests performed within the last four years by a qualified testing agency, for each class, grade, and size of roof window.
8. Maintenance Data: For weather stripping, operable sash, operating hardware, and finishes to include in maintenance manuals.
9. Warranties: Sample of special warranties.

E. Quality Assurance

1. Manufacturer Qualifications: A manufacturer capable of fabricating roof windows that meet or exceed performance requirements indicated and of documenting this performance by inclusion in lists and by labels, test reports, and calculations.
2. Installer Qualifications: An installer acceptable to roof window manufacturer for installation of units required for this Project.
 - a. Installer's responsibilities include providing professional engineering services needed to assume engineering responsibility including preparation of data for roof windows, including Shop Drawings and Designated Design Submittal, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
3. Forest Certification: Fabricate products from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
4. Fenestration Standard: Comply with AAMA/WDMA/CSA 101/I.S.2/A440, "Standard/Specification for Windows, Doors, and Unit Skylights," for minimum standards of performance, materials, components, accessories, and fabrication. Comply with more stringent requirements if indicated.
 - a. Provide WDMA-certified units with an attached label.
5. Glazing Publication: Comply with published recommendations of glass manufacturers and with GANA's "Glazing Manual" unless more stringent requirements are indicated.

F. Delivery, Storage, And Handling

1. Protect roof windows during transit, storage, and handling to prevent damage, soiling, and deterioration. Store off ground and covered in a clean, dry, well-ventilated, protected space. Comply with manufacturer's written instructions.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace roof windows that fail in materials or workmanship within specified warranty period.



- a. Failures include, but are not limited to, the following:
 - 1) Failure to meet performance requirements.
 - 2) Structural failures including excessive deflection.
 - 3) Water leakage or air infiltration.
 - 4) Faulty operation of movable panels and hardware.
 - 5) Deterioration of wood, metals, vinyl, other materials, and finishes beyond normal weathering.
 - 6) Deterioration of insulating glass and laminated glass, **as directed**, as defined in Division 08 Section "Glazing".
- b. Warranty Period:
 - 1) Roof Window: Five **OR** 10, **as directed**, years from date of Final Completion.
 - 2) Glazing: 10 **OR** 20, **as directed**, years from date of Final Completion.
 - 3) Exterior Finish: Five years from date of Final Completion.

1.2 PRODUCTS

A. Materials

1. Wood: Clear fir or pine or another suitable fine-grained lumber; kiln-dried to a moisture content of 6 to 12 percent at time of fabrication; free of visible finger joints, blue stain, knots, pitch pockets, and surface checks larger than 1/32 inch (0.8 mm) deep by 2 inches (51 mm) wide; water-repellent preservative treated.
 - a. Finish: Unfinished **OR** Manufacturer's standard transparent finish **OR** Manufacturer's standard prime-painted finish complying with WDMA T.M. 11 **OR** Manufacturer's standard opaque finish complying with WDMA T.M. 12, **as directed**.
2. Aluminum: Manufacturer's standard formed sheet or extruded aluminum. Provide aluminum alloy and temper recommended by roof window manufacturer for strength, corrosion resistance, and application of required finish.
 - a. Baked-Enamel Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - 1) Color and Gloss: White **OR** Bronze **OR** Brown **OR** As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. High-Performance Organic Finish: Two-coat fluoropolymer finish complying with AAMA 620 **OR** AAMA 2604 **OR** AAMA 2605, **as directed**, and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
3. Copper: ASTM B 370; Temper H00, cold rolled unless Temper 060, soft is required for forming; not less than 16 oz./sq. ft. (0.55 mm thick).
 - a. Finish: Manufacturer's standard **OR** As selected from manufacturer's full range, **as directed**.
4. Reinforced Thermoset Fiberglass: AAMA 305 with manufacturer's standard finish.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
5. Trim and Glazing Stops: Material and finish to match wood frame members.
6. Fasteners: Aluminum, nonmagnetic stainless steel, or other materials warranted by manufacturer to be noncorrosive for SC 3 severe service conditions and compatible with roof window members, cladding, trim, hardware, anchors, and other components.
 - a. Exposed Fasteners: Unless unavoidable for applying hardware, do not use exposed fasteners. For application of hardware, use fasteners that match finish of member or hardware being fastened, as appropriate.



7. Anchors, Clips, Mounting Brackets, and Accessories: Aluminum, nonmagnetic stainless steel, or zinc-coated steel or iron complying with ASTM B 456 or ASTM B 633 for SC 3 severe service conditions; provide sufficient strength to withstand design pressure indicated.
8. Mullions: Provide mullions and mullion casing and cover plates as shown, matching roof window units, complete with anchors for support to structure and installation of roof window units. Allow for erection tolerances and provide for movement of roof window units due to thermal expansion and building deflections, as indicated. Provide mullions and cover plates capable of withstanding design loads of roof window units.
9. Reinforcing Members: Aluminum, nonmagnetic stainless steel, nickel/chrome-plated steel complying with ASTM B 456 or zinc-coated steel or iron complying with ASTM B 633 for SC 3 severe service conditions; provide sufficient strength to withstand design pressure indicated.
10. Compression-Type Weather Stripping: Provide compressible weather stripping designed for permanently resilient sealing under bumper or wiper action, and completely concealed when roof window is closed.
 - a. Weather-Stripping Material: Closed-cell elastomeric, preformed gaskets complying with ASTM C 509.
OR
Weather-Stripping Material: Dense elastomeric gaskets complying with ASTM C 864.
OR
Weather-Stripping Material: Manufacturer's standard system and materials complying with AAMA/WDMA/CSA 101/I.S.2/A440.
11. Flashing: Manufacturer's standard flashing system for application indicated.
 - a. Material: Aluminum **OR** Copper **OR** Flexible EPDM flashing, **as directed**.
 - b. Rigid aluminum **OR** copper, **as directed**, nailing flange formed into frame.
 - c. Auxiliary Water Diverter: Provide at roof window head as back flashing.

B. Roof Window

1. AAMA/WDMA/CSA Performance Requirements: Provide roof windows of performance indicated that comply with AAMA/WDMA/CSA 101/I.S.2/A440 unless more stringent performance requirements are indicated.
 - a. Performance Class and Grade: R15 **OR** 20 **OR** 25, **as directed**.
 - b. Performance Class and Grade: C30 **OR** 35 **OR** 40, **as directed**.
 - c. Performance Class and Grade: As indicated.
2. Thermal Transmittance: Provide roof windows with a whole fenestration product U-factor maximum indicated, when tested according to AAMA 1503 **OR** determined according to ASTM E 1423 **OR** determined according to NFRC 100, **as directed**.
 - a. U-Factor: 0.35 **OR** 0.40 **OR** 0.65, **as directed**, Btu/sq. ft. x h x deg F (W/sq. m x K).
 - b. U-Factor: 0.60 Btu/sq. ft. x h x deg F (W/sq. m x K) (this is the maximum U-factor allowed by the IECC 2006 for skylights in all but climate zones 1 to 3).
3. Solar Heat-Gain Coefficient (SHGC): Provide roof windows with a whole-window SHGC maximum of 0.40 **OR** 0.50 **OR** 0.55, **as directed**, determined according to NFRC 200.
4. Air-Leakage Resistance: Maximum rate not more than indicated when tested according to AAMA/WDMA/CSA 101/I.S.2/A440, Air Leakage Resistance Test.
 - a. Maximum Rate: 0.3 cfm/sq. ft. (1.5 L/s x sq. m) of area at an inward test pressure of 1.6 lbf/sq. ft. (75 Pa) (equivalent to 25-mph (40-km/h) wind speed and typically used to test R and C performance classes).
5. Water-Penetration Resistance: No water leakage as defined in AAMA/WDMA/CSA referenced test methods at a water test pressure equaling that indicated, when tested according to AAMA/WDMA/CSA 101/I.S.2/A440, Water Penetration Resistance Test.
 - a. Test Pressure: 15 percent of positive design pressure, but not less than 2.9 lbf/sq. ft. (140 Pa) or more than 12 lbf/sq. ft. (580 Pa).
6. Forced-Entry Resistance: Comply with Performance Grade 10 (lowest recognized by ASTM F 588 and is mandatory if AAMA/WDMA/CSA 101/I.S.2/A440 is the method selected for specifying roof window performance) requirements when tested according to ASTM F 588.



7. Operating Force and Auxiliary (Durability) Tests: According to and complying with AAMA/WDMA/CSA 101/I.S.2/A440.
- C. Glazing
1. Glass and Glazing System: Comply with Division 08 Section "Glazing" for glass, insulating-glass units, laminated glass, and glazing requirements applicable to glazed roof windows.
- D. Hardware
1. Comply with AAMA/WDMA/CSA 101/I.S.2/A440 for fixed skylights.
 2. General: Provide manufacturer's standard hardware, fabricated from a corrosion-resistant material compatible with wood and aluminum cladding **OR** and copper cladding, **as directed**, complying with AAMA 907; designed to smoothly operate, tightly close, and securely lock sliding wood-framed roof windows; and sized to accommodate sash weight and dimensions. Do not use aluminum in frictional contact with other metals.
 - a. Hardware Finish: Manufacturer's standard **OR** Match cladding appearance, **as directed**.
 3. Gear-Type Rotary Operators: Comply with AAMA 901 when tested according to ASTM E 405, Method A.
 4. Pole Operator: Manufacturer's standard manual **OR** motorized, **as directed**, pole for operating venting units that are more than 72 inches (1800 mm) above floor.
 5. Motor Operator: Manufacturer's standard electric motor and remote control for operating venting units that are more than 72 inches (1800 mm) above floor.
 - a. Provide rain sensor that automatically closes venting unit when water is detected.
OR
Provide motor operator with wireless remote-control device.
 6. Roof Window Operation:
 - a. Operator and Control: Gear-type rotary operator with plastic or metal cable that uncoils and stiffens to open sash; with locking mechanism.
 - 1) Operation: Crank handle **OR** Pole, **as directed**, for manual operation.
 - 2) Operation: Electric.
OR
Operator and Control: Gear-type rotary operator with arm(s) that scissors or swings to open sash; with locking mechanism.
 - 1) Operation: Crank handle **OR** Pole, **as directed**, for manual operation.
 - 2) Operation: Electric.
OR
Operator and Control: Spring-assisted, counter-balanced operator that allows sash to remain open in any position; with lever-handle-operated latches and lock for manual operation.
 - b. Hinge: Continuous.
OR
Hinges: Pivot **OR** Manufacturer's standard, **as directed**; two per operable sash.
- E. Accessories
1. Insect Screens: Manufacturer's standard removable screen; aluminum or vinyl frame with mitered or coped joints and with ASTM D 3656 mesh of plastic-coated glass-fiber threads. Provide frame in manufacturer's standard finish and mesh in manufacturer's standard color.
 2. Shades: Manufacturer's standard of type indicated and in color and pattern selected from manufacturer's full range.
 - a. Type: Pleated **OR** Venetian blind **OR** Roll up, **as directed**.
 - b. Pole Operation: Provide manual **OR** motorized, **as directed**, pole for operating shades that are more than 72 inches (1800 mm) above floor.
OR
Motorized Operation: Provide manufacturer's standard electric motor and remote control for operating shades with wireless remote-control device, **as directed**.
- F. Fabrication



1. Fabricate roof windows in sizes indicated. Include a complete system for assembling components and anchoring and flashing windows.
2. Fabricate roof windows that are reglazable without dismantling sash framing.
3. Weather Stripping: Provide full-perimeter weather stripping for each operable sash.
4. Provide condensation gutter or other means to hold condensed moisture or drain it to exterior.
5. Complete fabrication, assembly, finishing, hardware application, and other work in the factory to greatest extent possible. Disassemble components only as necessary for shipment and installation. Allow for scribing, trimming, and fitting at Project site.
6. Factory-Glazed Fabrication: Glaze roof windows in the factory. Comply with requirements in Division 08 Section "Glazing" and with AAMA/WDMA/CSA 101/I.S.2/A440.

1.3 EXECUTION

A. Examination

1. Examine openings, substrates, structural support, anchorage, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of work. Verify rough opening dimensions, slope of roof construction, and operational clearances. Examine roof decks, vapor retarders, water and weather barriers, and other built-in components to ensure a coordinated, weathertight roof window installation.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Comply with manufacturer's written installation instructions for installing roof windows, hardware, **as directed**, motor operators, **as directed**, accessories, and other components.
2. Install roof windows square, true, and without distortion, warp, or rack of frames and sash. Securely anchor windows to structural support without impeding thermal movement and in proper relation to adjacent construction.
3. Install flashing to provide a watertight and weathertight seal.
4. Separate aluminum, copper, and other corrodible surfaces from sources of corrosion or electrolytic action at points of contact with other materials according to recommendations in ASTM E 2112.

C. Adjusting, Cleaning, And Protection

1. Lubricate hardware and moving parts.
2. Adjust operating sash, operators, **as directed**, screens, and accessories for a tight fit at contact points and for smooth operation and weathertight closure.
3. Adjust hardware for proper alignment, smooth operation, and proper latching without unnecessary force or excessive clearance.
4. Adjust shades to hang true to line without rack. Provide unencumbered operation.
5. Clean frame surfaces immediately after installing roof windows. Comply with manufacturer's written instructions for final cleaning and maintenance. Avoid damaging protective coatings and finishes.
6. Inspect drainage holes for blockage. Clean and free holes of any obstructions to allow drainage.
7. Clean glass immediately after installing roof windows. Comply with manufacturer's written instructions for final cleaning and maintenance. Remove nonpermanent labels and clean surfaces.
8. Remove and replace glass that has been broken, chipped, cracked, abraded, or damaged during construction period.
9. Protect roof window surfaces from contact with contaminating substances resulting from construction operations. If contaminating substances contact roof window surfaces, remove contaminants immediately according to manufacturer's written instructions.
10. Refinish or replace roof windows that have damaged finishes.
11. Replace damaged components.



END OF SECTION 08 62 00 00



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Task	Specification	Specification Description
08 62 23 00	08 62 00 00	Roof Windows
08 63 13 00	08 62 00 00	Roof Windows



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SECTION 08 90 00 00 - LOUVERS AND VENTS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for louvers and vents. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Fixed, extruded-aluminum and formed-metal louvers.
 - b. Adjustable, extruded-aluminum and formed-metal louvers.
 - c. Adjustable, extruded-aluminum and formed-metal insulated louvers.
 - d. Fixed, formed-metal acoustical louvers.
 - e. Wall vents (brick vents).

C. Definitions

1. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.
2. Horizontal Louver: Louver with horizontal blades; i.e., the axes of the blades are horizontal.
3. Vertical Louver: Louver with vertical blades; i.e., the axes of the blades are vertical.
4. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.
5. Storm-Resistant Louver: Louver that provides specified wind-driven rain performance, as determined by testing according to AMCA 500-L.

D. Performance Requirements

1. Delegated Design: Design louvers, including comprehensive engineering analysis by a qualified professional engineer, using structural and seismic performance requirements and design criteria indicated.
2. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors.
 - a. Wind Loads:
 - 1) Determine loads based on pressures as indicated on Drawings.
OR
Determine loads based on a uniform pressure of 20 lbf/sq. ft. (957 Pa) **OR** 30 lbf/sq. ft. (1436 Pa), **as directed**, acting inward or outward.
3. Seismic Performance: Louvers, including attachments to other construction, shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. Design earthquake spectral response acceleration, short period (Sds) for Project is **as directed**.
 - b. Component Importance Factor is 1.5 **OR** 1.0, **as directed**.
4. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
5. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.



6. Acoustic Performance: Provide acoustical louvers complying with ratings specified, as demonstrated by testing manufacturer's stock units identical to those specified, except for length and width for airborne sound-transmission loss according to ASTM E 90 **OR** outdoor-indoor sound-transmission loss according to ASTM E 966, **as directed**.

E. Submittals

1. Product Data: For each type of product indicated.
 - a. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
2. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
3. Samples: For each type of metal finish required.
4. Delegated-Design Submittal: For louvers indicated to comply with structural and seismic performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Product Test Reports: Based on tests performed according to AMCA 500-L.

F. Quality Assurance

1. Welding: Qualify procedures and personnel according to the following:
 - a. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - b. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - c. AWS D1.6, "Structural Welding Code - Stainless Steel."
2. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.
3. UL and NEMA Compliance: Provide motors and related components for motor-operated louvers that are listed and labeled by UL and comply with applicable NEMA standards.

1.2 PRODUCTS

A. Materials

1. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5, T-52, or T6.
2. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.
3. Aluminum Castings: ASTM B 26/B 26M, Alloy 319.
4. Galvanized-Steel Sheet: ASTM A 653/A 653M, G60 (Z180) **OR** G90 (Z275), **as directed**, zinc coating, mill phosphatized.
5. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304, No. 2B finish **OR** No. 2D finish **OR** No. 4 finish, with grain running parallel to length of blades and frame members **OR** No. 4 finish, with grain running perpendicular to length of blades and frame members **OR** No. 4 finish, with grain running perpendicular to length of blades and parallel to length of frame members **OR** No. 6 finish, **as directed**.
6. Fasteners: Use types and sizes to suit unit installation conditions.
 - a. Use Phillips flat-head **OR** hex-head or Phillips pan-head **OR** tamper-resistant, **as directed**, screws for exposed fasteners unless otherwise indicated.
 - b. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
 - c. For fastening galvanized steel, use hot-dip-galvanized steel or 300 series stainless-steel fasteners.
 - d. For fastening stainless steel, use 300 series stainless-steel fasteners.
 - e. For color-finished louvers, use fasteners with heads that match color of louvers.
7. Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
8. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

**B. Fabrication, General**

1. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
2. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.
 - a. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern unless horizontal mullions are indicated **OR** where indicated, **as directed**.
 - b. Horizontal Mullions: Provide horizontal mullions at joints unless continuous vertical assemblies are indicated **OR** where indicated, **as directed**.
3. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, **as directed**, to produce uniform appearance.
4. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
 - a. Frame Type: Channel **OR** Exterior flange **OR** Interior flange, **as directed**, unless otherwise indicated.
5. Include supports, anchorages, and accessories required for complete assembly.
6. Provide vertical mullions of type and at spacings indicated, but not more than recommended by manufacturer, or 72 inches (1830 mm) o.c., whichever is less.
 - a. Fully Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
 - b. Semirecessed Mullions: Where indicated, provide mullions partly recessed behind louver blades so louver blades appear continuous. Where length of louver exceeds fabrication and handling limitations, fabricate with interlocking split mullions and close-fitting blade splices designed to permit expansion and contraction.
 - c. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.
 - d. Exterior Corners: Prefabricated corner units with mitered and welded blades **OR** blades with concealed close-fitting splices, **as directed**, and with fully recessed **OR** semirecessed, **as directed**, mullions at corners.
7. Provide subsills made of same material as louvers **OR** extended sills, **as directed**, for recessed louvers.
8. Join frame members to each other and to fixed louver blades with fillet welds concealed from view **OR** welds, threaded fasteners, or both, as standard with louver manufacturer, **as directed**, unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

C. Fixed, Extruded-Aluminum Louvers

1. Horizontal Storm-Resistant Louver:
 - a. Louver Depth: 4 inches (100 mm) **OR** 5 inches (125 mm) **OR** 7 inches (175 mm) **OR** 8 inches (200 mm) **OR** 9 inches (225 mm), **as directed**.
 - b. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm) **OR** 0.060 inch (1.52 mm) for blades and 0.080 inch (2.03 mm) for frames, **as directed**.
 - c. Louver Performance Ratings:
 - 1) Free Area: Not less than 5.0 sq. ft. (0.46 sq. m) **OR** 6.0 sq. ft. (0.56 sq. m) **OR** 7.0 sq. ft. (0.65 sq. m), **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 600-fpm (3.0-m/s) **OR** 700-fpm (3.6-m/s) **OR** 800-fpm (4.1-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.



- 3) Wind-Driven Rain Performance: Not less than 99 **OR** 95 **OR** 80, **as directed**, percent effectiveness when subjected to a rainfall rate of 3 inches (75 mm) per hour and a wind speed of 29 mph (13 m/s) **OR** 8 inches (200 mm) per hour and a wind speed of 50 mph (22.4 m/s), **as directed**, at a core-area intake velocity of 300 fpm (1.5 m/s) **OR** 400 fpm (2.0 m/s) **OR** 500 fpm (2.5 m/s), **as directed**.
- d. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
2. Vertical Storm-Resistant Louver:
 - a. Louver Depth: 4 inches (100 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm) **OR** 9 inches (225 mm) **OR** 12 inches (300 mm), **as directed**.
 - b. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm) **OR** 0.060 inch (1.52 mm) for blades and 0.080 inch (2.03 mm) for frames, **as directed**.
 - c. Louver Performance Ratings:
 - 1) Free Area: Not less than 5.0 sq. ft. (0.46 sq. m) **OR** 6.0 sq. ft. (0.56 sq. m) **OR** 7.0 sq. ft. (0.65 sq. m) **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 600-fpm (3.0-m/s) **OR** 700-fpm (3.6-m/s) **OR** 800-fpm (4.1-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.
 - 3) Wind-Driven Rain Performance: Not less than 99 percent effectiveness when subjected to a rainfall rate of 3 inches (75 mm) per hour and a wind speed of 29 mph (13 m/s) **OR** 8 inches (200 mm) per hour and a wind speed of 50 mph (22.4 m/s), **as directed**, at a core-area intake velocity of 300 fpm (1.5 m/s) **OR** 400 fpm (2.0 m/s) **OR** 500 fpm (2.5 m/s), **as directed**.
 - d. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
3. Horizontal, Drainable-Blade Louver:
 - a. Louver Depth: 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**.
 - b. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm) **OR** 0.060 inch (1.52 mm) for blades and 0.080 inch (2.03 mm) for frames, **as directed**.
 - c. Mullion Type: Exposed.
 - d. Louver Performance Ratings:
 - 1) Free Area: Not less than 7.0 sq. ft. (0.65 sq. m) **OR** 7.5 sq. ft. (0.70 sq. m) **OR** 8.0 sq. ft. (0.74 sq. m) **OR** 8.5 sq. ft. (0.79 sq. m), **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 900 fpm (4.6 m/s) **OR** 950 fpm (4.8 m/s) **OR** 1000 fpm (5.1 m/s) **OR** 1050 fpm (5.3 m/s) **OR** 1100 fpm (5.6 m/s), **as directed**.
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 700-fpm (3.6-m/s) **OR** 750-fpm (3.8-m/s) **OR** 800-fpm (4.1-m/s) **OR** 850-fpm (4.3-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.
 - 4) Air Performance: Not more than 0.15-inch wg (37-Pa) static pressure drop at 900-fpm (4.6-m/s) **OR** 950-fpm (4.8-m/s) **OR** 1000-fpm (5.1-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.
 - e. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
4. Horizontal, Continuous-Line, Drainable-Blade Louver: Drainable-blade louver with blade gutters (drains) in rear two-thirds of blades only and with semirecessed mullions capable of collecting and draining water from blades.
 - a. Louver Depth: 6 inches (150 mm).
 - b. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm).
 - c. Louver Performance Ratings:
 - 1) Free Area: Not less than 7.8 sq. ft. (0.72 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 850 fpm (4.3 m/s).
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 800-fpm (4.1-m/s) free-area exhaust **OR** intake, **as directed**, velocity.
5. Horizontal, Sightproof, Drainable-Blade Louver:



- a. Louver Depth: 5 inches (125 mm).
 - b. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm) **OR** 0.060 inch (1.52 mm) for blades and 0.080 inch (2.03 mm) for frames, **as directed**.
 - c. Mullion Type: Exposed.
 - d. Louver Performance Ratings:
 - 1) Free Area: Not less than 8.3 sq. ft. (0.77 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 750 fpm (3.8 m/s) **OR** 950 fpm (4.8 m/s), **as directed**.
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 550-fpm (2.8-m/s) free-area exhaust **OR** intake, **as directed**, velocity.
6. Horizontal, Nondrainable-Blade Louver:
- a. Louver Depth: 2 inches (50 mm) **OR** 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**.
 - b. Blade Profile: Plain blade without **OR** Blade with, **as directed**, center baffle.
 - c. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm) **OR** 0.060 inch (1.52 mm) for blades and 0.080 inch (2.03 mm) for frames, **as directed**.
 - d. Mullion Type: Exposed **OR** Semirecessed **OR** Fully recessed, **as directed**.
 - e. Louver Performance Ratings:
 - 1) Free Area: Not less than 7.5 sq. ft. (0.70 sq. m) **OR** 8.0 sq. ft. (0.74 sq. m) **OR** 8.5 sq. ft. (0.79 sq. m), **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 700 fpm (3.6 m/s) **OR** 750 fpm (3.8 m/s) **OR** 800 fpm (4.1 m/s) **OR** 850 fpm (4.3 m/s) **OR** 900 fpm (4.6 m/s) **OR** 950 fpm (4.8 m/s), **as directed**.
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 650-fpm (3.3-m/s) **OR** 700-fpm (3.6-m/s) **OR** 750-fpm (3.8-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.
7. Vertical, Sightproof, Louver:
- a. Louver Depth: 4 inches (100 mm).
 - b. Blade Profile: Chevron **OR** Y **OR** Labyrinth, **as directed**, -shaped blade.
 - c. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm) **OR** 0.060 inch (1.52 mm) for blades and 0.080 inch (2.03 mm) for frames, **as directed**.
 - d. Blade Spacing: 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, o.c.
 - e. Mullion Type: Exposed **OR** Semirecessed **OR** Fully recessed, **as directed**.
- D. Fixed, Formed-Metal Louvers
1. Horizontal, Drainable-Blade Louver:
 - a. Louver Depth: 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**.
 - b. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, not less than 0.052 inch (1.32 mm) for frames and 0.040 inch (1.02 mm) for blades **OR** 0.052 inch (1.32 mm) **OR** 0.064 inch (1.63 mm), **as directed**.
 - c. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, not less than 0.050 inch (1.27 mm) **OR** 0.062 inch (1.59 mm), **as directed**.
 - d. Mullion Type: Exposed.
 - e. Louver Performance Ratings:
 - 1) Free Area: Not less than 7.0 sq. ft. (0.65 sq. m) **OR** 7.5 sq. ft. (0.70 sq. m) **OR** 8.0 sq. ft. (0.74 sq. m) **OR** 8.5 sq. ft. (0.79 sq. m), **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 800 fpm (4.1 m/s) **OR** 850 fpm (4.3 m/s) **OR** 900 fpm (4.6 m/s) **OR** 950 fpm (4.8 m/s) **OR** 1000 fpm (5.1 m/s), **as directed**.
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 700-fpm (3.6-m/s) **OR** 750-fpm (3.8-m/s) **OR** 800-fpm (4.1-m/s) **OR** 850-fpm (4.3-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.



- 4) Air Performance: Not more than 0.15-inch wg (37-Pa) static pressure drop at 900-fpm (4.6-m/s) **OR** 950-fpm (4.8-m/s) **OR** 1000-fpm (5.1-m/s), **as directed**, free-area velocity.
- f. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
2. Horizontal, Nondrainable-Blade Louver:
 - a. Louver Depth: 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**.
 - b. Blade Profile: Plain blade without **OR** Blade with, **as directed**, center baffle.
 - c. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, not less than 0.052 inch (1.32 mm) for frames and 0.040 inch (1.02 mm) for blades **OR** 0.052 inch (1.32 mm) **OR** 0.064 inch (1.63 mm), **as directed**.
 - d. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, not less than 0.050 inch (1.27 mm) **OR** 0.062 inch (1.59 mm), **as directed**.
 - e. Mullion Type: Exposed **OR** Semirecessed **OR** Fully recessed, **as directed**.
 - f. Louver Performance Ratings:
 - 1) Free Area: Not less than 6.5 sq. ft. (0.60 sq. m) **OR** 7.0 sq. ft. (0.65 sq. m) **OR** 7.5 sq. ft. (0.70 sq. m) **OR** 8.0 sq. ft. (0.74 sq. m), **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 550 fpm (2.8 m/s) **OR** 600 fpm (3.0 m/s) **OR** 650 fpm (3.3 m/s) **OR** 700 fpm (3.6 m/s), **as directed**.
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 550-fpm (2.8-m/s) **OR** 600-fpm (3.0-m/s) **OR** 650-fpm (3.3-m/s) **OR** 700-fpm (3.6-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.
- E. Adjustable, Extruded-Aluminum Louvers
 1. Louver Construction and Operation: Provide adjustable louvers with extruded-aluminum frames and blades not less than 0.080-inch (2.03-mm) nominal thickness, and with operating mechanisms to suit louver sizes.
 - a. Hand operation with push bars.
 - b. Crank operation with removable-crank operator in sill or jamb.
 - c. Chain operation with tension spring, wall clip, pull chain, and 160 deg F (71 deg C) fusible link.
 - d. Motor operation with 2-position, spring-return application (with power on, motor opens louver; with power off, spring closes louver); 110-V, 60-Hz motor and limit switch **OR** 2-direction, 110-V, 60-Hz motor and limit switches, **as directed**; equipped with frame-mounted switch **OR** remote-mounted switch with indicator light **OR** terminals for controlling devices, **as directed**.
 - e. Pneumatic piston operation for use with 80- to 100-psi (550- to 690-kPa) compressed air for 2-position **OR** modulating, **as directed**, operation; power open, power close with spring-return fail-safe, **as directed**.
 2. Dual-Blade, Drainable-Blade, Adjustable Louver: Fixed drainable blades and adjustable plain blades combined in single frame.
 - a. Louver Depth: 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, overall.
 - b. Louver Performance Ratings:
 - 1) Free Area: Not less than 6.0 sq. ft. (0.56 sq. m) **OR** 6.5 sq. ft. (0.60 sq. m) **OR** 7.0 sq. ft. (0.65 sq. m) **OR** 7.5 sq. ft. (0.70 sq. m) **OR** 8.0 sq. ft. (0.74 sq. m), **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 750 fpm (3.8 m/s) **OR** 800 fpm (4.1 m/s) **OR** 850 fpm (4.3 m/s) **OR** 900 fpm (4.6 m/s) **OR** 950 fpm (4.8 m/s) **OR** 1000 fpm (5.1 m/s), **as directed**.
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 750-fpm (3.8-m/s) **OR** 800-fpm (4.1-m/s) **OR** 850-fpm (4.3-m/s) **OR** 900-fpm (4.6-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.
 - 4) Air Leakage: Not more than 1.5 cfm/sq. ft. (7.6 L/s per sq. m) of louver gross area at a differential static pressure of 0.15-inch wg (37 Pa) with adjustable louver blades closed.



- c. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
3. Single-Blade, Adjustable Louver:
 - a. Louver Depth: 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**.
 - b. Blade Type: Drainable **OR** Plain, **as directed**.
 - c. Accessories: Equip louvers as follows:
 - 1) Vinyl blade-edge gaskets for each louver blade.
 - 2) Stainless-steel jamb seals **OR** vinyl blade-end gaskets, **as directed**.
 - d. Louver Performance Ratings:
 - 1) Free Area: Not less than 6.5 sq. ft. (0.60 sq. m) **OR** 7.0 sq. ft. (0.65 sq. m) **OR** 7.5 sq. ft. (0.70 sq. m) **OR** 8.0 sq. ft. (0.74 sq. m), **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 500 fpm (2.5 m/s) **OR** 600 fpm (3.0 m/s) **OR** 700 fpm (3.6 m/s) **OR** 800 fpm (4.1 m/s) **OR** 900 fpm (4.6 m/s) **OR** 1000 fpm (5.1 m/s), **as directed**.
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 500-fpm (2.5-m/s) **OR** 600-fpm (3.0-m/s) **OR** 700-fpm (3.6-m/s) **OR** 800-fpm (4.1-m/s) **OR** 900-fpm (4.6-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.
 - 4) Air Leakage: Not more than 3.5 cfm/sq. ft. (17.8 L/s per sq. m) of louver gross area at a differential static pressure of 0.15-inch wg (37 Pa) with adjustable louver blades closed.
 - e. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
- F. Adjustable, Formed-Metal Louvers
 1. Louver Operation: Provide adjustable louvers with operating mechanisms to suit louver sizes.
 - a. Hand operation with push bars.
 - b. Crank operation with removable-crank operator in sill or jamb.
 - c. Chain operation with tension spring, wall clip, pull chain, and 160 deg F (71 deg C) fusible link.
 - d. Motor operation with 2-position, spring-return application (with power on, motor opens louver; with power off, spring closes louver); 110-V, 60-Hz motor and limit switch **OR** 2-direction, 110-V, 60-Hz motor and limit switches, **as directed**; equipped with frame-mounted switch **OR** remote-mounted switch with indicator light **OR** terminals for controlling devices, **as directed**.
 - e. Pneumatic piston operation for use with 80- to 100-psi (550- to 690-kPa) compressed air for 2-position **OR** modulating, **as directed**, operation; power open, power close with spring-return fail-safe, **as directed**.
 2. Dual-Blade, Drainable-Blade, Adjustable Louver: Fixed drainable blades and adjustable plain blades combined in single frame.
 - a. Louver Depth: 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, overall.
 - b. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, not less than 0.052 inch (1.32 mm) for frames and 0.040 inch (1.02 mm) for blades **OR** 0.052 inch (1.32 mm) **OR** 0.064 inch (1.63 mm), **as directed**.
 - c. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, not less than 0.050 inch (1.27 mm) **OR** 0.062 inch (1.59 mm), **as directed**.
 - d. Louver Performance Ratings:
 - 1) Air Leakage: Not more than 1.5 cfm/sq. ft. (7.6 L/s per sq. m) of louver gross area at a differential static pressure of 0.15-inch wg (37 Pa) with adjustable louver blades closed.
 - e. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
 3. Single-Blade, Adjustable Louver:
 - a. Louver Depth: 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**.
 - b. Blade Type: Drainable **OR** Plain, **as directed**.
 - c. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, not less than 0.052 inch (1.32 mm) for frames and 0.040 inch (1.02 mm) for blades **OR** 0.052 inch (1.32 mm) **OR** 0.064 inch (1.63 mm), **as directed**.



- d. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, not less than 0.050 inch (1.27 mm) **OR** 0.062 inch (1.59 mm), **as directed**.
- e. Accessories: Equip louvers as follows:
 - 1) Vinyl blade-edge gaskets for each louver blade.
 - 2) Stainless-steel jamb seals **OR** vinyl blade-end gaskets, **as directed**.
- f. Louver Performance Ratings:
 - 1) Free Area: Not less than 6.5 sq. ft. (0.60 sq. m) **OR** 7.0 sq. ft. (0.65 sq. m) **OR** 7.5 sq. ft. (0.70 sq. m) **OR** 8.0 sq. ft. (0.74 sq. m), **as directed**, for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - 2) Point of Beginning Water Penetration: Not less than 500 fpm (2.5 m/s) **OR** 600 fpm (3.0 m/s) **OR** 700 fpm (3.6 m/s) **OR** 800 fpm (4.1 m/s) **OR** 900 fpm (4.6 m/s) **OR** 1000 fpm (5.1 m/s), **as directed**.
 - 3) Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 500-fpm (2.5-m/s) **OR** 600-fpm (3.0-m/s) **OR** 700-fpm (3.6-m/s) **OR** 800-fpm (4.1-m/s) **OR** 900-fpm (4.6-m/s), **as directed**, free-area exhaust **OR** intake, **as directed**, velocity.
 - 4) Air Leakage: Not more than 3.5 cfm/sq. ft. (17.8 L/s per sq. m) of louver gross area at a differential static pressure of 0.15-inch wg (37 Pa) with adjustable louver blades closed.
- g. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

G. Adjustable, Insulated Louvers

- 1. Louver Operation: Provide adjustable louvers with operating mechanisms to suit louver sizes.
 - a. Hand operation with push bars.
 - b. Crank operation with removable-crank operator in sill or jamb.
 - c. Chain operation with tension spring, wall clip, pull chain, and 160 deg F (71 deg C) fusible link.
 - d. Motor operation with 2-position, spring-return application (with power on, motor opens louver; with power off, spring closes louver); 110-V, 60-Hz motor and limit switch **OR** 2-direction, 110-V, 60-Hz motor and limit switches, **as directed**; equipped with frame-mounted switch **OR** remote-mounted switch with indicator light **OR** terminals for controlling devices, **as directed**.
 - e. Pneumatic piston operation for use with 80- to 100-psi (550- to 690-kPa) compressed air for 2-position **OR** modulating, **as directed**, operation; power open, power close with spring-return fail-safe, **as directed**.
- 2. Adjustable, Insulated, Extruded-Aluminum Louver: Single-blade, adjustable louver with gasketed, insulated blades. Frames and blade frames have urethane thermal break. Frames are extruded aluminum, not less than 0.080-inch (2.03-mm) nominal thickness. Blade facings are aluminum sheet, not less than 0.032-inch (0.81-mm) nominal thickness.
 - a. Louver Depth: 6 inches (150 mm) **OR** 9 inches (225 mm), **as directed**.
 - b. Insulation: Extruded-polystyrene foam, 2 inches (50 mm) thick **OR** Foamed-in-place polyurethane, **as directed**.
- 3. Adjustable, Insulated, Formed-Metal Louver: Single-blade, adjustable louver with gasketed, insulated blades.
 - a. Louver Depth: 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**.
 - b. Frame Material and Nominal Thickness: Galvanized-steel sheet, not less than 0.052 inch (1.32 mm) **OR** 0.064 inch (1.63 mm), **as directed**.
 - c. Frame Material and Nominal Thickness: Stainless-steel sheet, not less than 0.050 inch (1.27 mm) **OR** 0.062 inch (1.59 mm), **as directed**.
 - d. Blade Material and Nominal Thickness: Galvanized-steel sheet, not less than 0.028 inch (0.71 mm) **OR** 0.040 inch (1.02 mm) **OR** 0.052 inch (1.32 mm) **OR** 0.064 inch (1.63 mm), **as directed**.
 - e. Blade Material and Nominal Thickness: Stainless-steel sheet, not less than 0.025 inch (0.64 mm) **OR** 0.038 inch (0.95 mm) **OR** 0.050 inch (1.27 mm) **OR** 0.062 inch (1.59 mm), **as directed**.



- f. Insulation: Extruded-polystyrene foam, 1 inch (25 mm) thick **OR** Rigid, glass-fiber-board insulation, 1 inch (25 mm) thick **OR** Foamed-in-place polyurethane, 1/2 inch (13 mm) thick, **as directed**.
- H. Fixed, Acoustical Louvers
1. Fixed, Formed-Metal Acoustical Louver: Louver with formed-metal blades filled on interior with mineral-fiber, rigid-board, acoustical insulation retained by perforated metal sheet of same material and finish as blade.
 - a. Louver Depth: 6 inches (150 mm) **OR** 8 inches (200 mm) **OR** 12 inches (300 mm), **as directed**.
 - b. Frame Material: Extruded-aluminum or aluminum sheet, not less than 0.080-inch (2.03-mm) nominal thickness.
 - c. Frame Material: Galvanized-steel sheet, not less than 0.052-inch (1.32-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal thickness.
 - d. Blade Material: Aluminum sheet, not less than 0.063-inch (1.60-mm) **OR** 0.080-inch (2.03-mm), **as directed**, nominal thickness.
 - e. Blade Material: Galvanized-steel sheet, not less than 0.034-inch (0.86-mm) **OR** 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - f. Blade Shape: Straight **OR** Airfoil **OR** Chevron, **as directed**.
 - g. Blade Angle: 45 degrees unless otherwise indicated.
 - h. Blade Spacing: 6 inches (150 mm) o.c. for 6-inch- (150-mm-) deep louvers.
 - i. Blade Spacing: 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**, o.c. for 8-inch- (200-mm-) deep louvers.
 - j. Blade Spacing: 9 inches (225 mm) **OR** 12 inches (300 mm), **as directed**, o.c. for 12-inch- (300-mm-) deep louvers.
 - k. Free Area: Not less than 4 sq. ft. (0.37 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - l. Airborne Sound-Transmission Loss: STC 10 per ASTM E 413, determined by testing per ASTM E 90.
 - m. Outdoor-Indoor Sound-Transmission Loss: OITC 10 per ASTM E 1332, determined by testing per ASTM E 966.
 - I. Louver Screens
 1. General: Provide screen at each exterior louver **OR** louvers indicated, **as directed**.
 - a. Screen Location for Fixed Louvers: Interior face.
 - b. Screen Location for Adjustable Louvers: Interior **OR** Exterior, **as directed**, face unless otherwise indicated.
 - c. Screening Type: Bird screening **OR** Bird screening except where insect screening is indicated **OR** Insect screening, **as directed**.
 2. Secure screen frames to louver frames with stainless-steel machine screws **OR** machine screws with heads finished to match louver, **as directed**, spaced a maximum of 6 inches (150 mm) from each corner and at 12 inches (300 mm) o.c.
 3. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
 - a. Metal: Same kind and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips, **as directed**.
 - b. Finish: Same finish as louver frames to which louver screens are attached **OR** Mill finish unless otherwise indicated, **as directed**.
 - c. Type: Rewirable frames with a driven spline or insert **OR** Non-rewirable, U-shaped frames, **as directed**.
 4. Louver Screening for Aluminum Louvers:
 - a. Bird Screening: Aluminum, 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.60-mm) wire.
 - b. Bird Screening: Stainless steel, 1/2-inch- (13-mm-) square mesh, 0.047-inch (1.19-mm) wire.
 - c. Bird Screening: Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick.
 - d. Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) wire.



- e. Insect Screening: Stainless steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm) wire.
 5. Louver Screening for Galvanized-Steel Louvers:
 - a. Bird Screening: Galvanized steel, 1/2-inch- (13-mm-) square mesh, 0.041-inch (1.04-mm) wire.
 - b. Bird Screening: Stainless steel, 1/2-inch- (13-mm-) square mesh, 0.047-inch (1.19-mm) wire.
 - c. Insect Screening: Galvanized steel, 18-by-14 (1.4-by-1.8-mm) mesh, 0.011-inch (0.28-mm) wire.
 - d. Insect Screening: Stainless steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm) wire.
 6. Louver Screening for Stainless-Steel Louvers:
 - a. Bird Screening: Stainless steel, 1/2-inch- (13-mm-) square mesh, 0.047-inch (1.19-mm) wire.
 - b. Insect Screening: Stainless steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm) wire.
- J. Blank-Off Panels
1. Uninsulated, Blank-Off Panels: Metal sheet attached to back of louver.
 - a. Aluminum sheet for aluminum louvers, not less than 0.050-inch (1.27-mm) nominal thickness.
 - b. Galvanized-steel sheet for galvanized-steel louvers, not less than 0.040-inch (1.02-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal thickness.
 - c. Stainless-steel sheet for stainless-steel louvers, not less than 0.038-inch (0.95-mm) **OR** 0.050-inch (1.27-mm), **as directed**, nominal thickness, with grain running in same direction as grain of louver blades.
 - d. Panel Finish: Same finish applied to louvers **OR** Same type of finish applied to louvers, but black color, **as directed**.
 - e. Attach blank-off panels with clips **OR** sheet metal screws, **as directed**.
 2. Insulated, Blank-Off Panels: Laminated panels consisting of insulating core surfaced on back and front with metal sheets and attached to back of louver.
 - a. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Metal Facing Sheets: Aluminum sheet, not less than 0.032-inch (0.81-mm) nominal thickness.
 - c. Metal Facing Sheets: Galvanized-steel sheet, not less than 0.028-inch (0.71-mm) nominal thickness.
 - d. Metal Facing Sheets: Stainless-steel sheet, not less than 0.031-inch (0.79-mm) nominal thickness.
 - e. Insulating Core: Rigid, glass-fiber-board insulation **OR** extruded-polystyrene foam, **as directed**.
 - f. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames, not less than 0.080-inch (2.03-mm) nominal thickness **OR** channel frames, **as directed**, with corners mitered and with same finish as panels.
 - g. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
 - h. Panel Finish: Same finish applied to louvers **OR** Same type of finish applied to louvers, but black color, **as directed**.
 - i. Attach blank-off panels with clips **OR** sheet metal screws, **as directed**.
- K. Wall Vents (Brick Vents)
1. Extruded-Aluminum Wall Vents:
 - a. Extruded-aluminum louvers and frames, not less than 0.125-inch (3.18-mm) nominal thickness, assembled by welding; with 18-by-14- (1.4-by-1.8-mm-) mesh, aluminum insect screening on inside face; incorporating weep holes, continuous drip at sill, and integral waterstop on inside edge of sill; of load-bearing design and construction.



- b. Dampers: Aluminum blades and frames mounted on inside of wall vents; operated from exterior with Allen wrench in socket-head cap screw. Fabricate operating mechanism from Type 304 stainless-steel components.
 - c. Finish: Mill finish.
 2. Cast-Aluminum Wall Vents:
 - a. One-piece, cast-aluminum louvers and frames; with 18-by-14- (1.4-by-1.8-mm-) mesh, aluminum insect screening on inside face; incorporating integral waterstop on inside edge of sill; of load-bearing design and construction.
 - b. Dampers: Aluminum blades and frames mounted on inside of wall vents; operated from exterior with Allen wrench in socket-head cap screw. Fabricate operating mechanism from Type 304 stainless-steel components.
 - c. Finish: Mill finish.
- L. Finishes, General
 1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- M. Aluminum Finishes
 1. Finish louvers after assembly.
 2. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
 3. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - a. Color: As selected from full range of industry colors and color densities.
 4. Conversion-Coated Finish: AA-C12C42 (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating).
 5. Conversion-Coated and Factory-Primed Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below).
 - a. Organic Coating: Air-dried primer of not less than 2-mil (0.05-mm) dry film thickness.
 6. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 7. High-Performance Organic Finish: 2-coat fluoropolymer finish complying with AAMA 2604 **OR** AAMA 2605, **as directed**, and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 8. High-Performance Organic Finish: 3 **OR** 4, **as directed**, -coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
- N. Galvanized-Steel Sheet Finishes
 1. Finish louvers after assembly.
 2. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and repair according to ASTM A 780.
 3. Baked-Enamel or Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard 2-coat, baked-on finish consisting of prime coat and thermosetting



topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).

a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

O. Stainless-Steel Sheet Finishes

1. Repair sheet finish by grinding and polishing irregularities, weld spatter, scratches, and forming marks to match surrounding finish.

1.3 EXECUTION

A. Installation

1. Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work.
2. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
3. Form closely fitted joints with exposed connections accurately located and secured.
4. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
5. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
6. Protect unpainted galvanized and nonferrous-metal surfaces that will be in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
7. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Division 07 Section "Joint Sealants" for sealants applied during louver installation.

B. Adjusting And Cleaning

1. Test operation of adjustable louvers and adjust as needed to produce fully functioning units that comply with requirements.
2. Clean exposed surfaces of louvers and vents that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.
3. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
4. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by the Owner, remove damaged units and replace with new units.
 - a. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 08 90 00 00



Task	Specification	Specification Description
08 91 16 00	08 90 00 00	Louvers And Vents
08 95 13 00	01 22 16 00	No Specification Required
08 95 16 00	01 22 16 00	No Specification Required
08 95 16 00	05 50 00 00	Metal Fabrications
08 95 16 00	05 73 00 00	Miscellaneous Ornamental Metals



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SECTION 09 51 13 00 - ACOUSTICAL PANEL CEILINGS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for acoustical panel ceilings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes acoustical panels and exposed suspension systems for ceilings.
2. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete at ceilings.

C. Definitions

1. AC: Articulation Class.
2. CAC: Ceiling Attenuation Class.
3. LR: Light Reflectance coefficient.
4. NRC: Noise Reduction Coefficient.

D. Submittals

1. Product Data: For each type of product indicated.
2. Coordination Drawings: Drawn to scale and coordinating acoustical panel ceiling installation with hanger attachment to building structure and ceiling mounted items:
3. Samples: For each exposed finish.
4. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
 - b. Product Data for Credit EQ 4.1: For sealants, including printed statement of VOC content.
5. Product test reports.
6. Research/evaluation reports.
7. Maintenance data.

E. Quality Assurance

1. Acoustical Testing Agency Qualifications: An independent testing laboratory, or an NVLAP-accredited laboratory, with the experience and capability to conduct the testing indicated. NVLAP-accredited laboratories must document accreditation, based on a "Certificate of Accreditation" and a "Scope of Accreditation" listing the test methods specified.
2. Fire-Test-Response Characteristics
 - a. Fire-Resistance Characteristics: Where indicated, provide acoustical panel ceilings identical to those of assemblies tested for fire resistance per ASTM E 119 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
 - 1) Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another testing and inspecting agency.
 - 2) Identify materials with appropriate markings of applicable testing and inspecting agency.
 - b. Surface-Burning Characteristics: Provide acoustical panels with the following surface-burning characteristics complying with ASTM E 1264 for Class A **OR B OR C, as directed**, materials as determined by testing identical products per ASTM E 84:
 - 1) Smoke-Developed Index: 450 or less.



3. Seismic Standard: Provide acoustical panel ceilings designed and installed to withstand the effects of earthquake motions according to the following:
 - a. Standard for Ceiling Suspension Systems Requiring Seismic Restraint: Comply with ASTM E 580.
 - b. CISCA's Recommendations for Acoustical Ceilings: Comply with CISCA's "Recommendations for Direct-Hung Acoustical Tile and Lay-in Panel Ceilings--Seismic Zones 0-2."
 - c. CISCA's Guidelines for Systems Requiring Seismic Restraint: Comply with CISCA's "Guidelines for Seismic Restraint of Direct-Hung Suspended Ceiling Assemblies--Seismic Zones 3 & 4."
 - d. IBC Standard for Metal Suspension Systems for Acoustical Tile and for Lay-in Panel Ceilings.
 - e. ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."
4. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Deliver acoustical panels, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
2. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.
3. Handle acoustical panels carefully to avoid chipping edges or damaging units in any way.

1.2 PRODUCTS

A. Acoustical Panels, General

1. Acoustical Panel Standard: Provide manufacturer's standard panels of configuration indicated that comply with ASTM E 1264 classifications as designated by types, patterns, acoustical ratings, and light reflectances, unless otherwise indicated.
 - a. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches (400 mm) away from test surface per ASTM E 795.
2. Acoustical Panel Colors and Patterns: Match appearance characteristics indicated for each product type.
 - a. Where appearance characteristics of acoustical panels are indicated by referencing pattern designations in ASTM E 1264 and not manufacturers' proprietary product designations, provide products selected by the Owner from each manufacturer's full range that comply with requirements indicated for type, pattern, color, light reflectance, acoustical performance, edge detail, and size.
3. Broad Spectrum Antimicrobial Fungicide and Bactericide Treatment: Provide acoustical panels treated with manufacturer's standard antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested according to ASTM D 3273 and evaluated according to ASTM D 3274 or ASTM G 21.
4. Antimicrobial Fungicide Treatment: Provide acoustical panels with face and back surfaces coated with antimicrobial treatment consisting of manufacturer's standard formulation with fungicide added to inhibit growth of mold and mildew and showing no mold or mildew growth when tested according to ASTM D 3273 and evaluated according to ASTM D 3274 or ASTM G 21.

B. Acoustical Panels For Acoustical Panel Ceiling

1. Classification: Provide fire-resistance-rated, **as directed**, panels complying with ASTM E 1264 for type, form, and pattern as follows:



- a. Type and Form: Type III, mineral base with painted finish; Form 1, nodular **OR** 2, water felted **OR** 4, cast or molded, **as directed**.
 - b. Type and Form: Type IV, mineral base with membrane-faced overlay; Form 1, nodular; with glass-fiber cloth **OR** washable vinyl-film, **as directed**, overlay.
 - c. Type and Form: Type IV, mineral base with membrane-faced overlay; Form 2, water felted; with vinyl overlay on face **OR** vinyl overlay on face and back **OR** vinyl overlay on face, back, and sealed edges **OR** fiberglass-fabric overlay on face, **as directed**.
 - d. Type and Form: Type XII, glass-fiber base with membrane-faced overlay; Form 1, plastic **OR** 2, cloth **OR** 3, other, **as directed**.
 - e. Type and Form: Type XX, other types; described as high-density, ceramic- and mineral-base panels with scrubbable finish, resistant to heat, moisture, and corrosive fumes.
 - f. Pattern: C (perforated, small holes) **OR** CD (perforated, small holes and fissured) **OR** CE (perforated, small holes and lightly textured) **OR** D (fissured) **OR** E (lightly textured) **OR** F (heavily textured) **OR** G (smooth) **OR** GH (smooth and printed) **OR** I (embossed) **OR** J (embossed-in-register) **OR** K (surface scored) **OR** Z (other patterns as described) **OR** As indicated by manufacturer's designation, **as directed**.
2. Color: White **OR** As selected from manufacturer's full range **OR** Match sample **OR** As indicated by manufacturer's designation **OR** As indicated on Drawings **OR** As indicated in a schedule, **as directed**.
 3. LR: Not less than 0.65 **OR** 0.70 **OR** 0.75 **OR** 0.80 **OR** 0.85 **OR** 0.90, **as directed**.
 4. NRC: Not less than 0.10 **OR** 0.35 **OR** 0.40 **OR** 0.50 **OR** 0.55 **OR** 0.60 **OR** 0.65 **OR** 0.70 **OR** 0.75 **OR** 0.80 **OR** 0.85 **OR** 0.90 **OR** 0.95 **OR** 1.00, **as directed**.
 5. CAC: Not less than 20 **OR** 25 **OR** 30 **OR** 35 **OR** 40, **as directed**.
 6. AC: Not less than 170 **OR** 180 **OR** 190 **OR** 200 **OR** 210, **as directed**.
 7. Edge/Joint Detail: Square **OR** Reveal sized to fit flange of exposed suspension system members **OR** Flush reveal sized to fit flange of exposed suspension system members **OR** Beveled, kerfed and rabbeted long edges and square, butt-on short edges, **as directed**.
 8. Thickness: 5/8 inch (15 mm) **OR** 3/4 inch (19 mm) **OR** 7/8 inch (22 mm) **OR** As indicated on Drawings **OR** As indicated in a schedule, **as directed**.
 9. Thickness (For glass-fiber-based panels): 1/8 inch (3 mm) **OR** 9/16 inch (15 mm) **OR** 5/8 inch (15 mm) **OR** 7/16 inch (22 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm) **OR** As indicated on Drawings **OR** As indicated in a schedule, **as directed**.
 10. Modular Size: 24 by 24 inches (610 by 610 mm) **OR** 24 by 48 inches (610 by 1220 mm) **OR** 600 by 600 mm **OR** 600 by 1200 mm **OR** As indicated on Drawings **OR** As indicated in a schedule, **as directed**.
 11. Antimicrobial Treatment: Broad spectrum fungicide and bactericide **OR** Fungicide, **as directed**, based.
- C. Metal Suspension Systems, General
1. Recycled Content: Provide products made from steel sheet with average recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
 2. Metal Suspension System Standard: Provide manufacturer's standard direct-hung metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable requirements in ASTM C 635.
 3. Finishes and Colors, General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Provide manufacturer's standard factory-applied finish for type of system indicated.
 - a. High-Humidity Finish: Comply with ASTM C 635 requirements for "Coating Classification for Severe Environment Performance" where high-humidity finishes are indicated.
 4. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
 - a. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing per



ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.

- 1) Type: Cast-in-place **OR** Postinstalled expansion **OR** Postinstalled bonded, **as directed**, anchors.
 - 2) Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition.
 - 3) Corrosion Protection: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Group 1 Alloy 304 or 316 for bolts; Alloy 304 or 316 for anchor.
 - 4) Corrosion Protection: Components fabricated from nickel-copper-alloy rods complying with ASTM B 164 for UNS No. N04400 alloy.
- b. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing per ASTM E 1190, conducted by a qualified testing and inspecting agency.
5. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:
- a. Zinc-Coated, Carbon-Steel Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
OR
Stainless-Steel Wire: ASTM A 580/A 580M, Type 304, nonmagnetic.
OR
Nickel-Copper-Alloy Wire: ASTM B 164, nickel-copper-alloy UNS No. N04400.
 - b. Size: Select wire diameter so its stress at 3 times hanger design load (ASTM C 635, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter wire.
6. Hanger Rods **OR** Flat Hangers, **as directed**: Mild steel, zinc coated or protected with rust-inhibitive paint.
7. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide; formed with 0.04-inch- (1-mm-) thick, galvanized steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation; with bolted connections and 5/16-inch- (8-mm-) diameter bolts.
8. Seismic Stabilizer Bars: Manufacturer's standard perimeter stabilizers designed to accommodate seismic forces.
9. Seismic Struts: Manufacturer's standard compression struts designed to accommodate seismic forces.
10. Seismic Clips: Manufacturer's standard seismic clips designed and spaced to secure acoustical panels in-place.
11. Hold-Down Clips: Where indicated, provide manufacturer's standard hold-down clips spaced 24 inches (610 mm) o.c. on all cross tees.
12. Impact Clips: Where indicated, provide manufacturer's standard impact-clip system designed to absorb impact forces against acoustical panels.
13. Clean-Room Gasket System: Where indicated, provide manufacturer's standard system, including manufacturer's standard **OR** closed-cell PVC **OR** neoprene **OR** antimicrobial, **as directed**, gasket and related adhesives, tapes, seals, and retention clips, designed to seal out foreign material from and maintain positive pressure in clean room.
- D. Metal Suspension System For Acoustical Panel Ceiling
1. Wide-Face, Capped, Double-Web, Fire-Rated, **as directed**, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytically zinc coated, or hot-dip galvanized according to ASTM A 653/A 653M, not less than G30 (Z90) coating designation, with prefinished 15/16-inch- (24-mm-) wide metal caps on flanges.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. End Condition of Cross Runners: Override (stepped) **OR** Butt-edge, **as directed**, type.
 - c. Face Design: Flat, flush.
 - d. Cap Material: Steel **OR** Aluminum, **as directed**, cold-rolled sheet.
 - e. Cap Finish: Painted white **OR** Painted in color as selected from manufacturer's full range **OR** Painted to match color indicated by manufacturer's designation **OR** Painted to match



- color of acoustical unit **OR** Plated with metallic finish, as selected from manufacturer's full range **OR** Plated with metallic finish indicated by manufacturer's designation **OR** Natural finish for aluminum, **as directed**.
2. Narrow-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytically zinc coated, or hot-dip galvanized according to ASTM A 653/A 653M, not less than G30 (Z90) coating designation, with prefinished 9/16-inch- (15-mm-) wide metal caps on flanges.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. End Condition of Cross Runners: Override (stepped) **OR** Butt-edge, **as directed**, type.
 - c. Face Design: Flat, flush **OR** Flanges formed with an integral center reveal, **as directed**.
 - d. Cap Material: Steel **OR** Aluminum, **as directed**, cold-rolled sheet.
 - e. Cap Finish: Painted white **OR** Painted in color as selected from manufacturer's full range **OR** Painted to match color indicated by manufacturer's designation **OR** Painted to match color of acoustical unit **OR** Plated with metallic finish, as selected from manufacturer's full range **OR** Plated with metallic finish indicated by manufacturer's designation **OR** Natural finish for aluminum, **as directed**.
 3. Narrow-Face, Steel-Capped, Double-Web, Fire-Rated Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytically zinc coated, or hot-dip galvanized according to ASTM A 653/A 653M, not less than G30 (Z90) coating designation, with prefinished, cold-rolled, 9/16-inch- (15-mm-) wide metal caps on flanges.
 - a. Structural Classification: Intermediate-duty system.
 - b. Face Design: Flat, flush.
 - c. Cap Finish: Painted white **OR** Painted in color as selected from manufacturer's full range **OR** Painted to match color indicated by manufacturer's designation **OR** Painted to match color of acoustical unit **OR** Plated with metallic finish, as selected from manufacturer's full range **OR** Plated with metallic finish indicated by manufacturer's designation **OR** Natural finish for aluminum, **as directed**.
 4. Narrow-Face, Uncapped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytically zinc coated, or hot-dip galvanized, to produce structural members with 9/16-inch- (15-mm-) wide faces.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. Face Design: With 1/8-inch- (3.2-mm-) wide, slotted, box-shaped flange **OR** With 1/4-inch- (6.35-mm-) wide, slotted, box-shaped flange **OR** Flanges formed in stepped design with a center protrusion projecting 19/64 inch (7.54 mm) below flange surfaces supporting panel faces and forming 3/16-inch- (4.76-mm-) wide reveals between edges of protrusion and those of panels, **as directed**.
 - c. Face Finish: Painted white **OR** in color as selected from manufacturer's full range **OR** to match color indicated by manufacturer's designation **OR** to match color of acoustical unit, **as directed**.
 - d. Reveal Finish: Painted to match flange color **OR** white **OR** black **OR** in color other than flange color as selected from manufacturer's full range of contrasting reveal colors, **as directed**.
 5. Wide-Face, Capped, Double-Web, Fire-Rated, **as directed**, Hot-Dip Galvanized, G60 (Z180), Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, hot-dip galvanized according to ASTM A 653/A 653M, G60 (Z180) coating designation, with prefinished, cold-rolled, 15/16-inch- (24-mm-) wide, aluminum caps on flanges.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. Face Design: Flat, flush.
 - c. Face Finish: Painted white **OR** Painted to match color indicated by manufacturer's designation **OR** Painted to match color of acoustical unit **OR** Natural finish, **as directed**.
 6. Wide-Face, Single-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet electrolytically zinc coated, with prefinished flanges of width indicated.
 - a. Structural Classification: Heavy-duty system.
 - b. Face Finish: Painted white **OR** black, **as directed**.



7. Wide-Face, Capped, Double-Web, Stainless-Steel Suspension System: Main and cross runners roll formed from Type 304 or 316, stainless-steel sheet, with prefinished 15/16-inch- (24-mm-) wide, stainless-steel caps on flanges.
 - a. Structural Classification: Intermediate-duty system.
 - b. Face Design: Flat, flush.
 8. Narrow-Face, Single-Web, Extruded-Aluminum Suspension System: Main and cross runners formed from extruded aluminum to produce structural members with 9/16-inch- (15-mm-) wide faces.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. Face Design: Screw-slot profile.
 - c. Face Finish: Painted white **OR** Satin anodized per AA-M12C22A31 and AAMA 611, **as directed**.
 - d. Reveal Finish: Match face finish **OR** Painted white **OR** Painted black, **as directed**.
 9. Extra-Wide-Face, Double-Web **OR** Single-Web, **as directed**, Metal Suspension System: Main and cross runners formed from extruded aluminum **OR** aluminum-capped steel **OR** steel-capped steel, **as directed**, to produce structural members with 1-1/2-inch- (50-mm-) **OR** 2-inch- (50-mm-), **as directed**, wide flanges.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. Face Design: Flat, flush.
 - c. Face Finish: Painted white **OR** Satin anodized per AA-M12C22A31 and AAMA 611, **as directed**.
 - d. Gasket System: Clean-room type.
- E. Metal Edge Moldings And Trim
1. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension system runners.
 - a. Provide manufacturer's standard edge moldings that fit acoustical panel edge details and suspension systems indicated and that match width and configuration of exposed runners, unless otherwise indicated.
 - b. For lay-in panels with reveal edge details, provide stepped edge molding that forms reveal of same depth and width as that formed between edge of panel and flange at exposed suspension member.
 - c. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.
 2. Extruded-Aluminum Edge Moldings and Trim: Where indicated, provide manufacturer's extruded-aluminum edge moldings and trim of profile indicated or referenced by manufacturer's designations, including splice plates, corner pieces, and attachment and other clips, complying with seismic design requirements and the following:
 - a. Aluminum Alloy: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of aluminum extrusions complying with ASTM B 221 (ASTM B 221M) for Alloy and Temper 6063-T5.
 - b. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes.
 - c. Conversion-Coated Finish: AA-M12C42 (Chemical Finish: cleaned with inhibited chemicals; acid-chromate-fluoride-phosphate conversion coating).
 - d. Conversion-Coated and Factory-Primed Finish: AA-M12C42R1x (Chemical Finish: cleaned with inhibited chemicals; acid-chromate-fluoride-phosphate conversion coating; organic coating as follows):
 - 1) Manufacturer's standard, factory-applied prime-coat finish ready for field painting.
 - e. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.



- f. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; organic coating: as specified below). Apply baked enamel complying with paint manufacturer's written instructions for cleaning, conversion coating, and painting.
 - 1) Organic Coating: Thermosetting, primer/topcoat system with a minimum dry film thickness of 0.8 to 1.2 mils (0.02 to 0.03 mm).

F. Acoustical Sealant

1. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), complying with ASTM C 834 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.
2. Acoustical Sealant for Concealed Joints: Manufacturer's standard nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), recommended for sealing interior concealed joints to reduce airborne sound transmission.

1.3 EXECUTION

A. Preparation

1. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

B. Installation

1. General: Install acoustical panel ceilings to comply with ASTM C 636 **OR** IBC Standard, **as directed**, and seismic design requirements indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
 - a. Fire-Rated Assembly: Install fire-rated ceiling systems according to tested fire-rated design.
2. Suspend ceiling hangers from building's structural members and as follows:
 - a. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
 - b. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 - c. Splay hangers only where required and, if permitted with fire-resistance-rated ceilings, to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 - d. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
 - e. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
 - f. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
 - g. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.



- h. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
 - i. Do not attach hangers to steel deck tabs.
 - j. Do not attach hangers to steel roof deck. Attach hangers to structural members.
 - k. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers, unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
 - l. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.
3. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.
 4. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.
 - a. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
 - b. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3.2 mm in 3.6 m). Miter corners accurately and connect securely.
 - c. Do not use exposed fasteners, including pop rivets, on moldings and trim.
 5. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
 6. Install acoustical panels with undamaged edges and fit accurately into suspension system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.
 - a. Arrange directionally patterned acoustical panels as follows:
 - 1) As indicated on reflected ceiling plans.
OR
Install panels with pattern running in one direction parallel to long **OR** short, **as directed**, axis of space.
OR
Install panels in a basket-weave pattern.
 - b. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension system runners and moldings.
 - c. For reveal-edged panels on suspension system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
 - d. For reveal-edged panels on suspension system members with box-shaped flanges, install panels with reveal surfaces in firm contact with suspension system surfaces and panel faces flush with bottom face of runners.
 - e. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.
 - f. Install hold-down clips in areas indicated, in areas required by authorities having jurisdiction, and for fire-resistance ratings; space as recommended by panel manufacturer's written instructions, unless otherwise indicated.
 - g. Install clean-room gasket system in areas indicated, sealing each panel and fixture as recommended by panel manufacturer's written instructions.
 - h. Protect lighting fixtures and air ducts to comply with requirements indicated for fire-resistance-rated assembly.

C. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.



2. Tests and Inspections: Testing and inspecting of completed installations of acoustical panel ceiling hangers and anchors and fasteners shall take place in successive stages, in areas of extent and using methods as follows. Do not proceed with installations of acoustical panel ceiling hangers for the next area until test results for previously completed installations of acoustical panel ceiling hangers show compliance with requirements.
 - a. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no panels have been installed.
 - 1) Within each test area, testing agency will select 1 of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf (890 N) of tension; it will also select one of every 2 postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf (1957 N) of tension.
 - 2) When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.
3. Remove and replace acoustical panel ceiling hangers and anchors and fasteners that do not pass tests and inspections and retest as specified above.

D. Cleaning

1. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

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SECTION 09 51 23 00 - ACOUSTICAL TILE CEILINGS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for acoustical tile ceilings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes acoustical tiles for ceilings and the following:
 - a. Concealed suspension systems.
 - b. Direct attachment of tiles to substrates with adhesive.
 - c. Direct attachment of tiles to substrates with staples.
2. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete at ceilings.

C. Definitions

1. AC: Articulation Class.
2. CAC: Ceiling Attenuation Class.
3. LR: Light-Reflectance coefficient.
4. NRC: Noise Reduction Coefficient.

D. Submittals

1. Product Data: For each type of product indicated.
2. Coordination Drawings: Drawn to scale and coordinating acoustical tile ceiling installation with hanger attachment to building structure and ceiling mounted items. Show size and location of initial access modules.
3. Samples: For each exposed finish.
4. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
5. Field quality-control test reports.
6. Product test reports.
7. Research/evaluation reports.
8. Maintenance data.

E. Quality Assurance

1. Acoustical Testing Agency Qualifications: An independent testing laboratory, or an NVLAP-accredited laboratory, with the experience and capability to conduct the testing indicated. NVLAP-accredited laboratories must document accreditation, based on a "Certificate of Accreditation" and a "Scope of Accreditation" listing the test methods specified.
2. Fire-Test-Response Characteristics: Provide acoustical tile ceilings that comply with the following requirements:
 - a. Fire-Resistance Characteristics: Where indicated, provide acoustical tile ceilings identical to those of assemblies tested for fire resistance per ASTM E 119 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
 - 1) Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another testing and inspecting agency.



- 2) Identify materials with appropriate markings of applicable testing and inspecting agency.
- b. Surface-Burning Characteristics: Provide acoustical tiles with the following surface-burning characteristics complying with ASTM E 1264 for Class A **OR B OR C**, **as directed**, materials as determined by testing identical products per ASTM E 84:
 - 1) Smoke-Developed Index: 450 or less.
3. Seismic Standard: Provide acoustical tile ceilings designed and installed to withstand the effects of earthquake motions according to the following:
 - a. Standard for Ceiling Suspension Systems Requiring Seismic Restraint: Comply with ASTM E 580.
 - b. CISCA's Recommendations for Acoustical Ceilings: Comply with CISCA's "Recommendations for Direct-Hung Acoustical Tile and Lay-in Panel Ceilings--Seismic Zones 0-2."
 - c. CISCA's Guidelines for Systems Requiring Seismic Restraint: Comply with CISCA's "Guidelines for Seismic Restraint of Direct-Hung Suspended Ceiling Assemblies--Seismic Zones 3 & 4."
 - d. IBC Standard for Metal Suspension Systems for Acoustical Tile and for Lay-in Panel Ceilings.
 - e. ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."
4. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Deliver acoustical tiles, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
2. Before installing acoustical tiles, permit them to reach room temperature and a stabilized moisture content.
3. Handle acoustical tiles carefully to avoid chipping edges or damaging units in any way.

1.2 PRODUCTS

A. Acoustical Tiles, General

1. Acoustical Tile Standard: Provide manufacturer's standard tiles of configuration indicated that comply with ASTM E 1264 classifications as designated by types, patterns, acoustical ratings, and light reflectances, unless otherwise indicated.
 - a. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches (400 mm) away from test surface per ASTM E 795.
2. Acoustical Tile Colors and Patterns: Match appearance characteristics indicated for each product type.
 - a. Where appearance characteristics of acoustical tiles are indicated by referencing pattern designations in ASTM E 1264 and not manufacturers' proprietary product designations, provide products selected by the Owner from each manufacturer's full range that comply with requirements indicated for type, pattern, color, light reflectance, acoustical performance, edge detail, and size.
3. Broad Spectrum Antimicrobial Fungicide and Bactericide Treatment: Provide acoustical tiles treated with manufacturer's standard antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested according to ASTM D 3273 and evaluated according to ASTM D 3274 or ASTM G 21.
4. Antimicrobial Fungicide Treatment: Provide acoustical tiles with face and back surfaces coated with antimicrobial treatment consisting of manufacturer's standard formulation with fungicide



added to inhibit growth of mold and mildew and showing no mold or mildew growth when tested according to ASTM D 3273 and evaluated according to ASTM D 3274 or ASTM G 21.

- B. Acoustical Tiles For Acoustical Tile Ceiling
1. Classification: Provide fire-resistance-rated, **as directed**, tiles complying with ASTM E 1264 for type, form, and pattern as follows:
 - a. Type III, mineral base with painted finish; Form 1, nodular **OR** 2, water felted **OR** 4, cast or molded, **as directed**.
 - b. Pattern: C (perforated, small holes) **OR** CD (perforated, small holes and fissured) **OR** CE (perforated, small holes and lightly textured) **OR** D (fissured) **OR** E (lightly textured) **OR** F (heavily textured) **OR** G (smooth) **OR** I (embossed) **OR** J (embossed-in-register) **OR** As indicated by manufacturer's designation, **as directed**.
 2. Color: White **OR** As selected from manufacturer's full range **OR** Match sample **OR** As indicated by manufacturer's designation **OR** As indicated on Drawings **OR** As indicated in a schedule, **as directed**.
 3. LR: Not less than 0.65 **OR** 0.70 **OR** 0.75 **OR** 0.80, **as directed**.
 4. NRC: Not less than 0.50 **OR** 0.55 **OR** 0.60 **OR** 0.65 **OR** 0.70, **as directed**.
 5. CAC: Not less than 20 **OR** 25 **OR** 30 **OR** 35 **OR** 40, **as directed**.
 6. AC: Not less than 170 **OR** 180 **OR** 190 **OR** 200 **OR** 210, **as directed**.
 7. Edge/Joint Detail: Square, kerfed and rabbeted, or tongue and grooved, or butt **OR** Beveled, kerfed and rabbeted, or tongue and grooved, or butt **OR** Beveled, kerfed and rabbeted long edges and square, butt on short edges, **as directed**.
 8. Thickness: 5/8 inch (15 mm) **OR** 3/4 inch (19 mm) **OR** As indicated on Drawings **OR** As indicated in a schedule, **as directed**.
 9. Modular Size: 12 by 12 inches (305 by 305 mm) **OR** 300 by 300 mm **OR** As indicated on Drawings **OR** As indicated in a schedule, **as directed**.
 10. Antimicrobial Treatment: Broad spectrum fungicide and bactericide **OR** Fungicide, **as directed**, based.
- C. Metal Suspension Systems, General
1. Recycled Content: Provide products made from steel sheet with average recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
 2. Metal Suspension System Standard: Provide manufacturer's standard metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable requirements in ASTM C 635.
 3. Finishes and Colors, General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Provide manufacturer's standard factory-applied finish for type of system indicated.
 4. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
 - a. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing per ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.
 - 1) Type: Cast-in-place **OR** Postinstalled expansion **OR** Postinstalled bonded, **as directed**, anchors.
 - 2) Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition.
 - 3) Corrosion Protection: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Group 1 Alloy 304 or 316 for bolts; Alloy 304 or 316 for anchors.
 - b. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without



failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing per ASTM E 1190, conducted by a qualified testing and inspecting agency.

5. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:
 - a. Zinc-Coated, Carbon-Steel Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
 - b. Size: Select wire diameter so its stress at 3 times hanger design load (ASTM C 635, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter wire.
 6. Hanger Rods **OR** Flat Hangers, **as directed**: Mild steel, zinc coated or protected with rust-inhibitive paint.
 7. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide; formed with 0.04-inch- (1-mm-) thick, galvanized steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation; with bolted connections and 5/16-inch- (8-mm-) diameter bolts.
 8. Seismic Struts: Manufacturer's standard compression struts designed to accommodate lateral forces.
 9. Seismic Clips: Manufacturer's standard seismic clips designed and spaced to secure acoustical tiles in-place.
- D. Metal Suspension System For Acoustical Tile Ceiling
1. Direct-Hung, Double-Web, Fire-Rated, **as directed**, Suspension System: Main and cross runners roll formed from and capped with cold-rolled steel sheet, prepainted, electrolytically zinc coated, or hot-dip galvanized according to ASTM A 653/A 653M, G30 (Z90) coating designation.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. Access: Upward **OR** Downward, **as directed**, and end pivoted, **OR** side pivoted, **as directed**, with initial access openings of size indicated below and located throughout ceiling within each module formed by main and cross runners, with additional access available by progressively removing remaining acoustical tiles.
 2. Indirect-Hung, Fire-Rated, **as directed**, Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytically zinc coated, or hot-dip galvanized according to ASTM A 653/A 653M, G30 (Z90) coating designation.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. Carrying Channels: Cold-rolled steel, 0.059850-inch- (1.52-mm-) minimum base (uncoated) metal thickness, not less than 3/16-inch- (4.7-mm-) wide flanges by 1-1/2-inch- (38-mm-) deep steel channels, 475 lb/1000 feet (0.707 kg/m), with rust-inhibitive paint finish **OR** hot-dip galvanized according to ASTM A 653/A 653M, G60 (Z180) coating designation, **as directed**.
 - c. Access: Where access is indicated, provide special cross runners or split splines to allow for removal of acoustical units in indicated access areas. Identify access tile with manufacturer's standard unobtrusive markers for each access unit.
- E. Metal Edge Moldings And Trim
1. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension system runners.
 - a. Provide manufacturer's standard edge moldings that fit acoustical tile edge details and suspension systems indicated and that match width and configuration of exposed runners, unless otherwise indicated.
 - b. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.
 2. Extruded-Aluminum Edge Moldings and Trim: Where indicated, provide manufacturer's extruded-aluminum edge moldings and trim of profile indicated or referenced by manufacturer's designations, including splice plates, corner pieces, and attachment and other clips, complying with seismic design requirements and the following:
 - a. Aluminum Alloy: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability



properties of aluminum extrusions complying with ASTM B 221 (ASTM B 221M) for Alloy and Temper 6063-T5.

- b. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes.
- c. Conversion-Coated Finish: AA-M12C42 (Chemical Finish: cleaned with inhibited chemicals; acid-chromate-fluoride-phosphate conversion coating).
- d. Conversion-Coated and Factory-Primed Finish: AA-M12C42R1x (Chemical Finish: cleaned with inhibited chemicals; acid-chromate-fluoride-phosphate conversion coating; organic coating as follows):
 - 1) Manufacturer's standard factory-applied prime-coat finish ready for field painting.
- e. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
- f. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; organic coating: as specified below). Apply baked enamel complying with paint manufacturer's written instructions for cleaning, conversion coating, and painting.
 - 1) Organic Coating: Thermosetting, enamel primer/topcoat system with a minimum dry film thickness of 0.8 to 1.2 mils (0.02 to 0.03 mm).

F. Acoustical Sealant

1. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), complying with ASTM C 834 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.
2. Acoustical Sealant for Concealed Joints: Manufacturer's standard nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), recommended for sealing interior concealed joints to reduce airborne sound transmission.

G. Miscellaneous Materials

1. Tile Adhesive: Type recommended by tile manufacturer, bearing UL label for Class 0-25 flame spread.
 - a. Use adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Staples: 5/16-inch- (8-mm-) long, divergent-point staples.

1.3 EXECUTION

A. Preparation

1. Testing Substrates: Before installing adhesively applied tiles on wet-placed substrates such as cast-in-place concrete or plaster, test and verify that moisture level is below tile manufacturer's recommended limits.
2. Measure each ceiling area and establish layout of acoustical tiles to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width tiles at borders, and comply with layout shown on reflected ceiling plans.

B. Installation, Suspended Acoustical Tile Ceilings

1. General: Install acoustical tile ceilings to comply with ASTM C 636 **OR** IBC Standard, **as directed**, and seismic design requirements indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
 - a. Fire-Rated Assembly: Install fire-rated ceiling systems according to tested fire-rated design.
2. Suspend ceiling hangers from building's structural members and as follows:



- a. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
 - b. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
OR
Splay hangers only where required and, if permitted with fire-resistance-rated ceilings, to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 - c. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
 - d. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
OR
Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
 - e. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
 - f. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
 - g. Do not attach hangers to steel deck tabs.
 - h. Do not attach hangers to steel roof deck. Attach hangers to structural members.
 - i. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers, unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
 - j. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.
3. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.
 4. Install edge moldings and trim of type indicated at perimeter of acoustical tile ceiling area and where necessary to conceal edges of acoustical tiles.
 - a. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
 - b. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3.2 mm in 3.6 m). Miter corners accurately and connect securely.
 - c. Do not use exposed fasteners, including pop rivets, on moldings and trim.
 5. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
 6. Arrange directionally patterned acoustical tiles as follows:
 - a. As indicated on reflected ceiling plans.
OR
Install tiles with pattern running in one direction parallel to long **OR** short, **as directed**, axis of space.
OR



- Install tiles in a basket-weave pattern.
7. Install acoustical tiles in coordination with suspension system and exposed moldings and trim. Place splines or suspension system flanges into kerfed edges so tile-to-tile joints are closed by double lap of material.
 - a. Fit adjoining tile to form flush, tight joints. Scribe and cut tile for accurate fit at borders and around penetrations through tile.
 - b. Hold tile field in compression by inserting leaf-type, spring-steel spacers between tile and moldings, spaced 12 inches (305 mm) o.c.
 - c. Protect lighting fixtures and air ducts to comply with requirements indicated for fire-resistance-rated assembly.
- C. Installation, Directly Attached Acoustical Tile Ceilings
1. Adhesive Installation: Install acoustical tile by bonding to substrate, using amount of adhesive and procedure recommended in writing by tile manufacturer and as follows:
 - a. Remove loose dust from backs of tiles by brushing and prime them with a thin coat of adhesive.
 - b. Install splines in joints between tiles; maintain level of bottom surface of tiles to a tolerance of 1/8 inch in 12 feet (3 mm in 3.6 m) and not exceeding 1/4 inch (6.35 mm) cumulatively.
 - c. Maintain tight butt joints, aligned in both directions and coordinated with ceiling fixtures.
 2. Stapled Installation: Fasten acoustical tile to substrate using a minimum of two staples per tile that are installed in flanges of tile and as follows:
 - a. Form double-lapped joint between tiles by securely pressing tile tongues into corresponding tile grooves.
 - b. Maintain level of bottom surface of tiles to a tolerance of 1/8 inch in 12 feet (3 mm in 3.6 m) and not exceeding 1/4 inch (6.35 mm) cumulatively. Shim tile or correct substrate as required to maintain tolerance.
 - c. Maintain tight butt joints, aligned in both directions and coordinated with ceiling fixtures.
 3. Install edge moldings and trim of type indicated at perimeter of acoustical tile ceiling area and where necessary to conceal edges of acoustical units.
 4. Arrange directionally patterned acoustical tiles as follows:
 - a. As indicated on reflected ceiling plans.
OR
Install tiles with pattern running in one direction parallel to long axis of space.
OR
Install tiles with pattern running in one direction parallel to short axis of space.
OR
Install tiles in a basket-weave pattern.
- D. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
 2. Tests and Inspections: Testing and inspecting of completed installations of acoustical tile ceiling hangers and anchors and fasteners shall take place in successive stages, in areas of extent and using methods as follows. Do not proceed with installations of acoustical tile ceiling hangers for the next area until test results for previously completed installations of acoustical tile ceiling hangers show compliance with requirements.
 - a. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no tiles have been installed.
 - 1) Within each test area, testing agency will select 1 of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf (890 N) of tension; it will also select one of every 2 postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf (1957 N) of tension.
 - 2) When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.



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3. Remove and replace acoustical tile ceiling hangers and anchors and fasteners that do not pass tests and inspections and retest as specified above.

E. Cleaning

1. Clean exposed surfaces of acoustical tile ceilings, including trim and edge moldings. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace tiles and other ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION 09 51 23 00



SECTION 09 51 33 13 - ACOUSTICAL METAL PAN CEILINGS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for acoustical metal pan ceilings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes clip-in, lay-in, snap-in, and torsion-spring acoustical metal pans and the following suspension system for ceilings:
 - a. Direct hung, exposed tee and slot-bolt grid.
 - b. Direct-hung and Indirect-hung, concealed grid designed to support metal pans.
2. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete at ceilings.

C. Definitions

1. CAC: Ceiling Attenuation Class.
2. LR: Light Reflectance coefficient.
3. NRC: Noise Reduction Coefficient.

D. Performance Requirements

1. Structural Performance: Exterior snap-in metal pan ceilings shall withstand exterior exposure and the effects of gravity loads and the following loads and stresses without showing permanent deformation of ceiling system components including pans and suspension system; noise or metal fatigue caused by vibration, deflection, and displacement of ceiling units; or permanent damage to fasteners and anchors.
 - a. Wind Load: Uniform pressure of 20 lbf/sq. ft. (960 Pa) **OR** of 30 lbf/sq. ft. (1436 Pa) **OR** as indicated on Drawings, **as directed**, acting inward or outward.
2. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 100 deg F (55 deg C).

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
 - b. Product Data for Credit EQ 4.1: For sealants, including printed statement of VOC content.
3. Samples: For each exposed finish.
4. Performance Data: For installed products indicated to comply with design loads and other criteria, include structural analysis and other analytical data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Coordination Drawings: Drawn to scale and coordinating and showing the following:
 - a. Ceiling suspension members.
 - b. Method of attaching hangers to building structure.
 - c. Ceiling-mounted items.
 - d. Ceiling perimeter and penetrations through the ceiling; and trim and moldings.
6. Product test reports.



7. Evaluation reports.
8. Field quality-control reports.
9. Maintenance data.

F. Quality Assurance

1. Acoustical Testing Agency Qualifications: An independent testing laboratory or an NVLAP-accredited laboratory, with the experience and capability to conduct the testing indicated. NVLAP-accredited laboratories must document accreditation, based on a "Certificate of Accreditation" and a "Scope of Accreditation" listing the test methods specified.
2. Surface-Burning Characteristics: Complying with ASTM E 1264 for Class A materials as determined by testing identical products according to ASTM E 84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
3. Seismic Standard: Provide acoustical metal pan ceilings designed and installed to withstand the effects of earthquake motions according to the following:
 - a. Standard for Ceiling Suspension Systems Requiring Seismic Restraint: Comply with ASTM E 580.
 - b. CISCA's Recommendations for Acoustical Ceilings: Comply with CISCA's "Recommendations for Direct-Hung Acoustical Tile and Lay-in Panel Ceilings - Seismic Zones 0-2."
 - c. CISCA's Guidelines for Systems Requiring Seismic Restraint: Comply with CISCA's "Guidelines for Seismic Restraint of Direct-Hung Suspended Ceiling Assemblies - Seismic Zones 3 & 4."
 - d. IBC Standard for Metal Suspension Systems for Acoustical Tile and for Lay-in Panel Ceilings.
 - e. SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."
4. Preinstallation Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Deliver acoustical metal pans, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
2. Handle acoustical metal pans, suspension system components, and accessories carefully to avoid damaging units and finishes in any way.

1.2 PRODUCTS

A. Acoustical Metal Ceiling Pans

1. Acoustical Metal Pan Standard: Provide manufacturer's standard acoustical metal pans of configuration indicated that comply with ASTM E 1264 classifications as designated by types, acoustical ratings, and light reflectances unless otherwise indicated.
 - a. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches (400 mm) away from test surface per ASTM E 795.
2. Sheet Metal Characteristics: For metal components exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, roughness, stains, or discolorations.
 - a. Aluminum Sheet: Roll-formed aluminum sheet, complying with ASTM B 209 (ASTM B 209M); alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
 - b. Steel Sheet: Commercial-quality, cold-rolled, carbon-steel sheet; stretcher leveled; with protective coating complying with ASTM C 635.



- 1) Recycled Content: Provide products made from steel sheet with average recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
 - 2) Painted Finishes: Electrolytic zinc-coated steel complying with ASTM A 591/A 591M, 40Z (12G) coating, surface treatment as recommended by finish manufacturer for type of use and finish indicated.
 - 3) Chemical/Mechanical Finishes: Uncoated steel sheet complying with ASTM A 1008/A 1008M with luster or bright finish as required by finisher for applying electroplating or other metallic-finishing processes.
 - c. Stainless-Steel Sheet: Complying with ASTM A 240/A 240M, Type 304 **OR** Type 430, **as directed**.
3. Sound-Absorbent Fabric Layer: Provide fabric layer, sized to fit concealed surface of pan, and consisting of black, nonwoven, nonflammable, sound-absorbent material with surface-burning characteristics for flame-spread index of 25 or less and smoke-developed index of 50 or less, as determined by testing per ASTM E 84.
- a. Bond fabric layer to panels in the factory with manufacturer's standard nonflammable adhesive.
4. Sound-Absorbent Pads: Provide width and length to completely fill concealed surface of pan, with surface-burning characteristics for flame-spread index of 25 or less and smoke-developed index of 50 or less, as determined by testing per ASTM E 84, and to comply with the following requirements:
- a. Plastic Sheet-Wrapped Mineral-Fiber Insulation: Pads consisting of nonrigid, PVC plastic sheet encapsulating unfaced mineral-fiber insulation complying with ASTM C 553, Type I, II, or III, and as follows:
 - 1) Mineral-Fiber Type and Thickness: Glass fiber; 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 3 inches (76 mm), **as directed**.
 - 2) Mineral-Fiber Density: 3/4 lb/cu. ft. (12 kg/cu. m) **OR** 1 lb/cu. ft. (16 kg/cu. m) **OR** 1-1/2 lb/cu. ft. (24 kg/cu. m), **as directed**.
 - 3) Plastic Sheet Thickness and Color: Not less than 0.003 inch (0.076 mm); clear **OR** flat black **OR** white, **as directed**.
 - b. Unwrapped, Glass-Fiber Insulation: Black coated, unfaced, complying with ASTM C 553, Type I, II, or III; not less than 1-lb/cu. ft. (16-kg/cu. m) density; treated to be nondusting; and as follows:
 - 1) Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - c. Spacer Grids: Provide manufacturer's standard aluminum **OR** galvanized-steel, **as directed**, grid units that provide an air cushion between metal pans and insulation pads and that act to improve sound absorption.
 - d. Sound Attenuation Panels: Provide manufacturer's standard aluminum **OR** galvanized-steel, **as directed**, unperforated metal backing unit that acts as a sound-attenuating pan to reduce the travel of sound through ceiling plenum into adjoining rooms.
 - 1) Sound-Absorbent Pads: Provide secondary sound-absorbent pads, same as specified for primary pads, for placement over sound attenuation pan to reduce plenum sound.
- B. Aluminum Pans For Acoustical Metal Pan Ceiling
1. Classification: Units complying with ASTM E 1264 for Type VII, perforated aluminum facing (pan) with mineral- or glass-fiber-base backing **OR** Type XX, other types described as perforated aluminum facing (pan) units with sound-absorbent fabric backing **OR** Type XX, other types described as unperforated aluminum facing (pan) units, **as directed**.
 - a. Pattern: Pattern A (perforated, regularly spaced large holes), arranged in diagonal **OR** parallel, **as directed**, alignment to pan edge with uniform perforations of dimension, holes per square foot or inch, and percent open area as indicated by product designation **OR** selected from manufacturer's full range, **as directed**.
OR



Pattern: Pattern C (perforated, small holes) regularly spaced, with uniform perforations of dimension, holes per square foot or inch, and percent open area as specified by product designation **OR** selected from manufacturer's full range, **as directed**.

2. Pan Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated and finished to comply with requirements indicated.
 - a. Lay-in Pans: Formed to set in exposed suspension grid.
 - b. Clip-in Pans: Designed to clip-in and be securely retained in exposed suspension grid by formed edges or accessory clips.
 - c. Snap-in Pans: Designed with dimples or continuous beads on flanges for snap-in, secure engagement with concealed suspension system.
 - d. Torsion-Spring-Hinged Pans: Designed to be securely retained in preslotted exposed suspension grid by torsion springs.
3. Pan Thickness: Not less than 0.020 inch (0.5 mm) **OR** 0.025 inch (0.6 mm) **OR** 0.032 inch (0.8 mm) **OR** 0.040 inch (1.0 mm), **as directed**.
4. Pan Edge Detail: Square **OR** Beveled **OR** Reveal **OR** Manufacturer's standard edge detail, **as directed**.
OR
Pan Joint Detail: Butt **OR** Wide reveal, not less than 15/16 inch (24 mm) wide **OR** Narrow reveal, not greater than 9/16 inch (15 mm) wide **OR** Flush narrow reveal, not greater than 9/16 inch (15 mm) wide, **as directed**.
5. Pan Size: 12 by 12 inches (305 by 305 mm) **OR** 12 by 24 inches (305 by 610 mm) **OR** 12 by 36 inches (305 by 915 mm) **OR** 24 by 24 inches (610 by 610 mm) **OR** 24 by 48 inches (610 by 1220 mm) **OR** 24 by 60 inches (610 by 1525 mm) **OR** 30 by 30 inches (760 by 760 mm) **OR** 30 by 60 inches (760 by 1525 mm) **OR** As indicated on Drawings, **as directed**.
6. Scoring: Score pans at intervals to appear as 12-by-12-inch (305-by-305-mm) ceiling units.
7. Pan Face Finish: Mill **OR** Lacquered mill **OR** Clear anodized **OR** Clear mirror-anodized **OR** Painted white **OR** Painted to match color indicated by product designation **OR** Painted to match sample **OR** Painted in color selected from manufacturer's full range **OR** Bright-reflective metallic finish selected from manufacturer's full range, **as directed**.
8. LR: Not less than 0.70 **OR** 0.75, **as directed**.
9. NRC: Not less than 0.60 **OR** 0.65 **OR** 0.70 **OR** 0.75 **OR** 0.80 **OR** 0.85 **OR** 0.90 **OR** 0.95, **as directed**.
10. CAC: Not less than 35 **OR** 40 **OR** 45, **as directed**.

C. Steel Pans For Acoustical Metal Pan Ceiling

1. Classification: Units complying with ASTM E 1264 for Type V, perforated steel facing (pan) with mineral- or glass-fiber-base backing **OR** Type XX, other types described as perforated steel facing (pan) units with sound-absorbent fabric backing **OR** Type XX, other types described as unperforated steel facing (pan) units, **as directed**.
 - a. Pattern: Pattern A (perforated, regularly spaced large holes), arranged in diagonal **OR** parallel, **as directed**, alignment to pan edge with uniform perforations of dimension, holes per square foot or inch, and percent open area as indicated by product designation **OR** selected from manufacturer's full range, **as directed**.
OR
Pattern: Pattern C (perforated, small holes) regularly spaced, with uniform perforations of dimension, holes per square foot or inch, and percent open area as specified by product designation **OR** selected from manufacturer's full range, **as directed**.
2. Pan Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated and finished to comply with requirements indicated.
 - a. Lay-in Pans: Formed to set in exposed suspension grid.
 - b. Clip-in Pans: Designed to clip-in and be securely retained in exposed suspension grid by formed edges or accessory clips.
 - c. Snap-in Pans: Designed with dimples or continuous beads on flanges for snap-in, secure engagement with concealed suspension system.



- d. Torsion-Spring-Hinged Pans: Designed to be securely retained in preslotted exposed suspension grid by torsion springs.
3. Pan Thickness: Not less than 0.010-inch (0.25-mm) **OR** 0.020-inch (0.5-mm) **OR** 0.024-inch (0.6-mm) **OR** 0.030-inch (0.75-mm) **OR** 0.036-inch (0.9-mm), **as directed**, nominal thickness.
4. Pan Edge Detail: Square **OR** Beveled **OR** Reveal **OR** Manufacturer's standard edge detail, **as directed**.
OR
Pan Joint Detail: Butt **OR** Wide reveal, not less than 15/16 inch (24 mm) wide **OR** Narrow reveal, not greater than 9/16 inch (15 mm) wide **OR** Flush narrow reveal, not greater than 9/16 inch (15 mm) wide, **as directed**.
5. Pan Size: 12 by 12 inches (305 by 305 mm) **OR** 12 by 24 inches (305 by 610 mm) **OR** 12 by 36 inches (305 by 915 mm) **OR** 24 by 24 inches (610 by 610 mm) **OR** 24 by 48 inches (610 by 1220 mm) **OR** 24 by 60 inches (610 by 1525 mm) **OR** 30 by 30 inches (760 by 760 mm) **OR** 30 by 60 inches (760 by 1525 mm) **OR** As indicated on Drawings, **as directed**.
6. Scoring: Score pans at intervals to appear as 12-by-12-inch (305-by-305-mm) ceiling units.
7. Pan Face Finish: Painted white **OR** Painted to match color indicated by product designation **OR** Painted to match sample **OR** Painted in color selected from manufacturer's full range **OR** Plated with metallic finish, as selected from manufacturer's full range **OR** Bright-reflective metallic finish selected from manufacturer's full range, **as directed**.
8. LR: Not less than 0.70 **OR** 0.75, **as directed**.
9. NRC: Not less than 0.60 **OR** 0.65 **OR** 0.70 **OR** 0.75 **OR** 0.80 **OR** 0.85 **OR** 0.90 **OR** 0.95, **as directed**.
10. CAC: Not less than 35 **OR** 40 **OR** 45, **as directed**.

D. Stainless-Steel Pans For Acoustical Metal Pan Ceiling

1. Classification: Units complying with ASTM E 1264 for Type VI, perforated stainless-steel facing (pan) with mineral- or glass-fiber-base backing **OR** Type XX, other types described as perforated stainless-steel facing (pan) units with sound-absorbent fabric backing **OR** Type XX, other types described as unperforated stainless-steel facing (pan) units, **as directed**.
 - a. Pattern: Pattern A (perforated, regularly spaced large holes), arranged in parallel alignment to pan edge with uniform perforations of 0.109-inch (2.8-mm) diameter, 1800 holes/sq. ft. or inch, and 11.8 percent open area.
2. Pan Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated and finished to comply with requirements indicated.
 - a. Lay-in Pans: Formed to set in exposed suspension grid.
 - b. Clip-in Pans: Designed to clip-in and be securely retained in exposed suspension grid by formed edges or accessory clips.
 - c. Snap-in Pans: Designed with dimples or continuous beads on flanges for snap-in, secure engagement with concealed suspension system.
 - d. Torsion-Spring-Hinged Pans: Designed to be securely retained in preslotted exposed suspension grid by torsion springs.
3. Pan Thickness: Not less than 0.019 inch (0.5 mm) **OR** 0.025 inch (0.65 mm) **OR** 0.030 inch (0.76 mm), **as directed**.
4. Pan Edge Detail: Square **OR** Beveled **OR** Reveal **OR** Manufacturer's standard edge detail, **as directed**.
OR
Pan Joint Detail: Butt **OR** Wide reveal, not less than 15/16 inch (24 mm) wide **OR** Narrow reveal, not greater than 9/16 inch (15 mm) wide **OR** Flush narrow reveal, not greater than 9/16 inch (15 mm) wide, **as directed**.
5. Pan Size: 12 by 12 inches (305 by 305 mm) **OR** 12 by 24 inches (305 by 610 mm) **OR** 12 by 36 inches (305 by 915 mm) **OR** 24 by 24 inches (610 by 610 mm) **OR** 24 by 48 inches (610 by 1220 mm) **OR** 30 by 30 inches (760 by 760 mm) **OR** As indicated on Drawings, **as directed**.
6. Scoring: Score pans at intervals to appear as 12-by-12-inch (305-by-305-mm) ceiling units.
7. Pan Face Finish: Brushed, directional polish **OR** Satin, directional polish **OR** Mirrorlike reflective, nondirectional polish, **as directed**.



8. NRC: Not less than 0.60 **OR** 0.65 **OR** 0.70 **OR** 0.75 **OR** 0.80 **OR** 0.85 **OR** 0.90 **OR** 0.95, **as directed**.
9. CAC: Not less than 35 **OR** 40 **OR** 45, **as directed**.

E. Metal Suspension Systems

1. Recycled Content: Provide products made from steel sheet with average recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Metal Suspension System Standard: Provide manufacturer's standard metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable ASTM C 635 requirements.
3. Suspension Systems: Provide systems complete with carriers, runners, splice sections, connector clips, alignment clips, leveling clips, hangers, molding, trim, retention clips, load-resisting struts, and other suspension components required to support ceiling units and other ceiling-supported construction.
4. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
 - a. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing per ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.
 - 1) Type: Cast-in-place **OR** Postinstalled expansion **OR** Postinstalled bonded, **as directed**, anchors.
 - 2) Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition.
 - 3) Corrosion Protection: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Group 1 Alloy 304 or 316 for bolts; Alloy 304 or 316 for anchor.
 - 4) Corrosion Protection: Components fabricated from nickel-copper-alloy rods complying with ASTM B 164 for UNS No. N04400 alloy.
 - b. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing per ASTM E 1190, conducted by a qualified testing and inspecting agency.
5. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:
 - a. Zinc-Coated, Carbon-Steel Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
 - b. Stainless-Steel Wire: ASTM A 580/A 580M, Type 304, nonmagnetic.
 - c. Nickel-Copper-Alloy Wire: ASTM B 164, nickel-copper-alloy UNS No. N04400.
 - d. Size: Select wire diameter so its stress at 3 times the hanger design load indicated in ASTM C 635, Table 1, Direct Hung will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter wire.
6. Hanger Rods **OR** Flat Hangers, **as directed**: Mild steel, zinc coated or protected with rust-inhibitive paint.
7. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide; formed with 0.04-inch- (1.0-mm-) thick, galvanized-steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation; with bolted connections and 5/16-inch- (8-mm-) diameter bolts.
8. Seismic Stabilizer Bars: Manufacturer's standard perimeter stabilizers designed to accommodate seismic forces.
9. Seismic Struts: Manufacturer's standard compression struts designed to accommodate seismic forces.
10. Seismic Clips: Manufacturer's standard seismic clips designed and spaced to secure acoustical metal pans in place.
11. Hold-Down Clips: Manufacturer's standard hold-down clips spaced to secure acoustical metal pans in place to molding and trim at perimeter **OR** at each pan, **as directed**.



12. Exposed Metal Edge Moldings and Trim: Provide exposed members as indicated or as required to comply with seismic requirements of authorities having jurisdiction, to conceal edges of and penetrations through ceiling, to conceal edges of pans and runners, for fixture trim and adapters, for fasciae at changes in ceiling height, and for other conditions; of metal and finish matching acoustical metal pan ceiling units, unless otherwise indicated.
 - a. For Circular Penetrations of Ceiling: Fabricate edge moldings to diameter required to fit penetration exactly.
- F. Direct-Hung, Standard-Grid, Metal Suspension System For Acoustical Metal Pan Ceiling
1. Suspension System: For clip-in **OR** lay-in **OR** torsion-spring, **as directed**, pans.
 2. Wide-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytic zinc-coated or hot-dip galvanized according to ASTM A 653/A 653M, G30 (Z90) coating designation, with prefinished, cold-rolled, 15/16-inch- (24-mm-) wide sheet metal caps on flanges.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. End Condition of Cross Runners: Override (stepped) **OR** Butt-edge, **as directed**, type.
 - c. Face Design: Flat, flush.
 - d. Cap Material: Steel **OR** Aluminum, **as directed**, cold-rolled sheet.
 - e. Cap Finish: Painted white **OR** Painted in color as selected from manufacturer's full range **OR** Painted to match color indicated by manufacturer's designation **OR** Painted to match color of metal pan **OR** Plated with metallic finish, as selected from manufacturer's full range **OR** Plated with metallic finish indicated by manufacturer's designation **OR** Natural finish for aluminum, **as directed**.
 3. Narrow-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytic zinc-coated or hot-dip galvanized according to ASTM A 653/653M, G30 (Z90) coating designation, with prefinished, cold-rolled, 9/16-inch- (15-mm-) wide sheet metal caps on flanges.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. End Condition of Cross Runners: Override (stepped) **OR** Butt-edge, **as directed**, type.
 - c. Face Design: Flat, flush **OR** Flanges formed with an integral center reveal, **as directed**.
 - d. Cap Material: Steel **OR** Aluminum, **as directed**, cold-rolled sheet.
 - e. Cap Finish: Painted white **OR** Painted in color as selected from manufacturer's full range **OR** Painted to match color indicated by manufacturer's designation **OR** Painted to match color of metal pan **OR** Plated with metallic finish, as selected from manufacturer's full range **OR** Plated with metallic finish indicated by manufacturer's designation **OR** Natural finish for aluminum, **as directed**.
 4. Narrow-Face, Uncapped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytic zinc-coated or hot-dip galvanized, to produce structural members with 9/16-inch- (15-mm-) wide faces.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. Face Design: With 1/8-inch- (3.2-mm-) wide, slotted, box-shaped flange **OR** With 1/4-inch- (6.35-mm-) wide, slotted, box-shaped flange, **as directed**.
 - c. Face Finish: Painted white **OR** in color as selected from manufacturer's full range **OR** to match color indicated by manufacturer's designation **OR** to match color of metal pan, **as directed**.
 5. Wide-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, hot-dip galvanized according to ASTM A 653/A 653M, G60 (Z180) coating designation, with prefinished, cold-rolled, 15/16-inch- (24-mm-) wide aluminum caps on flanges.
 - a. Structural Classification: Intermediate-duty **OR** Heavy-duty, **as directed**, system.
 - b. Face Design: Flat, flush.
 - c. Face Finish: Painted white **OR** Painted to match color indicated by manufacturer's designation **OR** Painted to match color of acoustical unit **OR** Natural finish, **as directed**.
 6. Wide-Face, Capped, Double-Web, Stainless-Steel Suspension System: Main and cross runners roll formed from and capped with Type 304 or 316 stainless-steel sheet, with prefinished, cold-rolled, 15/16-inch- (24-mm-) wide stainless-steel caps on flanges.



- a. Structural Classification: Intermediate-duty system.
 - b. Face Design: Flat, flush.
7. Suspension System for Torsion-Spring Metal Pans: Provide runners with factory-cut slots fabricated to accept torsion-spring attachment.
- G. Metal Suspension System For Acoustical Snap-In Metal Pan Ceiling
1. Indirect-Hung, Snap-Tee **OR** Bar, **as directed**, System: Designed to support metal pans that snap into main runners, consisting of main runners connected to carrying channels that are attached by hangers to building structure, and complying with the following requirements:
 - a. Main Runners: Formed from the following metal:
 - 1) Aluminum Sheet: Alloy and temper recommended by aluminum producer and finisher for type of use indicated and manufacturer's standard finish, complying with ASTM B 209 (ASTM B 209M).
 - 2) Electrolytic Zinc-Coated Steel Sheet: ASTM A 591/A 591M, with not less than 80Z (24G) zinc coating.
 - 3) Hot-Dip Galvanized Steel: ASTM A 653/A 653M, not less than G60 (Z180) zinc coating.
 - 4) Stainless-Steel Sheet: ASTM A 666, Type 302 or 304, stretcher leveled, with cold-rolled mill finish.
 - 5) Metal Sheet: Metal as standard with ceiling system manufacturer with factory-applied protective finish complying with ASTM C 635.
 - b. Carrying Channels: Same member and metal as indicated for main runners.
OR
Carrying Channels: Cold-rolled steel, not less than 0.060-inch (1.5-mm) nominal thickness of base (uncoated) metal and 7/16-inch- (11-mm-) wide flanges, protected with rust-inhibitive paint **OR** hot-dip galvanized according to ASTM A 653/A 653M, G60 (Z180) coating designation, **as directed**, and as follows:
 - 1) Depth and Weight: 1-1/2 inches and 475 lb/1000 feet (38 mm and 215 kg/305 m) **OR** 2 inches and 590 lb/1000 feet (51 mm and 268 kg/305 m), **as directed**.
 - c. Exterior Bracing Channels and Angles: Cold-rolled steel, hot-dip galvanized to comply with ASTM A 653/A 653M, G60 (Z180) coating designation; size and profile as required to withstand wind load.
 2. Direct-Hung, Snap-Tee **OR** Bar, **as directed**, System: Designed to support metal pans that snap into main runners, consisting of main runners supported by hangers attached directly to building structure, and complying with the following requirements:
 - a. Hangers: Angles or channels, as standard with ceiling system manufacturer, formed from same metal as main runners.
 - b. Main Runners: Rolled aluminum sheet; alloy and temper recommended by aluminum producer and finisher for type of use indicated and manufacturer's standard finish, complying with ASTM B 209 (ASTM B 209M).
 3. Access Panels: For access at locations indicated, provide acoustical snap-in metal pan ceiling units, accessible by key or tool **OR** two access knobs; place one access knob at each end of panel near corners, **as directed**.
 - a. Access Key or Tool: Provide manufacturer' standard key or tool for opening access panels; one **OR** two, **as directed**.
- H. Acoustical Sealant
1. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), complying with ASTM C 834 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.
 2. Acoustical Sealant for Concealed Joints: Manufacturer's standard nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant, with a VOC content of 250 g/L or



less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), recommended for sealing interior concealed joints to reduce airborne sound transmission.

- I. General Finish Requirements
 1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - a. High-Humidity Finish: Comply with ASTM C 635 requirements for "Coating Classification for Severe Environment Performance" where high-humidity finishes are indicated.
 2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 3. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- J. Aluminum Finishes
 1. Mill Finish: AA-M10C10 (Mechanical Finish: as fabricated, unspecified; Chemical Finish: chemically cleaned).
 2. Lacquered Mill Finish: AA-M10C10R1x (Mechanical Finish: as fabricated, unspecified; Chemical Finish: chemically cleaned; Organic Coating: as specified below).
 - a. Organic Coating: Manufacturer's standard clear organic coating.
 3. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.
 4. Clear Mirror Anodic Finish: AA-M21C12A212, 0.005 mm or thicker.
 5. Color-Coated Finish: Manufacturer's standard powder-coat, **as directed**, baked paint complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.
 6. Bright-Reflective Finish: Manufacturer's standard chemical/mechanical bright-reflective metallic finish complying with finish manufacturer's written instructions for surface preparation, pretreatment, process, protective coating, and minimum thickness to produce a finish uniform in appearance and free of blisters, pits, roughness, nodules, burning, cracks, unfinished areas, and other visible defects.
- K. Galvanized-Steel Sheet Finishes
 1. Color-Coated Finish: Manufacturer's standard powder-coat, **as directed**, baked paint complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.
- L. Steel Sheet Finishes
 1. Electroplated Finish: Electroplating process complying with finish manufacturer's written instructions for surface preparation, pretreatment, process, and minimum thickness to produce a coating uniform in appearance and free of blisters, pits, roughness, nodules, burning, cracks, unplated areas, and other visible defects.
 2. Bright-Reflective Finish: Manufacturer's standard chemical/mechanical bright-reflective metallic finish complying with finish manufacturer's written instructions for surface preparation, pretreatment, process, protective coating, and minimum thickness to produce a finish uniform in appearance and free of blisters, pits, roughness, nodules, burning, cracks, unfinished areas, and other visible defects.
- M. Stainless-Steel Finishes
 1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.



1.3 EXECUTION

A. Preparation

1. Measure each ceiling area and establish layout of acoustical metal pans to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width pans at borders, and comply with layout shown on reflected ceiling plans and Coordination Drawings.

B. Installation

1. Install acoustical metal pan ceilings to comply with ASTM C 636 **OR** IBC Standard, **as directed**, and seismic requirements indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
2. Suspend ceiling hangers from building's structural members and as follows:
 - a. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
 - b. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 - c. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
 - d. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
OR
Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved.
 - e. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
 - f. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
 - g. Do not attach hangers to steel deck tabs.
 - h. Do not attach hangers to steel roof deck. Attach hangers to structural members.
 - i. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
 - j. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.
3. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.
4. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical metal pans.
 - a. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
 - b. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3.2 mm in 3.6 m). Miter corners accurately and connect securely.
 - c. Do not use exposed fasteners, including pop rivets, on moldings and trim.
5. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.



6. Cut acoustical metal pan units for accurate fit at borders and at interruptions and penetrations by other work through ceilings. Stiffen edges of cut units as required to eliminate evidence of buckling or variations in flatness exceeding referenced standards for stretcher-leveled metal sheet.
7. Install acoustical metal pans in coordination with suspension system and exposed moldings and trim.
 - a. For lay-in square-edge pans, install pans with edges fully hidden from view by flanges of suspension system runners and moldings.
 - b. For lay-in reveal-edge pans on suspension system runners, install pans with bottom of reveal in firm contact with top surface of runner flanges.
 - c. For lay-in reveal-edge pans on suspension system members with box-shaped flanges, install pans with reveal surfaces in firm contact with suspension system surfaces and panel faces flush with bottom face of runners.
 - d. For clip-in **OR** torsion-spring-hinged, **as directed**, pans, position pans according to manufacturer's written instructions.
 - e. For snap-in pans, fit adjoining units to form flush, tight joints.
 - f. Align joints in adjacent courses to form uniform, straight joints parallel to room axis in both directions unless otherwise indicated.
 - g. Fit adjoining units to form flush, tight joints.
 - h. Install directionally patterned or textured metal pans in directions indicated.
 - i. Install sound-absorbent fabric layers in perforated metal pans.
 - j. Install sound-absorbent pads in perforated metal pans over metal spacer grids, **as directed**.
8. Install sound attenuation panels in areas indicated by reflected ceiling plans or room finish schedules. Lay panels directly on ceiling system and close major openings to form complete coverage in required areas. Lay second sound-absorbent pads on sound attenuation panels.
9. Install hold-down clips where indicated.

C. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Tests and Inspections: Testing and inspecting of completed installations of acoustical panel ceiling hangers and anchors and fasteners shall take place in successive stages, in areas of extent and using methods as follows. Do not proceed with installations of acoustical panel ceiling hangers for the next area until test results for previously completed installations of acoustical panel ceiling hangers show compliance with requirements.
 - a. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no panels have been installed.
 - 1) Within each test area, testing agency will select 1 of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf (890 N) of tension; it will also select one of every 2 postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf (1957 N) of tension.
 - 2) When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.
3. Acoustical panel ceiling hangers and anchors and fasteners will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

D. Cleaning

1. Clean exposed surfaces of acoustical metal pan ceilings, including trim and edge moldings after removing strippable, temporary protective covering, if any. Comply with manufacturer's written instructions for stripping of temporary protective covering, cleaning, and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage, including dented and bent units.



END OF SECTION 09 51 33 13



Task	Specification	Specification Description
09 53 23 00	09 51 13 00	Acoustical Panel Ceilings



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SECTION 09 54 23 00 - LINEAR METAL CEILINGS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for linear metal ceilings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes strip linear metal pans and suspension systems for ceilings.

C. Definitions

1. LR: Light Reflectance coefficient.
2. NRC: Noise Reduction Coefficient.

D. Performance Requirements

1. Structural Performance: Exterior linear metal ceilings shall withstand exterior exposure and the effects of gravity loads and the following loads and stresses without showing permanent deformation of ceiling system components including pans and suspension system; noise or metal fatigue caused by vibration, deflection, and displacement of ceiling units; or permanent damage to fasteners and anchors.
 - a. Wind Load: Uniform pressure of 20 lbf/sq. ft. (960 Pa) **OR** of 30 lbf/sq. ft. (1436 Pa) **OR** as indicated on Drawings, **as directed**, acting inward or outward.
2. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), **as directed**, material surfaces.

E. Submittals

1. Product Data: For each type of product indicated.
2. Performance Data: For installed products indicated to comply with design loads and other criteria, include structural analysis and other analytical data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Samples: For each exposed finish.
4. Coordination Drawings: Drawn to scale and coordinating and showing the following:
 - a. Linear pattern.
 - b. Joint pattern.
 - c. Ceiling suspension members.
 - d. Method of attaching hangers to building structure.
 - e. Ceiling-mounted items.
 - f. Ceiling perimeter and penetrations through ceiling; trim and moldings.
5. Product test reports.
6. Evaluation reports.
7. Maintenance data.

F. Quality Assurance

1. Acoustical Testing Agency Qualifications: An independent testing laboratory or an NVLAP-accredited laboratory.
2. Surface-Burning Characteristics: Complying with ASTM E 1264 for Class A materials, as determined by testing identical products according to ASTM E 84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.



3. Seismic Standard: Comply with the following:
 - a. Standard for Ceiling Suspension Systems Requiring Seismic Restraint: Comply with ASTM E 580.
 - b. CISCA's Recommendations for Acoustical Ceilings: Comply with CISCA's "Recommendations for Direct-Hung Acoustical Tile and Lay-in Panel Ceilings - Seismic Zones 0-2."
 - c. CISCA's Guidelines for Systems Requiring Seismic Restraint: Comply with CISCA's "Guidelines for Seismic Restraint of Direct-Hung Suspended Ceiling Assemblies - Seismic Zones 3 & 4."
 - d. IBC Standard for Metal Suspension Systems for Acoustical Tile and for Lay-in Panel Ceilings.
 - e. SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

G. Delivery, Storage, And Handling

1. Deliver linear metal pans, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
2. Handle linear metal pans, suspension system components, and accessories carefully to avoid damaging units and finishes in any way.

1.2 PRODUCTS

A. Linear Metal Ceiling Pans

1. Acoustical Metal Pan Standard: Provide manufacturer's standard linear metal pans of configuration indicated that comply with ASTM E 1264.
 - a. Mounting Method for Measuring NRC: Type E-400.
2. Sheet Metal Characteristics: For metal components exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, roughness, stains, or discolorations.
 - a. Aluminum Sheet: Roll-formed aluminum sheet, complying with ASTM B 209 (ASTM B 209M); alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
 - b. Steel Sheet: Commercial-quality, cold-rolled, carbon-steel sheet; stretcher leveled; with protective coating complying with ASTM C 635.
 - c. Steel Sheet: Commercial-quality, cold-rolled, carbon-steel sheet; stretcher leveled and ASTM A 591/A 591M, 40Z (12G) coating for painted finish **OR** ASTM A 1008/A 1008M for electroplating, **as directed**; with protective coating complying with ASTM C 635 and recommended by finisher for finish indicated.
 - d. Stainless-Steel Sheet: Complying with ASTM A 240/A 240M, Type 304 **OR** Type 430, **as directed**.
3. Pan Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated to snap on and be securely retained on carriers without separate fasteners, and finished to comply with requirements indicated.
4. Pan Splices: Construction same as pans, in lengths 8 to 12 inches (200 to 300 mm); with manufacturer's standard finish.
5. End Caps: Metal matching pans **OR** Plastic **OR** Manufacturer's standard material, **as directed**; fabricated to fit and conceal exposed ends of pans.
6. Filler Strips: Metal matching pans **OR** Plastic **OR** Manufacturer's standard material, **as directed**; fabricated to uninterruptedly close voids between pans.
7. Moldings and Trim: Provide manufacturer's standard moldings and trim for exposed members, and as indicated or required, for edges and penetrations of ceiling, around fixtures, at changes in ceiling height, and for other conditions; of same metal and finish as linear metal ceiling pans.



8. Sound-Absorbent Fabric Layer: Provide fabric layer, sized to fit concealed surface of pan, and consisting of black, nonwoven, nonflammable, sound-absorbent material with surface-burning characteristics for flame-spread index of 25 or less and smoke-developed index of 50 or less, as determined by testing per ASTM E 84.
 - a. Bond fabric layer to pan in the factory with manufacturer's standard nonflammable adhesive.
 9. Sound-Absorbent Pads: Provide width and length to completely fill between carriers, joined at center of panel, with surface-burning characteristics for flame-spread index of 25 or less and smoke-developed index of 50 or less, as determined by testing per ASTM E 84, and to comply with the following requirements:
 - a. Plastic Sheet-Wrapped Mineral-Fiber Insulation: Pads consisting of nonrigid, PVC plastic sheet encapsulating unfaced mineral-fiber insulation complying with ASTM C 553, Type I, II, or III, and as follows:
 - 1) Mineral-Fiber Type and Thickness: Glass fiber; 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 3 inches (76 mm), **as directed**.
 - 2) Mineral-Fiber Density: 3/4 lb/cu. ft. (12 kg/cu. m) **OR** 1 lb/cu. ft. (16 kg/cu. m) **OR** 1-1/2 lb/cu. ft. (24 kg/cu. m), **as directed**.
 - 3) Plastic Sheet Thickness and Color: Not less than 0.003 inch (0.076 mm); clear **OR** flat black **OR** white, **as directed**.
 - b. Unwrapped, Glass-Fiber Insulation: Black-coated, unfaced, glass-fiber insulation complying with ASTM C 553, Type I, II, or III, not less than 1-lb/cu. ft. (16-kg/cu. m) density, treated to be nondusting, and as follows:
 - 1) Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
- B. Metal Suspension Systems
1. Metal Suspension Systems Standard: Provide ceiling manufacturer's standard metal suspension systems of types and finishes indicated that comply with applicable ASTM C 635 requirements.
 2. Suspension Systems: Provide systems complete with carriers, splice sections, connector clips, alignment clips, leveling clips, hangers, molding, trim, retention clips, load-resisting struts, fixture adapters, and other suspension components required to support ceiling units and other ceiling-supported construction.
 3. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, Direct Hung, unless otherwise indicated.
 - a. Cast-in-Place and Postinstalled Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing per ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.
 - 1) Type: Cast-in-place **OR** Postinstalled expansion **OR** Postinstalled bonded, **as directed**, anchors.
 - 2) Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC service condition (mild).
 - 3) Corrosion Protection: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Group 1 Alloy 304 or 316 for bolts; Alloy 304 or 316 for anchors.
 - 4) Corrosion Protection: Components fabricated from nickel-copper-alloy rods complying with ASTM B 164 for UNS No. N04400 alloy.
 - b. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing per ASTM E 1190, conducted by a qualified testing and inspecting agency.
 4. Wire Hangers, Braces, and Ties: Provide wire complying with the following requirements:
 - a. Zinc-Coated, Carbon-Steel Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
 - b. Stainless-Steel Wire: ASTM A 580/A 580M, Type 304, nonmagnetic.
 - c. Nickel-Copper-Alloy Wire: ASTM B 164, nickel-copper-alloy UNS No. N04400.



- d. Size: Select wire diameter so its stress at 3 times the hanger design load indicated in ASTM C 635, Table 1, Direct Hung will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter wire.
 5. Hanger Rods **OR** Flat Hangers, **as directed**: Mild steel, zinc coated or protected with rust-inhibitive paint.
 6. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide; formed from 0.04-inch- (1.0-mm-) thick, galvanized-steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation; with bolted connections and 5/16-inch- (8-mm-) diameter bolts.
 7. Carriers: Factory finished with matte-black baked finish, **as directed**.
 - a. Main Carriers: Aluminum, not less than 0.240-inch (6.0-mm) rolled sheet, alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, complying with ASTM B 209 (ASTM B 209M).
 - b. Main Carriers: Steel, not less than 0.0209-inch (0.53-mm) nominal thickness, cold-rolled sheet, with factory-applied protective coating, complying with ASTM C 635.
 - 1) Electrolytic Zinc-Coated Steel: ASTM A 591/A 591M, not less than 80Z (24G), **as directed**, zinc coating.
 - 2) Hot-Dip Galvanized Steel: ASTM A 653/A 653M, not less than G60 (Z180), **as directed**, zinc coating.
 - c. Adaptable Carriers: Manufacturer's standard carriers for direct attachment to existing suspended tees.
 - d. Flexible Radial Carriers: Manufacturer's standard radial carriers.
 - e. Expansion Carriers: Manufacturer's standard carriers allowing for irregularities or other unusual space conditions.
 8. Carrier Splices: Same metal, profile, and finish as indicated for carriers.
 9. Stabilizer Channels, Tees, and Bars: Manufacturer's standard components for stabilizing main carriers at regular intervals and at light fixtures, air-distribution equipment, access doors, and other equipment; spaced as standard with manufacturer for use indicated; and factory finished with matte-black baked finish.
 10. Seismic Struts: Manufacturer's standard compression struts designed to accommodate seismic forces.
 11. Exterior Bracing Channels and Angles: Cold-rolled steel, hot-dip galvanized to comply with ASTM A 653/A 653M, G60 (Z180) coating designation; size and profile as required to withstand wind load.
 12. Hold-Down Clips: Manufacturer's standard hold-down clips spaced as standard with manufacturer.
 13. Edge Moldings and Trim: Provide exposed members as indicated or required to comply with seismic requirements of authorities having jurisdiction, to conceal edges of penetrations through ceiling, to conceal ends of pans and carriers, for fixture trim and adapters, for fasciae at changes in ceiling height, and for other conditions; of metal and finish matching linear metal pans or extruded plastic unless otherwise indicated.
 - a. For Circular Penetrations of Ceiling: Fabricate edge moldings to diameter required to fit penetration exactly.
- C. Aluminum Pans And Suspension System For Linear Metal Ceiling
1. Aluminum Pans and Suspension System:
 2. Classification: Units complying with ASTM E 1264 for Type XIII, aluminum strips with mineral- or glass-fiber-base backing; Form 1, perforated **OR** Type XIII, aluminum strips with mineral- or glass-fiber-base backing; Form 2, unperforated **OR** Type XX, other types described as perforated aluminum strips with sound-absorbent fabric backing, **as directed**.
 3. Pan Thickness: Not less than 0.018 inch (0.46 mm) **OR** 0.022 inch (0.56 mm) **OR** 0.024 inch (0.6 mm) **OR** 0.025 inch (0.65 mm) **OR** 0.027 inch (0.7 mm) **OR** 0.032 inch (0.8 mm) **OR** 0.040 inch (1.0 mm), **as directed**.
 4. Pan Edge Detail: Beveled **OR** Square **OR** Round **OR** Manufacturer's standard edge detail, **as directed**.



5. Linear Module Width and Pan Face Width: 2-inch (51-mm) module width and 1-1/4-inch (32-mm) face width **OR** 4-inch (102-mm) module width and 3-1/4-inch (83-mm) face width **OR** 6-inch (152-mm) module width and 5-1/4-inch (133-mm) face width **OR** 8-inch (203-mm) module width and 7-1/4-inch (184-mm) face width **OR** 100-mm module width and 80-mm face width **OR** 200-mm module width and 180-mm face width **OR** 300-mm module width and 280-mm face width **OR** As indicated on Drawings, **as directed**.
6. Pan Depth: 5/8 inch (16 mm) deep **OR** 3/4 inch (19 mm) deep **OR** Not less than 1 to 1-1/2 inches (25 to 38 mm) deep **OR** 15 mm deep **OR** As indicated, **as directed**.
7. Pan Face Finish: Mill **OR** Lacquered mill **OR** Clear anodized **OR** Clear mirror-anodized **OR** Painted white **OR** Painted to match color indicated by product designation **OR** Painted to match sample **OR** Painted in color selected from manufacturer's full range **OR** High-performance organic coating in color selected from manufacturer's full range **OR** Bright-reflective finish selected from manufacturer's full range, **as directed**.
8. End Cap, Finish of Exposed Portions: Matte black **OR** To match pan **OR** Manufacturer's standard finish, **as directed**.
9. Filler Strip Design: Recessed **OR** Flush **OR** An integral extension of pan profile **OR** Expansion, for use with expansion carriers **OR** Slotted, for air diffusion, **as directed**.
10. Filler Strip, Finish of Exposed Portions: Matte black **OR** To match pan, **as directed**.
11. LR: Not less than 0.70 **OR** 0.75, **as directed**.
12. NRC: Not less than 0.65 **OR** 0.75 **OR** 0.95, **as directed**.
13. Suspension-System Main-Carrier Material: Aluminum **OR** Electrolytic zinc-coated steel **OR** Hot-dip galvanized steel **OR** Manufacturer's standard material and protective finish, **as directed**.

D. Steel Pans And Suspension System For Linear Metal Ceiling

1. Steel Pans and Suspension System:
2. Classification: Units complying with ASTM E 1264 for Type XIII, steel strips with mineral- or glass-fiber-base backing; Form 1, perforated **OR** Type XIII, steel strips with mineral- or glass-fiber-base backing; Form 2, unperforated **OR** Type XX, other types described as perforated steel strips with sound-absorbent fabric backing, **as directed**.
3. Pan Thickness: Not less than 0.015 inch (0.4 mm) **OR** 0.020 inch (0.5 mm) **OR** 0.024 inch (0.6 mm) **OR** 0.030 inch (0.75 mm), **as directed**.
4. Pan Edge Detail: Beveled **OR** Square **OR** Round **OR** Manufacturer's standard edge detail, **as directed**.
5. Linear Module Width and Pan Face Width: 2-inch (51-mm) module width and 1-1/4-inch (32-mm) face width **OR** 4-inch (102-mm) module width and 3-1/4-inch (83-mm) face width **OR** 6-inch (152-mm) module width and 5-1/4-inch (133-mm) face width **OR** 8-inch (203-mm) module width and 7-1/4-inch (184-mm) face width **OR** As indicated on Drawings, **as directed**.
6. Pan Depth: 5/8 inch (16 mm) deep **OR** 3/4 inch (19 mm) deep **OR** Not less than 1 to 1-1/2 inches (25 to 38 mm) deep **OR** 15 mm deep **OR** As indicated, **as directed**.
7. Pan Face Finish: Painted white **OR** Painted to match color indicated by product designation **OR** Painted to match sample **OR** Painted in color selected from manufacturer's full range **OR** Electroplated finish selected from manufacturer's full range, **as directed**.
8. End Cap, Finish of Exposed Portions: Matte black **OR** To match pan **OR** Manufacturer's standard finish, **as directed**.
9. Filler Strip Design: Recessed **OR** Flush **OR** An integral extension of pan profile **OR** Expansion, for use with expansion carriers **OR** Slotted, for air diffusion, **as directed**.
10. Filler Strip, Finish of Exposed Portions: Matte black **OR** To match pan, **as directed**.
11. LR: Not less than 0.70 **OR** 0.75, **as directed**.
12. NRC: Not less than 0.65 **OR** 0.75 **OR** 0.95, **as directed**.
13. Suspension-System Main-Carrier Material: Aluminum **OR** Electrolytic zinc-coated steel **OR** Hot-dip galvanized steel **OR** Manufacturer's standard material and protective finish, **as directed**.

E. Stainless-Steel Pans And Suspension System For Linear Metal Ceiling

1. Stainless-Steel Pans and Suspension System:
2. Classification: Units complying with ASTM E 1264 for Type XIII, stainless-steel strips with mineral- or glass-fiber-base backing; Form 1, perforated **OR** Type XIII, stainless-steel strips with



mineral- or glass-fiber-base backing; Form 2, unperforated **OR** Type XX, other types described as perforated stainless-steel strips with sound-absorbent fabric backing, **as directed**.

3. Pan Thickness: Not less than 0.016 inch (0.396 mm) **OR** 0.019 inch (0.475 mm), **as directed**.
4. Pan Edge Detail: Manufacturer's standard edge detail, **as directed**.
5. Linear Module Width and Pan Face Width: 2-inch (51-mm) module width and 1-1/4-inch (32-mm) face width **OR** 4-inch (102-mm) module width and 3-1/4-inch (83-mm) face width **OR** 6-inch (152-mm) module width and 5-1/4-inch (133-mm) face width **OR** 8-inch (203-mm) module width and 7-1/4-inch (184-mm) face width **OR** As indicated on Drawings, **as directed**.
6. Pan Depth: 5/8 inch (16 mm) deep **OR** As indicated, **as directed**.
7. Pan Face Finish: Brushed, directional polish **OR** Satin, directional polish **OR** Mirrorlike reflective, nondirectional polish, **as directed**.
8. End Cap, Finish of Exposed Portions: Matte black **OR** To match pan **OR** Manufacturer's standard finish, **as directed**.
9. Filler Strip Design: Recessed **OR** Flush **OR** An integral extension of pan profile **OR** Expansion, for use with expansion carriers **OR** Slotted, for air diffusion, **as directed**.
10. Filler Strip, Finish of Exposed Portions: Matte black **OR** To match pan, **as directed**.
11. NRC: Not less than 0.65 **OR** 0.75 **OR** 0.95, **as directed**.
12. Suspension-System Main-Carrier Material: Aluminum **OR** Electrolytic zinc-coated steel **OR** Hot-dip galvanized steel **OR** Manufacturer's standard material and protective finish, **as directed**.

F. Accessories

1. Access Panels: For access at locations indicated, provide door hinge assembly, retainer clip, and retainer bar, assembled with ceiling panels and carrier sections into access doors of required size, permitting upward or downward opening.

G. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

H. Aluminum Finishes

1. Mill Finish: AA-M10C10.
2. Lacquered Mill Finish: AA-M10C10R1x with manufacturer's standard clear, organic coating.
3. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.
4. Clear Mirror Anodic Finish: AA-M21C12A212, 0.005 mm or thicker.
5. Color-Coated Finish: Manufacturer's standard powder-coat baked paint finish complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.
6. High-Performance Organic Finish: 2-coat fluoropolymer finish complying with AAMA 2604 **OR** AAMA 2605, **as directed**, and containing not less than 50 **OR** 70, **as directed**, percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
7. Bright-Reflective Finish: Manufacturer's standard chemical/mechanical bright-reflective metallic finish complying with finish manufacturer's written instructions for surface preparation, pretreatment, process, protective coating, and minimum thickness to produce a finish uniform in appearance and free of blisters, pits, roughness, nodules, burning, cracks, unfinished areas, and other visible defects.

I. Galvanized-Steel Sheet Finishes



1. Color-Coated Finish: Manufacturer's standard powder-coat baked paint finish complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.

J. Steel Sheet Finishes

1. Electroplated Finish: Electroplating process complying with finish manufacturer's written instructions for surface preparation, pretreatment, process, and minimum thickness to produce a coating uniform in appearance and free of blisters, pits, roughness, nodules, burning, cracks, unplated areas, and other visible defects.
2. Bright-Reflective Finish: Manufacturer's standard chemical/mechanical bright-reflective metallic finish complying with finish manufacturer's written instructions for surface preparation, pretreatment, process, protective coating, and minimum thickness to produce a finish uniform in appearance and free of blisters, pits, roughness, nodules, burning, cracks, unfinished areas, and other visible defects.

K. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

1.3 EXECUTION

A. Installation

1. Comply with ASTM C 636 **OR** IBC Standard, **as directed**, and seismic requirement indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
2. Suspend ceiling hangers from building's structural members and as follows:
 - a. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
 - b. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 - c. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
 - d. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate to which hangers are attached and for type of hanger involved.
 - e. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
 - f. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
 - g. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
 - h. Do not attach hangers to steel deck tabs.
 - i. Do not attach hangers to steel roof deck. Attach hangers to structural members.
 - j. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.



- k. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.
 3. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers but without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.
 4. Install edge moldings and trim of type indicated at perimeter of linear metal ceiling area and where necessary to conceal edges and ends of linear metal pans.
 - a. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3.2 mm in 3.6 m). Miter corners accurately and connect securely.
 - b. Do not use exposed fasteners, including pop rivets, on moldings and trim.
 5. Install suspension system carriers so they are aligned and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
 6. Cut linear metal pans for accurate fit at borders and at interruptions and penetrations by other work through ceilings. Stiffen edges of cut units as required to eliminate evidence of buckling or variations in flatness exceeding referenced standards for stretcher-leveled metal sheet.
 7. Install linear metal pans in coordination with suspension system and exposed moldings and trim.
 - a. Align joints in adjacent courses to form uniform, straight joints parallel to room axis in both directions unless otherwise indicated.
 - b. Fit adjoining units to form flush, tight joints. Scribe and cut units for accurate fit at borders and around construction penetrating ceiling.
 - c. Install pans with butt joints using internal pan splices.
 - 1) Joint Configuration: Aligned **OR** Aligned, every other panel length **OR** Staggered a minimum of 12 inches (300 mm) **OR** Random **OR** As indicated, **as directed**.
 - d. Install directionally textured metal pans in directions indicated.
 - e. Where metal pan ends are visible, install end caps unless trim is indicated.
 - f. Install filler strips where indicated.
 - g. Install sound-absorbent fabric layers in perforated metal pans.
 - h. Install sound-absorbent pads at right angle to perforated metal pans so pads do not hang unsupported.
 8. Install hold-down clips where indicated.
- B. Cleaning
1. Clean exposed surfaces of linear metal ceilings, including trim and edge moldings after removing strippable, temporary protective covering if any. Comply with manufacturer's written instructions for stripping of temporary protective covering, cleaning, and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage, including dented and bent units.

END OF SECTION 09 54 23 00



Task	Specification	Specification Description
09 54 23 00	09 51 33 13	Acoustical Metal Pan Ceilings
09 81 16 00	09 84 13 00	Acoustical Wall Panels



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SECTION 09 84 13 00 - ACOUSTICAL WALL PANELS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for acoustical wall panels. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes spline-mounted **OR** back-mounted, **as directed**, acoustical wall panels.

C. Definitions

1. NRC: Noise reduction coefficient.

D. Submittals

1. Product Data: For each type of panel edge, core material, and mounting indicated.
2. Shop Drawings: For acoustical wall panels. Include mounting devices and details.
3. Coordination Drawings: Show intersections with adjacent work.
4. Samples: For each fabric and sample panels.
5. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For installation adhesive, including printed statement of VOC content.
6. Product certificates **OR** test reports, **as directed**.
7. Maintenance data.
8. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Fire-Test-Response Characteristics: Provide acoustical wall panels with the following surface-burning characteristics as determined by testing identical products per ASTM E 84 **OR** IBC Chapter 8, **as directed**, by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 450 or less.
2. Fire Growth Contribution: Meeting acceptance criteria of local code and authorities having jurisdiction when tested according to NFPA 265 **OR** NFPA 286, **as directed**.
3. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Comply with fabric and acoustical wall panel manufacturers' written instructions for minimum and maximum temperature and humidity requirements for shipment, storage, and handling.
2. Deliver materials and panels in unopened bundles and store in a temperature-controlled dry place with adequate air circulation.
3. Protect panel edges from crushing and impact.

G. Project Conditions

1. Environmental Limitations: Do not install acoustical wall panels until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
2. Lighting: Do not install acoustical wall panels until a permanent level of lighting **OR** a lighting level of not less than 50 fc (538 lux), **as directed**, is provided on surfaces to receive acoustical wall panels.



3. Air-Quality Limitations: Protect acoustical wall panels from exposure to airborne odors, such as tobacco smoke, and install panels under conditions free from odor contamination of ambient air.
4. Field Measurements: Verify locations of acoustical wall panels by field measurements before fabrication and indicate measurements on Shop Drawings.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of acoustical wall panels that fail in performance, materials, or workmanship within two years from date of Final Completion.
 - a. Failure in performance includes, but is not limited to, acoustical performance.
 - b. Failures in materials include, but are not limited to, fabric sagging, distorting, or releasing from panel edge; or warping of core.

1.2 PRODUCTS

A. Core Materials

1. Glass-Fiber Board: ASTM C 612, Type IA or Types IA and IB; density as specified, unfaced, dimensionally stable, molded rigid board, with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.
2. Mineral-Fiber Board: Maximum flame-spread and smoke-developed indexes of 15 and 5, respectively.
3. Cementitious-Fiber Board Core: Density of not less than 20 lb/cu. ft. (320 kg/cu. m).
4. Tackable, Impact-Resistant, High-Density Face Layer: 1/8-inch- (3.2-mm-) thick layer of compressed molded glass-fiber board with a minimum nominal density of 16 to 18 lb/cu. ft. (256 to 288 kg/cu. m) laminated to face of core.
5. Impact-Resistant, Acoustically Transparent, Copolymer Face-Sheet Layer for High-Abuse Applications: 1/16- to 1/8-inch- (1.6- to 3.2-mm-) thick layer of perforated, noncombustible, copolymer sheet laminated to face of core.
6. Wood: Clear, vertical grain, straight, kiln-dried hardwood of manufacturer's standard species, AWWPA C20, Interior Type A, fire-retardant treated, low-hygroscopic-type formulation. Use fire-retardant-treatment formulations that do not bleed through or otherwise adversely affect finishes. Kiln-dry material after treatment to 5 to 10 percent moisture content.

B. Spline-Mounted Acoustical Wall Panels With Perforated Mineral-Fiber Board Core Or Cementitious-Fiber Board Core

1. Panel Construction: Manufacturer's standard panel construction consisting of facing material laminated to front face of a perforated, water-felted, mineral-fiber board **OR** cementitious-fiber board, **as directed**, core; with long edges kerfed and rabbeted to receive splines.
 - a. Mineral-Fiber Board: Not less than 13-lb/cu. ft. (208-kg/cu. m) **OR** 20-lb/cu. ft. (320-kg/cu. m), **as directed**, nominal density; with perforated surface.
2. Facing Material: Fabric from same dye lot; color and pattern as indicated by manufacturer's designations **OR** matching samples **OR** as selected from manufacturer's full range **OR** as indicated on Drawings, **as directed**.
 - a. Fiber Content: 100 percent woven polyester **OR** nonwoven polyester **OR** polyolefin **OR** acoustically transparent vinyl, **as directed**.
 - b. Width: 54 inches (1371 mm) **OR** 66 inches (1676 mm), **as directed**.
 - c. Applied Treatments: Stain resistance.
3. Nominal Overall Panel Thickness: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
4. NRC: For Type A mounting per ASTM E 795, NRC 0.50 to NRC 0.90 **OR** NRC 0.60 to NRC 0.70 **OR** NRC 0.65 to NRC 0.75, **as directed**.
5. Panel Width: 24 inches (610 mm) **OR** 30 inches (762 mm) **OR** 48 inches (1220 mm) **OR** 600 mm **OR** As indicated on Drawings, **as directed**.
6. Panel Height: Fabricated from units 96 inches (2438 mm) **OR** 108 inches (2743 mm) **OR** 120 inches (3048 mm), **as directed**, in height; mounting height **as directed**.



7. Panel Edge: Core self-edge.
 8. Panel Short Edge Detail: Square.
- C. Spline-Mounted Acoustical Wall Panels With Glass-Fiber Board Core
1. Panel Construction: Manufacturer's standard panel construction consisting of facing material laminated to front face of a dimensionally stable, rigid glass-fiber board core with a nominal density of 6 to 7 lb/cu. ft. (96 to 112 kg/cu. m); with long edges kerfed and rabbeted to receive splines.
 2. Core-Face Layer: Tackable, impact-resistant, high-density board **OR** Impact-resistant, acoustically transparent, copolymer face-sheet, **as directed**.
 3. Facing Material: Fabric from same dye lot; color and pattern as indicated by manufacturer's designations **OR** matching samples **OR** as selected from manufacturer's full range **OR** as indicated on Drawings, **as directed**.
 - a. Fiber Content: 100 percent woven polyester **OR** nonwoven polyester **OR** polyolefin **OR** acoustically transparent vinyl, **as directed**.
 - b. Width: 54 inches (1371 mm) **OR** 66 inches (1676 mm), **as directed**.
 - c. Applied Treatments: Stain resistance.
 4. Nominal Overall Panel Thickness: 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**.
 5. NRC: For Type A mounting per ASTM E 795, not less than NRC 0.20 **OR** NRC 0.80 **OR** NRC 0.95, **as directed**.
 6. Panel Width: Manufacturer's standard **OR** 24 inches (610 mm) **OR** 30 inches (762 mm) **OR** 48 inches (1220 mm) **OR** 600 mm **OR** 1200 mm **OR** As indicated on Drawings, **as directed**.
 7. Panel Height: Fabricated from units 96 inches (2438 mm) **OR** 108 inches (2743 mm) **OR** 120 inches (3048 mm), **as directed**, in height; mounting height **as directed**.
 8. Panel Edge: Manufacturer's standard short edge.
 9. Panel Short Edge Detail: Square.
- D. Back-Mounted Acoustical Wall Panels With Perforated Mineral-Fiber Board Core
1. Panel Construction: Manufacturer's standard panel construction consisting of facing material laminated to front face of a perforated, water-felted, mineral-fiber board core of not less than 13-lb/cu. ft. (208-kg/cu. m) **OR** 20-lb/cu. ft. (320-kg/cu. m), **as directed**, nominal density; with perforated surface.
 2. Facing Material: Fabric from same dye lot; color and pattern as indicated by manufacturer's designations **OR** matching samples **OR** as selected from manufacturer's full range **OR** as indicated on Drawings, **as directed**.
 - a. Fiber Content: 100 percent woven polyester **OR** nonwoven polyester **OR** polyolefin **OR** acoustically transparent vinyl, **as directed**.
 - b. Width: 54 inches (1371 mm) **OR** 66 inches (1676 mm), **as directed**.
 - c. Applied Treatments: Stain resistance.
 3. Nominal Core Thickness and Overall System NRC: 1/2 inch (13 mm) and not less than NRC 0.35 **OR** 3/4 inch (19 mm) and not less than NRC 0.45, **as directed**, for Type A mounting.
 4. Panel Width: 24 inches (610 mm) **OR** 30 inches (762 mm) **OR** 48 inches (1220 mm) **OR** 600 mm **OR** As indicated on Drawings, **as directed**.
 5. Panel Height: Fabricated from units 96 inches (2438 mm) **OR** 108 inches (2743 mm) **OR** 120 inches (3048 mm), **as directed**, in height; mounting height **as directed**.
 6. Panel Edge: Core self-edge.
 7. Panel Short Edge Detail: Square.
- E. Back-Mounted, Edge-Reinforced Acoustical Wall Panels With Glass-Fiber Board Core
1. Panel Construction: Manufacturer's standard panel construction consisting of facing material laminated to front face, edges, and back border of dimensionally stable, rigid glass-fiber **OR** rock-fiber/slag-fiber, **as directed**, board core; with edges chemically hardened or impact resistant and resilient to reinforce panel perimeter against warpage and damage.
 2. Nominal Core Density: 4 to 7 lb/cu. ft. (64 to 112 kg/cu. m) **OR** 6 to 7 lb/cu. ft. (96 to 112 kg/cu. m), **as directed**.



3. Core-Face Layer: Tackable, impact-resistant, high-density board **OR** Impact-resistant, acoustically transparent, copolymer face-sheet, **as directed**.
 4. Facing Material: Fabric from same dye lot; color and pattern as indicated by manufacturer's designations **OR** matching samples **OR** as selected from manufacturer's full range **OR** as indicated on Drawings, **as directed**.
 - a. Fiber Content: 100 percent woven polyester **OR** nonwoven polyester **OR** polyolefin **OR** acoustically transparent vinyl, **as directed**.
 - b. Width: 54 inches (1371 mm) **OR** 66 inches (1676 mm), **as directed**.
 - c. Applied Treatments: Stain resistance.
 5. Nominal Core Thickness and Overall System NRC: 3/4 inch (19 mm) and not less than NRC 0.65 **OR** 1 inch (25 mm) and not less than NRC 0.80 **OR** 1-1/2 inches (38 mm) and not less than NRC 0.85 **OR** 2 inches (51 mm) and not less than NRC 0.90 **OR** 2 inches (51 mm) and not less than NRC 1.00, **as directed**, for Type A mounting per ASTM E 795.
 6. Panel Width: Manufacturer's standard **OR** 24 inches (610 mm) **OR** 30 inches (762 mm) **OR** 48 inches (1220 mm) **OR** 600 mm **OR** 1200 mm **OR** As indicated on Drawings, **as directed**.
 7. Panel Height: Fabricated height as indicated on Drawings **OR as directed**; mounting height as indicated on Drawings **OR as directed**.
 8. Panel Edge Detail: Square **OR** Bullnosed (radiused) **OR** Chamfered (beveled) **OR** Mitered **OR** Custom as indicated on Drawings, **as directed**.
 9. Corner Detail: Square **OR** Round, radius as indicated **OR** Off-square, dimensions as indicated, **as directed**, to form continuous profile to match edge detail.
- F. Back-Mounted, Edge-Framed Acoustical Wall Panels With Glass-Fiber Board Core
1. Panel Construction: Manufacturer's standard panel construction consisting of facing material stretched over front face of edge-framed, dimensionally stable, rigid glass-fiber board core and bonded or attached to edges and back of frame.
 2. Nominal Core Density: 4 to 7 lb/cu. ft. (64 to 112 kg/cu. m) **OR** 6 to 7 lb/cu. ft. (96 to 112 kg/cu. m), **as directed**.
 3. Core-Face Layer: Tackable, impact-resistant, high-density board **OR** Impact-resistant, acoustically transparent, copolymer face-sheet, **as directed**.
 4. Facing Material: Fabric from same dye lot; color and pattern as indicated by manufacturer's designations **OR** matching samples **OR** as selected from manufacturer's full range **OR** as indicated on Drawings, **as directed**.
 - a. Fiber Content: 100 percent woven polyester **OR** nonwoven polyester **OR** polyolefin **OR** acoustically transparent vinyl, **as directed**.
 - b. Width: 54 inches (1371 mm) **OR** 66 inches (1676 mm), **as directed**.
 - c. Applied Treatments: Stain resistance.
 5. Nominal Core Thickness and Overall System NRC: 1 inch (25 mm) and not less than NRC 0.80 **OR** 1-1/2 inches (38 mm) and not less than NRC 0.85 **OR** 2 inches (51 mm) and not less than NRC 0.90, **as directed**, for Type A mounting per ASTM E 795.
 6. Panel Width: Manufacturer's standard **OR** 24 inches (610 mm) **OR** 30 inches (762 mm) **OR** 48 inches (1220 mm) **OR** 600 mm **OR** 1200 mm **OR** As indicated on Drawings, **as directed**.
 7. Panel Height: Fabricated height as indicated on Drawings **OR as directed**; mounting height as indicated on Drawings **OR as directed**.
 8. Panel Edge and Frame: Extruded-aluminum or zinc-coated, rolled-steel shape **OR** Extruded PVC **OR** Hardwood, rabbeted, and splined with glued joints and machined corners, **as directed**.
 - a. Panel Edge Detail: Square.
- G. Fabrication
1. Sound-Absorption Performance: Provide acoustical wall panels with minimum NRCs indicated, as determined by testing per ASTM C 423 for mounting type specified.
 2. Acoustical Wall Panels: Panel construction consisting of facing material adhered to face, **as directed**, edges and back border of dimensionally stable core; with rigid edges to reinforce panel perimeter against warpage and damage.
 - a. Glass-Fiber Board: Resin harden areas of core for attachment of mounting devices.



3. Fabric Facing: Stretched straight, on the grain, tight, square, and free from puckers, ripples, wrinkles, sags, blisters, seams, adhesive, or other foreign matter. Applied with visible surfaces fully covered.
 - a. Where square corners are indicated, tailor corners. Heat seal vinyl fabric seams at corners.
 - b. Where radius or other nonsquare corners are indicated, attach facing material so there are no seams or gathering of material.
 - c. Where fabrics with directional or repeating patterns or directional weave are indicated, mark fabric top and attach fabric in same direction so pattern or weave matches in adjacent panels.
4. Core-Face Layer: Evenly stretched over core face and edges and securely attached to core; free from puckers, ripples, wrinkles, sags.
5. Dimensional Tolerances of Finished Units: Plus or minus 1/16 inch (1.6 mm) for the following:
 - a. Thickness.
 - b. Edge straightness.
 - c. Overall length and width.
 - d. Squareness from corner to corner.
 - e. Chords, radii, and diameters.
6. Spline-Mounting Accessories: Manufacturer's standard concealed, extruded-aluminum or plastic connecting splines designed and fabricated for screw attachment to walls, with other moldings and trim for interior and exterior corners, leveling and base support with factory-applied finish on exposed items.
 - a. Finish Color: White **OR** Black **OR** Match color of facing material **OR** Match sample, **as directed**.
7. Back-Mounting Devices: Concealed on backside of panel, recommended to support weight of panel, with base-support bracket system where recommended by manufacturer for additional support of panels, and as follows:
 - a. Adhesive. Use only adhesives that have a VOC content of 70 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Hook-and-loop tape.
 - c. Impaling clips.
 - d. Magnetic strip or devices.
 - e. Metal "Z" Clips: Two-part panel clips, with one part of each clip mechanically attached to back of panel and the other part to wall substrate, designed to allow for panel removal.
 - f. As recommended by manufacturer.
8. Owner-Furnished Fabric: Provide fabric acceptable to acoustical wall panel manufacturer for application indicated. Notify the Owner of fabric unacceptability.

1.3 EXECUTION

A. Installation

1. Install acoustical wall panels in locations indicated with vertical surfaces and edges plumb, top edges level and in alignment with other panels, faces flush, and scribed to fit adjoining work accurately at borders and at penetrations.
 - a. Cut units to be at least 50 percent of unit width, with facing material extended over cut edge to match uncut edge. Scribe acoustical wall panels to fit adjacent work. Butt joints tightly.
2. Comply with acoustical wall panel manufacturer's written instructions for installation of panels using type of concealed mounting accessories indicated or, if not indicated, as recommended by manufacturer. Anchor panels securely to supporting substrate.
3. Match and level fabric pattern and grain among adjacent panels.
4. Installation Tolerances: As follows:
 - a. Variation from Level and Plumb: Plus or minus 1/16 inch (1.6 mm).
 - b. Variation of Panel Joints from Hairline: Not more than 1/16 inch (1.6 mm) **OR** 1/32 inch (0.79 mm), **as directed**, wide.



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- B. Cleaning
 - 1. Clip loose threads; remove pills and extraneous materials.
 - 2. Clean panels with fabric facing, on completion of installation, to remove dust and other foreign materials according to manufacturer's written instructions.

 - C. Protection
 - 1. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, to ensure that acoustical wall panels are without damage or deterioration at time of Final Completion.
 - 2. Replace acoustical wall panels that cannot be cleaned and repaired, in a manner approved by the Owner, before time of Final Completion.

END OF SECTION 09 84 13 00



SECTION 09 85 00 00 - GYPSUM BOARD

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for gypsum board. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Interior gypsum board.
 - b. Exterior gypsum board for ceilings and soffits.
 - c. Tile backing panels.

C. Submittals

1. Product Data: For each type of product indicated.
2. Samples: For the following products:
 - a. Trim Accessories: Full-size Sample in 12-inch- (300-mm-) long length for each trim accessory indicated.
 - b. Textured Finishes: Manufacturer's standard size for each textured finish indicated and on same backing indicated for Work.
3. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
 - b. Product Data for Credit EQ 4.1: For adhesives used to laminate gypsum board panels to substrates, including printed statement of VOC content.

D. Quality Assurance

1. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.
2. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.

E. Storage And Handling

1. Store materials inside under cover and keep them dry and protected against damage from weather, condensation, direct sunlight, construction traffic, and other causes. Stack panels flat to prevent sagging.

F. Project Conditions

1. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written recommendations, whichever are more stringent.
2. Do not install interior products until installation areas are enclosed and conditioned.
3. Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.
 - a. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - b. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.



1.2 PRODUCTS

A. Panels, General

1. Recycled Content: Provide gypsum panel products with recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content constitutes a minimum of 25 percent by weight.
2. Size: Provide in maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

B. Interior Gypsum Board

1. General: Complying with ASTM C 36/C 36M or ASTM C 1396/C 1396M, as applicable to type of gypsum board indicated and whichever is more stringent.
2. Regular Type:
 - a. Thickness: 1/2 inch (12.7 mm).
 - b. Long Edges: Tapered **OR** Tapered and featured (rounded or beveled) for prefilling, **as directed**.
3. Type X:
 - a. Thickness: 5/8 inch (15.9 mm).
 - b. Long Edges: Tapered **OR** Tapered and featured (rounded or beveled) for prefilling, **as directed**.
4. Type C:
 - a. Thickness: As required by fire-resistance-rated assembly indicated on Drawings.
 - b. Long Edges: Tapered.
5. Flexible Type: Manufactured to bend to fit radii and to be more flexible than standard regular-type gypsum board of same thickness.
 - a. Thickness: 1/4 inch (6.4 mm).
 - b. Long Edges: Tapered.
6. Ceiling Type: Manufactured to have more sag resistance than regular-type gypsum board.
 - a. Thickness: 1/2 inch (12.7 mm).
 - b. Long Edges: Tapered.
7. Foil-Backed Type:
 - a. Core: As indicated on Drawings **OR** 3/8 inch (9.5 mm), regular type **OR** 1/2 inch (12.7 mm), regular type **OR** 5/8 inch (15.9 mm), Type X **OR** Type C as required by fire-resistance-rated assembly indicated on Drawings, **as directed**.
 - b. Long Edges: Tapered **OR** Tapered and featured (rounded or beveled) for prefilling, **as directed**.
8. Abuse-Resistant Type: Manufactured to produce greater resistance to surface indentation, through-penetration (impact resistance), and abrasion than standard, regular-type and Type X gypsum board.
 - a. Core: As indicated on Drawings **OR** 1/2 inch (12.7 mm), regular type **OR** 5/8 inch (15.9 mm), Type X, **as directed**.
 - b. Long Edges: Tapered.
9. High-Impact Type: Manufactured with Type X core, plastic film laminated to back side for greater resistance to through-penetration (impact resistance).
 - a. Core: As indicated on Drawings **OR** 5/8 inch (15.9 mm) thick, **as directed**.
 - b. Plastic-Film Thickness: 0.010 inch (0.254 mm) **OR** 0.020 inch (0.508 mm) **OR** 0.030 inch (0.762 mm) **OR** 0.081 inch (2.057 mm), **as directed**.
10. Moisture- and Mold-Resistant Type: With moisture- and mold-resistant core and surfaces.
 - a. Core: 5/8 inch (15.9 mm), Type X.
 - b. Long Edges: Tapered.

C. Exterior Gypsum Board For Ceilings And Soffits

1. Exterior Gypsum Soffit Board: ASTM C 931/C 931M or ASTM C 1396/C 1396M, with manufacturer's standard edges.



- 1) Core: As indicated **OR** 1/2 inch (12.7 mm), regular type **OR** 5/8 inch (15.9 mm), Type X, **as directed**.
 2. Glass-Mat Gypsum Sheathing Board: ASTM C 1177/C 1177M.
 - a. Core: As indicated **OR** 1/2 inch (12.7 mm), regular type **OR** 5/8 inch (15.9 mm), Type X, **as directed**.
- D. Tile Backing Panels
1. Water-Resistant Gypsum Backing Board: ASTM C 630/C 630M or ASTM C 1396/C 1396M.
 - a. Core: As indicated on Drawings **OR** 1/2 inch (12.7 mm), regular type **OR** 5/8 inch (15.9 mm), Type X **OR** Type C as required by fire-resistance-rated assembly indicated on Drawings, **as directed**.
 2. Glass-Mat, Water-Resistant Backing Board:
 - a. Complying with ASTM C 1178/C 1178M.
 - b. Complying with ASTM C1177/C 1177M.
 - c. Core: As indicated on Drawings **OR** 1/2 inch (12.7 mm), regular type **OR** 5/8 inch (15.9 mm), Type X, **as directed**.
 3. Cementitious Backer Units: ANSI A118.9.
 - a. Thickness: As indicated on Drawings **OR** 1/2 inch (12.7 mm), **as directed**.
- E. Trim Accessories
1. Interior Trim: ASTM C 1047.
 - a. Material: Galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized steel sheet **OR** Galvanized or aluminum-coated steel sheet or rolled zinc **OR** Plastic **OR** Paper-faced galvanized steel sheet, **as directed**.
 - b. Shapes:
 - 1) Cornerbead.
 - 2) Bullnose bead.
 - 3) LC-Bead: J-shaped; exposed long flange receives joint compound.
 - 4) L-Bead: L-shaped; exposed long flange receives joint compound.
 - 5) U-Bead: J-shaped; exposed short flange does not receive joint compound.
 - 6) Expansion (control) joint.
 - 7) Curved-Edge Cornerbead: With notched or flexible flanges.
 2. Exterior Trim: ASTM C 1047.
 - a. Material: Hot-dip galvanized steel sheet, plastic, or rolled zinc.
 - b. Shapes:
 - 1) Cornerbead.
 - 2) LC-Bead: J-shaped; exposed long flange receives joint compound.
 - 3) Expansion (Control) Joint: One-piece, rolled zinc with V-shaped slot and removable strip covering slot opening.
 3. Aluminum Trim: Extruded accessories of profiles and dimensions indicated.
 - a. Aluminum: Alloy and temper with not less than the strength and durability properties of ASTM B 221 (ASTM B 221M), Alloy 6063-T5.
 - b. Finish: Corrosion-resistant primer compatible with joint compound and finish materials specified.
- F. Joint Treatment Materials
1. General: Comply with ASTM C 475/C 475M.
 2. Joint Tape:
 - a. Interior Gypsum Wallboard: Paper.
 - b. Exterior Gypsum Soffit Board: Paper.
 - c. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.
 - d. Tile Backing Panels: As recommended by panel manufacturer.
 3. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.
 - a. Prefilling: At open joints, rounded or beveled panel edges, and damaged surface areas, use setting-type taping compound.



- b. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping **OR** drying-type, all-purpose, **as directed**, compound.
 - 1) Use setting-type compound for installing paper-faced metal trim accessories.
 - c. Fill Coat: For second coat, use setting-type, sandable topping **OR** drying-type, all-purpose, **as directed**, compound.
 - d. Finish Coat: For third coat, use setting-type, sandable topping **OR** drying-type, all-purpose, **as directed**, compound.
 - e. Skim Coat: For final coat of Level 5 finish, use setting-type, sandable topping compound **OR** drying-type, all-purpose compound **OR** high-build interior coating product designed for application by airless sprayer and to be used instead of skim coat to produce Level 5 finish, **as directed**.
4. Joint Compound for Exterior Applications:
 - a. Exterior Gypsum Soffit Board: Use setting-type taping compound and setting-type, sandable topping compound.
 - b. Glass-Mat Gypsum Sheathing Board: As recommended by sheathing board manufacturer.
 5. Joint Compound for Tile Backing Panels:
 - a. Water-Resistant Gypsum Backing Board: Use setting-type taping compound and setting-type, sandable topping compound.
 - b. Glass-Mat, Water-Resistant Backing Panel: As recommended by backing panel manufacturer.
 - c. Cementitious Backer Units: As recommended by backer unit manufacturer.

G. Auxiliary Materials

1. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written recommendations.
2. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.
 - a. Use adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.
 - a. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.
 - b. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.
4. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
 - a. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.
 - b. Recycled Content: Provide blankets with recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content constitutes a minimum of 25 percent by weight.
5. Acoustical Sealant: As specified in Division 07 Section "Joint Sealants".
 - a. Provide sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Thermal Insulation: As specified in Division 07 Section "Thermal Insulation".
7. Vapor Retarder: As specified in Division 07 Section "Thermal Insulation".

H. Texture Finishes

1. Primer: As recommended by textured finish manufacturer.
2. Polystyrene Aggregate Ceiling Finish: Water-based, job-mixed, polystyrene aggregate finish with flame-spread and smoke-developed indexes of not more than 25 when tested according to ASTM E 84.
 - a. Texture: Fine **OR** Medium **OR** Coarse, **as directed**.
3. Aggregate Finish: Water-based, job-mixed, aggregated, drying-type texture finish for spray application.



- a. Texture: Light spatter **OR** Spatter knock-down, **as directed**.
4. Acoustical Finish: Water-based, chemical-setting or drying-type, job-mixed texture finish for spray application.
 - a. Application Thickness: 1/2 inch (12.7 mm).
 - b. Fire-Test-Response Characteristics: Indices when tested according to ASTM E 84 as follows:
 - 1) Flame Spread: Less than 25.
 - 2) Smoke Developed: Less than 450.
 - c. NRC: 0.55 according to ASTM C 423.

1.3 EXECUTION

A. Examination

1. Examine areas and substrates, with Installer present, and including welded hollow-metal frames and framing, for compliance with requirements and other conditions affecting performance.
2. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Applying And Finishing Panels, General

1. Comply with ASTM C 840.
2. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.
3. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch (1.5 mm) of open space between panels. Do not force into place.
4. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.
5. Form control and expansion joints with space between edges of adjoining gypsum panels.
6. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
 - a. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.
 - b. Fit gypsum panels around ducts, pipes, and conduits.
 - c. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- (6.4- to 9.5-mm-) wide joints to install sealant.
7. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments, except floors. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations, and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.
8. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.
9. Wood Framing: Install gypsum panels over wood framing, with floating internal corner construction. Do not attach gypsum panels across the flat grain of wide-dimension lumber, including floor joists and headers. Float gypsum panels over these members, or provide control joints to counteract wood shrinkage.
10. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and with manufacturer's written recommendations for locating edge trim and closing off sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings.



11. Install sound attenuation blankets before installing gypsum panels, unless blankets are readily installed after panels have been installed on one side.

C. Applying Interior Gypsum Board

1. Install interior gypsum board in the following locations:
 - a. Regular Type: As indicated on Drawings **OR** Vertical surfaces, unless otherwise indicated, **as directed**.
 - b. Type X: As indicated on Drawings **OR** Where required for fire-resistance-rated assembly **OR** Vertical surfaces, unless otherwise indicated, **as directed**.
 - c. Type C: As indicated on Drawings **OR** Where required for specific fire-resistance-rated assembly indicated, **as directed**.
 - d. Flexible Type: As indicated on Drawings **OR** Apply in double layer at curved assemblies, **as directed**.
 - e. Ceiling Type: As indicated on Drawings **OR** Ceiling surfaces, **as directed**.
 - f. Foil-Backed Type: As indicated on Drawings **OR as directed**.
 - g. Abuse-Resistant Type: As indicated on Drawings **OR as directed**.
 - h. High-Impact Type: As indicated on Drawings **OR as directed**.
 - i. Moisture- and Mold-Resistant Type: As indicated on Drawings **OR as directed**.
2. Single-Layer Application:
 - a. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing, unless otherwise indicated.
 - b. On partitions/walls, apply gypsum panels vertically (parallel to framing) **OR** horizontally (perpendicular to framing), **as directed**, unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
 - 1) Stagger abutting end joints not less than one framing member in alternate courses of panels.
 - 2) At stairwells and other high walls, install panels horizontally, unless otherwise indicated or required by fire-resistance-rated assembly.
 - c. On Z-furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
 - d. Fastening Methods: Apply gypsum panels to supports with steel drill screws.
3. Multilayer Application:
 - a. On ceilings, apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints 1 framing member, 16 inches (400 mm) minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.
 - b. On partitions/walls, apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.
 - c. On Z-furring members, apply base layer vertically (parallel to framing) and face layer either vertically (parallel to framing) or horizontally (perpendicular to framing) with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.
 - d. Fastening Methods: Fasten base layers and face layers separately to supports with screws **OR** Fasten base layers with screws; fasten face layers with adhesive and supplementary fasteners, **as directed**.
4. Laminating to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's written recommendations and temporarily brace or fasten gypsum panels until fastening adhesive has set.
5. Curved Surfaces:



- a. Install panels horizontally (perpendicular to supports) and unbroken, to extent possible, across curved surface plus 12-inch- (300-mm-) long straight sections at ends of curves and tangent to them.
 - b. For double-layer construction, fasten base layer to studs with screws 16 inches (400 mm) o.c. Center gypsum board face layer over joints in base layer, and fasten to studs with screws spaced 12 inches (300 mm) o.c.
- D. Applying Exterior Gypsum Panels For Ceilings And Soffits
1. Apply panels perpendicular to supports, with end joints staggered and located over supports.
 - a. Install with 1/4-inch (6.4-mm) open space where panels abut other construction or structural penetrations.
 - b. Fasten with corrosion-resistant screws.
- E. Applying Tile Backing Panels
1. Water-Resistant Gypsum Backing Board: Install at showers, tubs, and where indicated. Install with 1/4-inch (6.4-mm) gap where panels abut other construction or penetrations.
 2. Glass-Mat, Water-Resistant Backing Panel: Comply with manufacturer's written installation instructions and install at showers, tubs, and where indicated **OR** locations indicated to receive tile, **as directed**. Install with 1/4-inch (6.4-mm) gap where panels abut other construction or penetrations.
 3. Cementitious Backer Units: ANSI A108.11, at showers, tubs, and where indicated **OR** locations indicated to receive tile, **as directed**.
 4. Areas Not Subject to Wetting: Install regular-type gypsum wallboard panels to produce a flat surface except at showers, tubs, and other locations indicated to receive water-resistant panels.
 5. Where tile backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.
- F. Installing Trim Accessories
1. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.
 2. Control Joints: Install control joints at locations indicated on Drawings **OR** according to ASTM C 840 and in specific locations approved by the Owner for visual effect, **as directed**.
 3. Interior Trim: Install in the following locations:
 - a. Cornerbead: Use at outside corners, unless otherwise indicated.
 - b. Bullnose Bead: Use at outside corners **OR** where indicated, **as directed**.
 - c. LC-Bead: Use at exposed panel edges.
 - d. L-Bead: Use where indicated.
 - e. U-Bead: Use at exposed panel edges **OR** where indicated, **as directed**.
 - f. Curved-Edge Cornerbead: Use at curved openings.
 4. Exterior Trim: Install in the following locations:
 - a. Cornerbead: Use at outside corners.
 - b. LC-Bead: Use at exposed panel edges.
 5. Aluminum Trim: Install in locations indicated on Drawings.
- G. Finishing Gypsum Board
1. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.
 2. Prefill open joints, rounded or beveled edges, and damaged surface areas.
 3. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.
 4. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:
 - a. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
 - b. Level 2: Panels that are substrate for tile **OR** Panels that are substrate for acoustical tile **OR** Where indicated on Drawings, **as directed**.



- c. Level 3: For surfaces receiving medium- or heavy-textured finishes before painting or heavy wallcoverings where lighting conditions are not critical **OR** Where indicated on Drawings, **as directed**.
- d. Level 4: For surfaces receiving light-textured finishes, wallcoverings, and flat paints **OR** At panel surfaces that will be exposed to view, unless otherwise indicated, **as directed**. This is generally the standard exposed finish. Gloss and semi-gloss enamel paints are not usually recommended over this level of finish. ASTM C 840 requires application of "drywall primer" on surfaces before final decoration
 - 1) Primer and its application to surfaces are specified in other Division 07.
- e. Level 5: For surfaces receiving gloss and semigloss enamels and other surfaces subject to severe lighting **OR** Where indicated on Drawings, **as directed**.
 - 1) Primer and its application to surfaces are specified in other Division 07.
- f. Glass-Mat Gypsum Sheathing Board: Finish according to manufacturer's written instructions for use as exposed soffit board.
- g. Glass-Mat, Water-Resistant Backing Panels: Finish according to manufacturer's written instructions.
- h. Cementitious Backer Units: Finish according to manufacturer's written instructions.

H. Applying Texture Finishes

- 1. Surface Preparation and Primer: Prepare and apply primer to gypsum panels and other surfaces receiving texture finishes. Apply primer to surfaces that are clean, dry, and smooth.
- 2. Texture Finish Application: Mix and apply finish using powered spray equipment, to produce a uniform texture free of starved spots or other evidence of thin application or of application patterns.
- 3. Prevent texture finishes from coming into contact with surfaces not indicated to receive texture finish by covering them with masking agents, polyethylene film, or other means. If, despite these precautions, texture finishes contact these surfaces, immediately remove droppings and overspray to prevent damage according to texture-finish manufacturer's written recommendations.

I. Protection

- 1. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
- 2. Remove and replace panels that are wet, moisture damaged, and mold damaged.
 - a. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - b. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION 09 85 00 00



SECTION 09 85 00 00a - GYPSUM BOARD RENOVATION**GENERAL**

Description Of Work

1. This specification covers the furnishing and installation of materials for gypsum board renovation. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

Submittals

2. Quality Assurance/Control Submittals
 - a. Certificates: Manufacturer's written certification that gypsum products meet or exceed specified requirements.

Quality Assurance

3. Regulatory Requirements:
 - a. Gypsum Board Partitions: Listed and labeled for fire-protective ratings as indicated or scheduled.
 - b. Gypsum Board Floor/Ceilings and Roof/Ceiling Assemblies: Listed and labeled for fire protective ratings as indicated or scheduled.
 - c. Fire-Rated Assemblies: Comply with UL 05, FM P8016, or GA 600 for required fire-rated assembly.

Delivery, Storage, And Handling

4. Storage and Protection: Store wallboard off ground to protect it from weather and damage due to moisture damage.
 - a. Wallboard: Dry, free of warpage, and have bundling tape intact immediately prior to use.

Project Conditions

5. Environmental Requirements: Comply with Detailed Scope of Work.
 - a. During gypsum-panel application and finishing, maintain indoor temperatures within range of 13 degrees C (55 degrees F) to 21 degrees C (70 degrees F). Provide adequate ventilation to carry off excess moisture.
6. Existing Conditions: See Division 1 Section "Summary of Work". Do not interfere with use of occupied buildings or portions of buildings. Maintain free and safe passage to and from occupied areas.
7. Protection: Protect grounds, plantings, buildings and any other facilities or property from damage caused by construction operations.

Scheduling And Sequencing

8. Scheduling and Completion: Comply with Detailed Scope of Work.

PRODUCTS

Materials

9. Materials for Patching, Extending, and Matching:



- a. Provide same products or types of construction as in existing structure, as needed to patch, extend, or match existing work.
 - 1) Generally, Contract Documents will not define products present in existing construction. Determine products by Inspection and any necessary testing.
 - 2) Patching, extending, and matching of existing work and systems shall result in a complete, finished system.
- b. Presence of product, finish, or type of construction requires that patching, extending, or matching be performed as necessary to make work complete and consistent.

Metals

10. Partition Metals: ASTM C 645, galvanized steel:
 - a. Interior Steel Studs: Minimum 0.46 mm (25 gage), provide sizes and gages to match existing or as indicated.
 - 1) Provide minimum of 0.84 mm (20 gage) studs both sides of hollow metal frames.
 - b. Steel Stud Runners: Match studs. Provide long leg runners for slip joint at structure above to allow for deflection.
 - c. Furring Channels: Hat-shaped furring channels, minimum 0.46 mm (25 gage).
 - d. Resilient Furring Channels: Manufacturer's standard product designed to reduce sound transmission by resilient attachment of gypsum board, 13 mm (1/2 inch) deep.
 - e. Sheet-Metal Reinforcement (Alternate to Wood Blocking): 1.52 mm (16 gage) minimum.
11. Suspended Coiling Metals:
 - a. Runner Channels: ASTM C 754 cold-rolled steel channels with rust-inhibitive finish.
 - 1) 50 mm (2 Inches) deep, 88 kg per 100 m (590 pounds per 1,000 LF).
 - 2) 38 mm (1-1/2 inch) deep, 70 kg per 100 m (475 pounds per 1,000 LF).
 - 3) 19 mm (3/4 Inch) deep, 45 kg per 100 m (300 pounds per 1,000 LF).
 - b. Furring Channels: Hat-shaped galvanized-steel furring channels, minimum 0.46 mm (25 gage).
 - c. Steel Studs: Galvanized steel as specified above, minimum 0.46 mm (25 gage).
 - d. Wire for Hangers and Ties: ASTM A 641, Class 1 zinc coating, soft temper.
 - 1) Hanger Wire: Minimum 4.1 mm (8 gage).
 - 2) Tie Wire: 6 mm (16 gage).

Gypsum Board And Related Materials

12. Gypsum Board: GA216 and ASTM C 36
 - a. Size: 12.7 mm and 15.9 mm (1/2 inch and 5/8 inch) thick to match existing, as indicated or scheduled. Provide boards 1 200 mm (48 inches) wide by length required to minimize cross joints.
 - b. Regular Tapered-edge gypsum panels.
 - 1) Provide Type X gypsum panels at fire-rated assemblies.
 - c. Water-Resistant: ASTM C 630, paintable, tapered-edge gypsum panels.
 - 1) Provide Type X water-resistant gypsum panels at fire-rated assemblies.
13. Cementitious Backer Units (CBU): ANSI A118.9, nailable/screwable backer board composed of stable portland cement, aggregates, and reinforcements with ability to remain unaffected by prolonged exposure to moisture, 12.7 mm (1/2 inch) thick.
14. Fasteners:
 - a. Screws: ASTM C 1002, drywall screws, corrosion resistant. Provide types as recommended by manufacturer for each application.
 - 1) Wallboard to Metal Framing: Minimum 25 mm (1 inch), Type S.
 - 2) Wall board to Wood Framing: Minimum 32 mm (1-1/4 inch) Type W bugle head.



- 3) Wall board to Wallboard: Type G.
- b. Nails: ASTM C 514.
15. Accessories: GA 216 and ASTM C 1047, galvanized steel.
 - a. Comer Bead: GA 216 Type CB-114 x 114.
 - b. Metal Trim (Casing Beads): GA 216 Type L, in depth to match gypsum-board thickness.
 - c. Control Joint: V-shaped control joint.
 - d. Adhesive: ASTM C 557 multi-purpose adhesive.
16. Finishing Materials: ASTM C 475.
 - a. Joint Tape: Provide type as recommended by panel manufacturer.
 - b. Joint Treatment: Joint compound, adhesive, water, and fasteners.
17. Sound-Isolation Materials:
 - a. Sound Insulation: ASTM C 665, Type I (unfaced) mineral fiber blankets, 3.7 to 4.9 kg per sq m (3/4 to 1 PCF), thickness as indicated, scheduled, or required by fire-rated assembly.
 - b. Acoustical Sealant:
 - 1) Concealed: ASTM C 919 nondrying, non-hardening, and non-skinning; non-bleeding; and non-staining.
 - 2) Exposed: ASTM C 919 non-oxidizing and skinning; permanently elastic; and paintable.
 - c. Ductwork Penetrations Packing: Low-density fiberglass.

EXECUTION

Examination

18. Units, Spaces, and Areas to be Renovated: Comply with Detailed Scope of Work.
 - a. Existing Conditions: Before beginning installation, examine substrates and framing to receive gypsum board for defects or conditions adversely affecting quality and execution of installation.

Preparation

19. Dust Protection: Comply with Detailed Scope of Work.
20. Building Occupation: Carry out demolition and renovation work to cause as little inconvenience to occupants as possible. See Detailed Scope of Work.
21. Protection: Comply with Detailed Scope of Work.
 - a. Protection: Provide drapes and drop cloths necessary to protect walls, floors, ductwork and piping, electrical work, etc. during drywall finishing operations.
22. Selective Demolition: Comply with Detailed Scope of Work.

Laying Out Work

23. Discrepancies: Verify dimensions and elevations indicated in layout of existing work.
 - a. Prior to commencing work, carefully compare and check Drawings (if any) for discrepancies in locations or elevations of work to be executed.
 - b. Refer discrepancies among Drawings (if any), Specifications, and existing conditions to the Owner or adjustment before work affected is performed.
 - 1) Failure to make such notification shall place responsibility on Contractor to carry out work in satisfactory, workmanlike manner.
 - c. Contractor: Responsible for location and elevation of construction indicated by Construction Documents.

Performance



24. Patching: Patch and extend existing work using skilled mechanics capable of matching existing quality of workmanship.
 - a. Quality of Patched or Extended Work: Not less than specified for new work. If similar new work is not specified, equal to existing work.
25. Damaged Surfaces: Comply with Detailed Scope of Work.
26. Transitions from Existing to New Work: Comply with Detailed Scope of Work.

Erection Of Drywall Stud Partitions

27. Reference Standard: Erect steel framing in accordance with ASTM C 754.
28. Layouts: Align partition studs accurately according to partition layout.
29. Anchoring: Anchor runner channels to concrete slabs with concrete stub nails or power-driven anchors at 600 mm (24 inches) OC. Anchor runner channels to coiling grid, where applicable, with stove bolts. Where studs extend above ceiling system, install headers where required to receive runners.
30. Studs: Position studs vertically in runners. Where studs are located adjacent to openings or partition intersections and comers. anchor studs to runners with manufacturer's metal lock fastener or with 13 mm (1/2 inch) Type S pan-head screws.
 - a. Space studs at 400 mm (16 Inches) and 600 mm (24 inches) OC as indicated or scheduled.
 - 1) Cementitious Backer Units (CBU): Space studs at maximum of 400 mm (16 inches) OC.
 - 2) Limiting Heights: Comply with ASTM C 754 for transverse load of 240 Pa (5 lb-force/SF) without exceeding either allowable stress or deflection of L/240. Comers and Intersections: Locate studs no more than 50 mm (2 inches) from abutting partitions, comers, etc.
 - b. Openings: Locate studs not more than 50 mm (2 inches) from opening frames. Anchor studs to frame anchor clips by bolt or screw attachment. Install headers over openings as recommended by the manufacturer.
 - 1) Solid-Core Wood Doors and Hollow Metal Doors: Provide two full-height studs at jambs fastened together back to back.
 - 2) Fire-Rated Openings: Comply with GA 219.
31. Bracing: Provide diagonal bracing at head of studs that terminate above the ceiling level. Bracing shall consist of metal studs bent to V-shape and extending at 45 degrees from partition head to structure above. Locate bracing 1 200 mm (48 inches) maximum OC.
32. Wood Blocking or Metal Reinforcement:
 - a. Wood Blocking: See Division 6 Section "Rough Carpentry."
 - b. Install metal reinforcement of size required for support of toilet and bath accessories, hardware, cabinets, shelving, counters, and other wall-mounted items.
 - c. Set true to line, level, or plumb well-secured in stud wall and flush with back of drywall or other wall finish.
 - d. Coordinate exact locations with other sections.

Miscellaneous Framing And Furring

33. General: Provide necessary framing and furring for special framing at recesses, offsets, specialty items, and at wall-mounted casework, shelving, and equipment.
34. Furring Channels: Install furring channels over back-up material. Position channels vertically at 600 mm (24 inches) OC. Use power-activated fasteners or stub nails at 600 mm (24 Inches) OC along alternating flanges. Shim channels level as required.
 - a. Cementitious Backer Units (CBU): Space furring at maximum of 400 mm (16 inches) OC.



35. Resilient Furring Channels: Screw-attach In accordance with manufacturer's recommendations.
 - a. Spacing: 600 mm (24 inches) OC for framing at 16 inches OC and 400 mm (16 inches) OC for framing at 24 Inches OC.

Ceiling Grillage Erection

36. Reference Standard: Erect steel framing In accordance with ASTM C 754.
37. Hangers: Install wire hangers spaced not over 1 200 mm (48 inches) OC in direction of 38 mm (1-1/2 inch) main runner channels and within 150 mm (6 inches) of ends of main runners or interruptions of ceiling continuity. Hang from structure above.
38. Runners: Place main runners not over 1 200 mm (48 inches) OC. Provide, position, and level hangers with hangers saddle-tied along runners. Space furring channels at 600 mm (24 inches) OC at right angles to runner channels and secure with furring channel clips.
39. Reinforcement: At light troffers or other openings, reinforce grillage with 19 mm (3/4 inch) cold-rolled channels wired atop and parallel to main runner channels.
 - a. Provide lateral seismic bracing as required by code.
40. Special Shapes: Provide necessary framing and suspension for off sets, verticals, etc.

Insulation

41. Sound Insulation: Place sound Insulation blankets in partitions tight within spaces, around cut openings. behind and around electrical and mechanical items within partitions, and tight to items passing through partitions.
 - a. Ductwork Penetrations: Provide one-inch wide clearance around ductwork and pack with fiberglass ready for joint sealers.

Installation Of Gypsum Drywall

42. Reference Standards: Apply and finish gypsum board in accordance with GA 216 and ASTM C 840.
43. Partition Gypsum Board Layout: Apply gypsum wallboard panels vertically with abutting ends and edges occurring over stud flanges or furring.
 - a. Joints on Opposite Sides of Partitions: Stagger; joints shall not occur over same stud.
 - b. Two Layer Construction: Stagger Joints between layers.
44. Ceiling Gypsum Board: Apply gypsum board of maximum practical length with long dimensions at right angles to furring channels. End and edge joints shall occur over furring channels with end joints staggered. Properly support gypsum board around cutouts and openings.
45. Fasteners: Apply board to studs or furring with drywall screws spaced 300 mm (12 inches) OC in field of board and 200 mm (8 inches) OC staggered along abutting edges.
46. Water-Resistant: Apply gypsum wallboard manufacturer's recommended sealant to raw cut edges and screw heads.
47. Cementitious Backer Units (CBU): Install in accordance with ANSI A108.11 and manufacturer's recommendations.
48. Accessories:
 - a. Comer Bead: Apply as recommended by manufacturer at exposed outer corners.
 - b. Trim (Casing Beads): Apply as recommended by manufacturer, where gypsum board abuts other materials, and as indicated.
 - c. Control Joints: Comply with GA 216.
 - 1) Walls: Install at not more than 9 m (30 feet) OC.
 - 2) Ceilings: Install at not more than 15 m (50 feet) OC and where framing changes direction.
 - 3) Coordinate locations with the Owner.
49. Access Panels: Securely install access panels furnished under other sections. Set plumb and square to align with finish surface.



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50. Acoustical Sealant: Seal perimeter and penetrations on both sides of sound-rated partitions and partitions with sound-attenuation blankets with minimum of single 6 mm (1/4 inch) bead of sealant
 - a. Locations:
 - 1) Seal around gypsum-board perimeter in angle formed by gypsum-board panels and abutting dissimilar materials.
 - 2) Seal intersections of gypsum board with dissimilar materials.
 - 3) Seal pipe, conduit, ductwork, penetrations, etc.
 - 4) Seal around cutouts for lights, cabinets, pipes, ductwork, electrical boxes, etc.
 - 5) Seal gypsum board panel terminations in door and window frames.
 - 6) Seal control-joint locations before installing control Joints to panels.
 - b. Installation: Comply with ASTM C 919 and requirements of indicated sound-rated assembly. Provide number and positions of beads to comply with sound rating of assembly.
 51. Tolerances: Gypsum-board surface plane within plus or minus 3 mm in 3 000 mm (1/8 inch in 10 feet).
 52. Finishing: Finish in accordance with GA 214.
 - a. Concealed Locations (Not Exposed to View in Rooms): Level 1
 - b. Beneath Tile: Level 2.
 - c. Other Finished Areas: Level 4. Finish joints, trim, and fastener dimples. Sand smooth.
 - d. Cementitious Backer Units (CBU): Treat joints in accordance with ANSI A108.11 and manufacturer's recommendations.

END OF SECTION 09 85 00 00a



SECTION 09 85 00 00b - GYPSUM BOARD SHAFT-WALL ASSEMBLIES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for gypsum board shaft-wall assemblies. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes gypsum board shaft-wall assemblies for the following:
 - a. Shaft-wall enclosures.
 - b. Chase enclosures.
 - c. Stair enclosures.
 - d. Horizontal enclosures.

C. Submittals

1. Product Data: For each gypsum board shaft-wall assembly indicated.
2. LEED Submittals:
 - a. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
 - b. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.

D. Quality Assurance

1. Fire-Resistance Ratings: Provide materials and construction identical to those of assemblies with fire-resistance ratings determined according to ASTM E 119 by a testing and inspecting agency.
2. STC-Rated Assemblies: Provide materials and construction identical to those of assemblies tested according to ASTM E 90 and classified according to ASTM E 413 by a testing and inspecting agency.
3. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling

1. Deliver materials in original packages, containers, and bundles bearing brand name and identification of manufacturer or supplier.
2. Store materials inside under cover and keep them dry and protected against damage from weather, direct sunlight, surface contamination, corrosion, construction traffic, and other causes.
3. Stack panels flat on leveled supports off floor or slab to prevent sagging.

F. Project Conditions

1. Environmental Limitations: Comply with ASTM C 840 requirements or with gypsum board manufacturer's written recommendations, whichever are more stringent.
2. Do not install interior products until installation areas are enclosed and conditioned.
3. Do not install panels that are wet, moisture damaged, or mold damaged.
 - a. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
 - b. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.



PART 2 - PRODUCTS

- A. Gypsum Board Shaft-Wall Assemblies, General
1. Provide materials and components complying with requirements of fire-resistance-rated assemblies indicated.
 - a. Provide panels in maximum lengths available to eliminate or minimize end-to-end butt joints.
 - b. Provide auxiliary materials complying with gypsum board shaft-wall assembly manufacturer's written recommendations.
- B. Panel Products
1. Recycled Content: Provide gypsum panel products with recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content constitutes a minimum of 25 percent by weight.
 2. Gypsum Liner Panels: Comply with ASTM C 442/C 442M.
 - a. Type X: Manufacturer's proprietary liner panels with moisture-resistant paper faces.
 - 1) Core: 1 inch (25.4 mm) thick.
 - 2) Long Edges: Double bevel.
 - b. Moisture- and Mold-Resistant Type X: Manufacturer's proprietary liner panels with moisture- and mold-resistant core and surfaces; comply with ASTM D 3273.
 - 1) Core: 1 inch (25.4 mm) thick.
 - 2) Long Edges: Double bevel.
 3. Gypsum Base for Gypsum Veneer Plaster: As specified in Division 09 Section "Gypsum Veneer Plastering".
 4. Gypsum Board: As specified in Division 09 Section "Gypsum Board".
 5. Water-Resistant Gypsum Backing Board: As specified in Division 09 Section "Gypsum Board".
 6. Cementitious Backer Units: As specified in Division 09 Section "Tiling".
- C. Non-Load-Bearing Steel Framing
1. Framing Members: Comply with ASTM C 754 for conditions indicated.
 2. Steel Sheet Components: Comply with ASTM C 645 requirements for metal, unless otherwise indicated.
 - a. Recycled Content: Provide steel sheet with average recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
 - b. Protective Coating: ASTM A 653/A 653M, G40 (Z120) **OR** ASTM A 653/A 653M, G60 (Z180) **OR** Coating with equivalent corrosion resistance of ASTM A 653/A 653M, G40 (Z120), **as directed**, hot-dip galvanized, unless otherwise indicated.
- D. Auxiliary Materials
1. General: Provide auxiliary materials that comply with referenced product standards and manufacturer's written recommendations.
 2. Trim Accessories: Cornerbead, edge trim, and control joints of material and shapes specified in Division 09 Section(s) "Gypsum Veneer Plastering" OR "Gypsum Board", **as directed**, that comply with gypsum board shaft-wall assembly manufacturer's written recommendations for application indicated.
 3. Gypsum Base Joint-Reinforcing Materials: As specified in Division 09 Section "Gypsum Veneer Plastering".
 4. Gypsum Veneer Plaster: As specified in Division 09 Section "Gypsum Veneer Plastering".
 5. Gypsum Board Joint-Treatment Materials: As specified in Division 09 Section "Gypsum Board".
 6. Laminating Adhesive: Adhesive or joint compound recommended by manufacturer for directly adhering gypsum face-layer panels and gypsum-base face-layer panels to backing-layer panels in multilayer construction.
 - a. Use adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).



7. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.
 - a. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.
8. Track Fasteners: Power-driven fasteners of size and material required to withstand loading conditions imposed on shaft-wall assemblies without exceeding allowable design stress of track, fasteners, or structural substrates in which anchors are embedded.
 - a. Expansion Anchors: Fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 5 times design load, as determined by testing per ASTM E 488 conducted by a qualified testing agency.
 - b. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 10 times design load, as determined by testing per ASTM E 1190 conducted by a qualified testing agency.
9. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing), produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
 - a. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.
 - b. Recycled Content: Provide blankets with recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content constitutes a minimum of 25 percent by weight.
10. Acoustical Sealant: As specified in Division 07 Section "Thermal Insulation".
 - a. Provide sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Gypsum Board Shaft-Wall Assemblies

1. Basis-of-Design Product: As indicated on Drawings by design designation of a qualified testing agency.
2. Fire-Resistance Rating: As indicated **OR** 1 hour **OR** 2 hours **OR** 3 hours **OR** 4 hours, **as directed**.
3. STC Rating: As indicated **OR** 51, minimum, **as directed**.
4. Studs: Manufacturer's standard profile for repetitive members, corner and end members, and fire-resistance-rated assembly indicated.
 - a. Depth: As indicated **OR** 2-1/2 inches (64 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm), **as directed**.
 - b. Minimum Base-Metal Thickness: As indicated **OR** 0.0179 inch (0.45 mm) **OR** 0.0220 inch (0.55 mm) **OR** 0.0329 inch (0.84 mm), **as directed**.
5. Runner Tracks: Manufacturer's standard J-profile track with long-leg length as standard with manufacturer, but at least 2 inches (51 mm) long and in depth matching studs.
 - a. Minimum Base-Metal Thickness: As indicated **OR** Matching steel studs **OR** 0.0179 inch (0.45 mm) **OR** 0.0220 inch (0.55 mm) **OR** 0.0329 inch (0.84 mm), **as directed**.
6. Firestop Tracks: Top runner manufactured to allow partition heads to expand and contract with movement of structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
7. Jamb Struts: Manufacturer's standard J-profile strut with long-leg length of 3 inches (76 mm), in depth matching studs, and not less than 0.0329 inch (0.84 mm) thick.
8. Room-Side Finish: As indicated **OR** Gypsum board **OR** Gypsum veneer plaster **OR** Cementitious backer units, **as directed**.
9. Shaft-Side Finish: As indicated **OR** As indicated by fire-resistance-rated assembly design designation, **as directed**.
10. Insulation: Sound attenuation blankets.

2.2 EXECUTION

A. Preparation



1. Sprayed Fire-Resistive Materials: Coordinate with gypsum board shaft-wall assemblies so both elements of Work remain complete and undamaged. Patch or replace sprayed fire-resistive materials removed or damaged during installation of shaft-wall assemblies to comply with requirements specified in Division 07 Section "Applied Fireproofing".
 - a. Before sprayed fire-resistive materials are applied, attach offset anchor plates or ceiling runner tracks to surfaces indicated to receive sprayed fire-resistive materials. Where offset anchor plates are required, provide continuous plates fastened to building structure not more than 24 inches (610 mm) o.c.
2. After sprayed fire-resistive materials are applied, remove only to extent necessary for installation of gypsum board shaft-wall assemblies and without reducing the fire-resistive material thickness below that which is required to obtain fire-resistance rating indicated. Protect remaining fire-resistive materials from damage.

B. Installation

1. General: Install gypsum board shaft-wall assemblies to comply with requirements of fire-resistance-rated assemblies indicated, manufacturer's written installation instructions, and the following:
 - a. ASTM C 754 for installing steel framing except comply with framing spacing indicated.
 - b. Division 09 Section(s) "Gypsum Veneer Plastering" OR "Gypsum Board", **as directed**, for applying and finishing panels.
 - c. Division 09 Section "Tiling" for cementitious backer units.
2. Do not bridge architectural or building expansion joints with shaft-wall assemblies; frame both sides of expansion joints with furring and other support.
3. Install supplementary framing in gypsum board shaft-wall assemblies around openings and as required for blocking, bracing, and support of gravity and pullout loads of fixtures, equipment, services, heavy trim, furnishings, and similar items that cannot be supported directly by shaft-wall assembly framing.
 - a. At elevator hoistway entrance door frames, provide jamb struts on each side of door frame.
 - b. Where handrails directly attach to gypsum board shaft-wall assemblies, provide galvanized steel reinforcing strip with 0.0312-inch (0.79-mm) minimum thickness of base (uncoated) metal, accurately positioned and secured behind at least 1 gypsum base for veneer plaster **OR** gypsum board **OR** cementitious backer unit, **as directed**, face-layer panel.
4. Integrate stair hanger rods with gypsum board shaft-wall assemblies by locating cavity of assemblies where required to enclose rods.
5. At penetrations in shaft wall, maintain fire-resistance rating of shaft-wall assembly by installing supplementary steel framing around perimeter of penetration and fire protection behind boxes containing wiring devices, elevator call buttons, elevator floor indicators, and similar items.
6. Isolate perimeter of gypsum panels from building structure to prevent cracking of panels, while maintaining continuity of fire-rated construction.
7. Firestop Tracks: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.
8. Control Joints: Install control joints at locations indicated on Drawings **OR** according to ASTM C 840 and in specific locations approved by the Owner, **as directed**, while maintaining fire-resistance rating of gypsum board shaft-wall assemblies.
9. Seal gypsum board shaft walls with acoustical sealant at perimeter of each assembly where it abuts other work and at joints and penetrations within each assembly. Install acoustical sealant to withstand dislocation by air-pressure differential between shaft and external spaces; maintain an airtight and smoke-tight seal; and comply with ASTM C 919 requirements or with manufacturer's written instructions, whichever are more stringent.
10. In elevator shafts where gypsum board shaft-wall assemblies cannot be positioned within 4 inches (102 mm) of the shaft face of structural beams, floor edges, and similar projections into shaft, install 1/2- or 5/8-inch- (13- or 16-mm-) thick, gypsum board cants covering tops of projections. No recesses allowed (at steel beams especially).



- a. Slope cant panels at least 75 degrees from horizontal. Set base edge of panels in adhesive and secure top edges to shaft walls at 24 inches (610 mm) o.c. with screws fastened to shaft-wall framing.
 - b. Where steel framing is required to support gypsum board cants, install framing at 24 inches (610 mm) o.c. and extend studs from the projection to shaft-wall framing.
11. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3mm) from the plane formed by faces of adjacent framing.

C. Protection

1. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
2. Remove and replace panels that are wet, moisture damaged, or mold damaged.
 - a. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
 - b. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION 09 85 00 00b



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SECTION 10 44 13 00 - FIRE PROTECTION CABINETS

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for fire extinguisher cabinets. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Fire protection cabinets for the following:
 - 1) Portable fire extinguishers.
 - 2) Fire hose valves.
 - 3) Fire hoses and racks.

C. Submittals

1. Product Data: For each type of product indicated.
2. Show location of knockouts for hose valves.
3. Shop Drawings: For fire protection cabinets. Include plans, elevations, sections, details, and attachments to other work.
4. Samples: For each type of fire protection cabinet indicated.
5. Maintenance Data.

D. Quality Assurance

1. Fire-Rated, Fire Protection Cabinets: Listed and labeled to comply with requirements in ASTM E 814 for fire-resistance rating of walls where they are installed.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Coordination

1. Coordinate size of fire protection cabinets to ensure that type and capacity of fire extinguishers indicated are accommodated.
2. Coordinate size of fire protection cabinets to ensure that type and capacity of fire hoses, hose valves, and hose racks indicated are accommodated.
3. Coordinate sizes and locations of fire protection cabinets with wall depths.

F. Sequencing

1. Apply decals **OR** vinyl lettering, **as directed**, on field-painted, fire protection cabinets after painting is complete.

1.2 PRODUCTS

A. Materials

1. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B.
2. Aluminum: Alloy and temper recommended by aluminum producer and manufacturer for type of use and finish indicated, and as follows:
 - a. Sheet: ASTM B 209 (ASTM B 209M).
 - b. Extruded Shapes: ASTM B 221 (ASTM B 221M).
3. Stainless-Steel Sheet: ASTM A 666, Type 304.
4. Copper-Alloy Brass Sheet: ASTM B 36/B 36M, alloy UNS No. C26000 (cartridge brass, 70 percent copper).



5. Copper-Alloy Bronze Sheet: ASTM B 36/B 36M, alloy UNS No. C28000 (muntz metal, 60 percent copper).
6. Clear Float Glass: ASTM C 1036, Type I, Class 1, Quality q3, 3 **OR** 6, **as directed**, mm thick.
7. Tempered Float Glass: ASTM C 1048, Kind FT, Condition A, Type I, Quality q3, 3 mm thick, Class 1 (clear) **OR** Class 2 (tinted, heat absorbing, and light reducing), bronze tint, **as directed**.
8. Break Glass: Clear annealed float glass, ASTM C 1036, Type I, Class 1, Quality q3, 1.5 mm thick, single strength.
9. Tempered Break Glass: ASTM C 1048, Kind FT, Condition A, Type I, Quality q3, 1.5 mm thick.
10. Wire Glass: ASTM C 1036, Type II, Class 1, Form 1, Quality q8, Mesh m1 (diamond), 6 mm thick.
11. Transparent Acrylic Sheet: ASTM D 4802, Category A-1 (cell-cast sheet), 1.5 **OR** 3 **OR** 6, **as directed**, mm thick, with Finish 1 (smooth or polished) **OR** Finish 2 (patterned, textured), **as directed**.
12. Acrylic Bubble: One piece.

B. Fire Protection Cabinet

1. Cabinet Type: Suitable for fire extinguisher **OR** extinguisher and hose valve **OR** hose, rack, valve, and extinguisher **OR** hose, rack, and valve **OR** hose valve, **as directed**.
2. Cabinet Construction: Nonrated **OR** 1-hour fire rated **OR** 2-hour fire rated, **as directed**.
 - a. Fire-Rated Cabinets: Construct fire-rated cabinets with double walls fabricated from 0.0428-inch- (1.1-mm-) thick, cold-rolled steel sheet lined with minimum 5/8-inch- (16-mm-) thick, fire-barrier material. Provide factory-drilled mounting holes.
3. Cabinet Material: Steel **OR** Aluminum **OR** Stainless-steel, **as directed**, sheet.
 - a. Shelf: Same metal and finish as cabinet.
4. Recessed Cabinet: Cabinet box recessed in walls of sufficient depth to suit style of trim indicated.
 - a. Trimless with Concealed Flange: Surface of surrounding wall finishes flush with exterior finished surface of cabinet frame and door, without overlapping trim attached to cabinet. Provide recessed flange, of same material as box, attached to box to act as plaster stop **OR** drywall bead, **as directed**.
 - b. Trimless with Hidden Flange: Flange of same metal and finish as box overlaps surrounding wall finish and is concealed from view by an overlapping door.
 - c. Exposed Flat Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend).
5. Semirecessed Cabinet: Cabinet box partially recessed in walls of sufficient depth to suit style of trim indicated; with one-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend). Provide where walls are of insufficient depth for recessed cabinets but are of sufficient depth to accommodate semirecessed cabinet installation.
 - a. Square-Edge Trim: 1-1/4- to 1-1/2-inch (32- to 38-mm) backbend depth.
 - b. Rolled-Edge Trim: 2-1/2-inch (64-mm) **OR** 4-inch (102-mm) **OR** 4-1/2-inch (114-mm), **as directed**, backbend depth.
6. Surface-Mounted Cabinet: Cabinet box fully exposed and mounted directly on wall with no trim. Provide where walls are of insufficient depth for semirecessed cabinet installation.
7. Cabinet Trim Material: Steel sheet **OR** Aluminum sheet **OR** Extruded-aluminum shapes **OR** Stainless-steel sheet **OR** Copper-alloy brass sheet **OR** Copper-alloy bronze sheet **OR** Same material and finish as door, **as directed**.
8. Door Material: Steel sheet **OR** Aluminum sheet **OR** Extruded-aluminum shapes **OR** Stainless-steel sheet **OR** Copper-alloy brass sheet **OR** Copper-alloy bronze sheet, **as directed**.
9. Door Style: Fully glazed, frameless, backless, acrylic panel **OR** Fully glazed panel with frame **OR** Full bubble, frameless **OR** Full bubble with frame **OR** Full bubble with frameless, rotating turntable **OR** Horizontal duo panel with frame **OR** Vertical duo panel with frame **OR** Center glass panel with frame **OR** Solid opaque panel with frame **OR** Flush opaque panel, frameless, with no exposed hinges, **as directed**.



10. Door Glazing: Clear float glass **OR** Tempered float glass (clear) **OR** Tempered float glass (bronze tint) **OR** Break glass **OR** Tempered break glass **OR** Wire glass **OR** Mirror glass **OR** Acrylic sheet **OR** Break acrylic bubble **OR** Molded acrylic bubble, **as directed**.
 - a. Acrylic Sheet Color: Clear **OR** Bronze, **as directed**, transparent acrylic sheet.
 - b. Acrylic Sheet Color: Clear transparent acrylic sheet painted white **OR** red **OR** black, **as directed**, on unexposed side.
 - c. Acrylic Bubble Color: Clear **OR** Bronze **OR** Red, **as directed**, transparent.
 11. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated.
 - a. Provide projecting lever handle with cam-action latch **OR** projecting door pull and friction latch **OR** recessed door pull and friction latch **OR** manufacturer's standard, **as directed**.
 - b. Provide continuous hinge, of same material and finish as trim, **OR** concealed hinge **OR** pivot hinge **OR** manufacturer's standard hinge, **as directed**, permitting door to open 180 degrees.
 12. Accessories:
 - a. Mounting Bracket: Manufacturer's standard steel, designed to secure fire extinguisher to fire protection cabinet, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.
 - b. Break-Glass Strike: Manufacturer's standard metal strike, complete with chain and mounting clip, secured to cabinet.
 - c. Lettered Door Handle: One-piece, cast-iron door handle with the word "FIRE" embossed into face.
 - d. Door Lock: Cam lock that allows door to be opened during emergency by pulling sharply on door handle **OR** Cylinder lock, keyed alike to other cabinets, **as directed**.
 - e. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as directed.
 - 1) Identify fire extinguisher in fire protection cabinet with the words "FIRE EXTINGUISHER."
 - a) Location: Applied to cabinet door **OR** cabinet glazing **OR** location indicated on Drawings, **as directed**.
 - b) Application Process: Silk-screened **OR** Engraved **OR** Etched **OR** Decals **OR** Pressure-sensitive vinyl letters, **as directed**.
 - c) Lettering Color: Red **OR** Black **OR** White, **as directed**.
 - d) Orientation: Vertical **OR** Horizontal **OR** As indicated on Drawings, **as directed**.
 - f. Alarm: Manufacturer's standard alarm that actuates when fire protection cabinet door is opened and that is powered by batteries **OR** low voltage, complete with transformer, **as directed**.
 13. Finishes:
 - a. Manufacturer's standard baked-enamel paint for the following:
 - 1) Exterior of cabinet door **OR** trim, **OR** door, and trim, **as directed**, except for those surfaces indicated to receive another finish.
 - 2) Interior of cabinet and door, **as directed**.
 - b. Aluminum: Clear anodic **OR** Color anodic **OR** Baked enamel or powder coat, **as directed**.
 - c. Steel: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - d. Stainless Steel: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.
 - e. Copper Alloy, Brass: Buffed **OR** Hand rubbed **OR** Hand rubbed, lacquered **OR** Medium satin **OR** Fine matte **OR** Statuary conversion **OR** Patina conversion, **as directed**.
 - f. Copper Alloy, Bronze: Buffed **OR** Hand rubbed **OR** Hand rubbed, lacquered **OR** Medium satin **OR** Fine matte **OR** Statuary conversion **OR** Patina conversion, **as directed**.
- C. Security Fire Protection Cabinet
1. Cabinet Type: Suitable for fire extinguisher **OR** extinguisher and hose valve **OR** hose, rack, valve, and extinguisher **OR** hose, rack, and valve **OR** hose valve, **as directed**.
 2. Cabinet Construction: Nonrated **OR** 1-hour fire rated **OR** 2-hour fire rated, **as directed**.



- a. Fire-Rated Cabinets: Construct fire-rated cabinets with double walls lined with minimum 5/8-inch- (16-mm-) thick, fire-barrier material.
3. Cabinet Material: 0.0677-inch- (1.7-mm-) thick steel **OR** 0.0966-inch- (2.5-mm-) thick steel **OR** 0.0781-inch- (2.0-mm-) thick, stainless-steel, **as directed**, sheet.
 - a. Shelf: Same metal and finish as cabinet.
4. Recessed Cabinet: Cabinet box recessed in walls of sufficient depth to suit style of trim indicated.
 - a. Exposed Flat Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend).
5. Semirecessed Cabinet: Cabinet box partially recessed in walls of sufficient depth to suit style of trim indicated; with one-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend). Provide where walls are of insufficient depth for recessed cabinets but are of sufficient depth to accommodate semirecessed cabinet installation.
 - a. Square-Edge Trim: 1-1/4- to 1-1/2-inch (32- to 38-mm) backbend depth.
 - b. Rolled-Edge Trim: 2-1/2-inch (64-mm) backbend depth.
6. Surface-Mounted Cabinet: Cabinet box fully exposed and mounted directly on wall; with no trim. Provide where walls are of insufficient depth for semirecessed cabinet installation.
7. Cabinet Trim Material: Steel sheet **OR** Stainless-steel sheet **OR** Same material and finish as door, **as directed**.
8. Door Material: 0.0966-inch- (2.5-mm-) thick steel **OR** 0.0781-inch- (2.0-mm-) thick, stainless-steel **OR** 0.1094-inch- (2.8-mm-) thick, stainless-steel, **as directed**, sheet.
9. Door Style: Solid opaque panel with frame.
10. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated, and as follows:
 - a. Recessed door pull.
 - b. Continuous Hinge: Same material and finish as trim, permitting door to open 180 degrees.
 - c. Mechanical Deadlock: Lockbolt retracted and extended by five-tumbler paracentric **OR** mogul, **as directed**, cylinder; keyed one side.
 - 1) Lockbolt: 1-1/2 inches high by 3/4 inch (38 mm high by 19 mm) thick; 5/8-inch (16-mm) throw.
 - d. Mechanical Deadlock: As specified in Division 08 Section "Detention Door Hardware".
 - e. Mechanical Snaplatch: Automatic snaplatch when closed; latchbolt retracted by five-tumbler paracentric **OR** mogul, **as directed**, cylinder; keyed one side.
 - 1) Lockbolt: 1 inch high by 7/16 inch (25 mm high by 11 mm) thick; 5/16-inch (8-mm) throw.
 - f. Mechanical Snaplatch: As specified in Division 08 Section "Detention Door Hardware".
11. Accessories:
 - a. Mounting Bracket: Manufacturer's standard steel, designed to secure fire extinguisher to security fire protection cabinet, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.
 - b. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as directed.
 - 1) Identify fire extinguisher in security fire protection cabinet with the words "FIRE EXTINGUISHER."
 - a) Location: Applied to cabinet door **OR** location indicated on Drawings, **as directed**.
 - b) Application Process: Silk-screened **OR** Engraved **OR** Etched **OR** Decals **OR** Pressure-sensitive vinyl letters, **as directed**.
 - c) Lettering Color: Red **OR** Black **OR** White, **as directed**.
 - d) Orientation: Vertical **OR** Horizontal **OR** As indicated on Drawings, **as directed**.
 - c. Keys to Door Locks: Three per lock.
12. Finishes:
 - a. Manufacturer's standard baked-enamel paint for the following:



- 1) Exterior of cabinet door **OR** trim, **OR** door, and trim, **as directed**, except for those surfaces indicated to receive another finish.
 - 2) Interior of cabinet and door, **as directed**.
 - b. Steel: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - c. Stainless Steel: No. 4 finish.
- D. Fabrication
1. Fire Protection Cabinets: Provide manufacturer's standard box (tub) with trim, frame, door, and hardware to suit cabinet type, trim style, and door style indicated.
 - a. Weld joints and grind smooth.
 - b. Provide factory-drilled mounting holes.
 - c. Prepare doors and frames to receive locks.
 - d. Install door locks at factory.
 2. Cabinet Doors: Fabricate doors according to manufacturer's standards, from materials indicated and coordinated with cabinet types and trim styles selected.
 - a. Fabricate door frames with tubular stiles and rails and hollow-metal design, minimum 1/2 inch (13 mm) thick.
 - b. Fabricate door frames of one-piece construction with edges flanged.
 - c. Miter and weld perimeter door frames.
 3. Cabinet Trim: Fabricate cabinet trim in one piece with corners mitered, welded, and ground smooth.
- E. General Finish Requirements
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 2. Protect mechanical finishes on exposed surfaces of fire protection cabinets from damage by applying a strippable, temporary protective covering before shipping.
 3. Finish fire protection cabinets after assembly.
 4. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- F. Aluminum Finishes
1. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
 2. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - a. Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black, **as directed**.
 - b. Color: As selected from full range of industry colors and color densities, **as directed**.
 3. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
- G. Steel Finishes
1. Surface Preparation: Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning" **OR** SSPC-SP 8, "Pickling", **as directed**. After cleaning, apply a conversion coating suited to the organic coating to be applied over it, **as directed**.
 2. Factory Prime Finish: Apply manufacturer's standard, fast-curing, lead- and chromate-free, universal primer immediately after surface preparation and pretreatment.
 3. Baked-Enamel or Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).



- a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

H. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - c. Directional Satin Finish: No. 4.
 - d. Dull Satin Finish: No. 6.
 - e. Reflective, Directional Polish: No. 7.
 - f. Mirrorlike Reflective, Nondirectional Polish: No. 8.
3. Bright, Cold-Rolled, Unpolished Finish: No. 2B.

I. Copper-Alloy Finishes

1. Buffed Finish, Lacquered: M21-O6x (Mechanical Finish: buffed, smooth specular; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in 2 coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
2. Hand-Rubbed Finish, Lacquered: M31-M34-O6x (Mechanical Finish: directionally textured, fine satin; Mechanical Finish: directionally textured, hand rubbed; Coating: clear organic, air drying, as specified below).
 - a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in 2 coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
3. Statuary Conversion Coating over Satin Finish: M31-C55 (Mechanical Finish: directionally textured, fine satin; Chemical Finish: conversion coating, sulfide).
 - a. Color: Match sample.
4. Patina Conversion Coating: CDA-M36-C12-C52 (Mechanical Finish: directionally textured, uniform; Chemical Finish: nonetched cleaned, degreased; Chemical Finish: conversion coating, ammonium sulfate).
 - a. Color: Match sample.

1.3 EXECUTION

A. Preparation

1. Prepare recesses for recessed and semirecessed fire protection cabinets as required by type and size of cabinet and trim style.

B. Installation

1. General: Install fire protection cabinets in locations and at mounting heights indicated or, if not indicated, at heights indicated below: or, if not indicated, at heights acceptable to authorities having jurisdiction.
 - a. Fire Protection Cabinets: 54 inches (1372 mm) above finished floor to top of cabinet.
2. Fire Protection Cabinets: Fasten cabinets to structure, square and plumb.
 - a. Unless otherwise indicated, provide recessed fire protection cabinets. If wall thickness is not adequate for recessed cabinets, provide semirecessed fire protection cabinets.
 - b. Provide inside latch and lock for break-glass panels.
 - c. Fasten mounting brackets to inside surface of fire protection cabinets, square and plumb.
 - d. Fire-Rated, Hose and Valve **OR** Hose-Valve, **as directed**, Cabinets:
 - 1) Install cabinet with not more than 1/16-inch (1.6-mm) tolerance between pipe OD and knockout OD. Center pipe within knockout.



- 2) Seal through penetrations with firestopping sealant as specified in Division 07 Section "Penetration Firestopping".
 3. Identification: Apply decals **OR** vinyl lettering, **as directed**, at locations indicated.
- C. Adjusting And Cleaning
1. Remove temporary protective coverings and strippable films, if any, as fire protection cabinets are installed unless otherwise indicated in manufacturer's written installation instructions.
 2. Adjust fire protection cabinet doors to operate easily without binding. Verify that integral locking devices operate properly.
 3. On completion of fire protection cabinet installation, clean interior and exterior surfaces as recommended by manufacturer.
 4. Touch up marred finishes, or replace fire protection cabinets that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by fire protection cabinet and mounting bracket manufacturers.
 5. Replace fire protection cabinets that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 10 44 13 00



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SECTION 10 44 16 13 - FIRE EXTINGUISHERS

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for fire extinguishers. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes portable, hand-carried and wheeled fire extinguishers and mounting brackets for fire extinguishers.
2. Owner-Furnished Material: Hand-carried **OR** Wheeled, **as directed**, fire extinguishers.

C. Submittals

1. Product Data: For each type of product indicated.
2. Operation and maintenance data.
3. Warranty: Sample of special warranty.

D. Quality Assurance

1. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."
2. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.
3. Preinstallation Conference: Conduct conference at Project site.
4. Coordinate type and capacity of fire extinguishers with fire protection cabinets to ensure fit and function.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within six years from date of Final Completion.
 - a. Failures include, but are not limited to, the following:
 - 1) Failure of hydrostatic test according to NFPA 10.
 - 2) Faulty operation of valves or release levers.

1.2 PRODUCTS

A. Portable, Hand-Carried Fire Extinguishers

1. Fire Extinguishers: Type, size, and capacity for each fire protection cabinet **OR** mounting bracket **OR** fire protection cabinet and mounting bracket, **as directed**, indicated.
 - a. Valves: Manufacturer's standard **OR** Nickel-plated, polished brass body, **as directed**.
 - b. Handles and Levers: Manufacturer's standard **OR** Stainless steel, **as directed**.
 - c. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B and bar coding for documenting fire extinguisher location, inspections, maintenance, and recharging.
2. Stored-Pressure Water Type: UL-rated 2-A, 2.5-gal. (9.5-L) nominal capacity, with water in stainless-steel container; with pressure-indicating gage.
3. Stored-Pressure Antifreeze Water Type: UL-rated 2-A, 2.5-gal. (9.5-L) nominal capacity, with water and approved antifreeze solution mixed for temperatures as low as minus 40 deg F (minus 40 deg C) in stainless-steel container; with pressure-indicating gage.



4. Stored-Pressure Water-Mist Type: UL-rated 2-A:C, 2.5-gal. (9.5-L) nominal capacity, with water in enameled-steel container; with pressure-indicating gage.
5. Pressurized, AFFF-Foam Type: UL-rated 2-A:10-B, 1.6-gal. (6-L) **OR** 3-A:20-B, 2.5-gal. (9.5-L), **as directed**, nominal capacity, with AFFF foam in stainless-steel container; with pressure-indicating gage.
6. Pressurized, FFFP-Foam Type: UL-rated 3-A:20-B, 2.5-gal. (9.5-L) nominal capacity, with FFFP foam in stainless-steel container; with pressure-indicating gage.
7. Wet-Chemical Type: UL-rated 2-A:1-B:C:K, 1.6-gal. (6-L) **OR** 2.5-gal. (9.5-L), **as directed**, nominal capacity, with potassium acetate-based **OR** citrate-based **OR** carbonate-based, **as directed**, chemical in stainless-steel container; with pressure-indicating gage.
8. Regular Dry-Chemical Type: UL-rated <Insert capacity> nominal capacity, with sodium bicarbonate-based dry chemical in manufacturer's standard enameled container.
9. Regular Dry-Chemical Type in Steel Container: UL-rated 2-B:C, 1-lb (0.4-kg) **OR** 10-B:C, 2.5-lb (1.1-kg) **OR** 10-B:C, 5-lb (2.3-kg) **OR** 40-B:C, 5.5-lb (2.5-kg) **OR** 40-B:C, 6-lb (2.7-kg) **OR** 60-B:C, 10-lb (4.5-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with sodium bicarbonate-based dry chemical in enameled-steel container.
10. Regular Dry-Chemical Type in Aluminum Container: UL-rated 2-B:C, 1-lb (0.4-kg) **OR** 10-B:C, 2.5-lb (1.1-kg) **OR** 10-B:C, 5-lb (2.3-kg) **OR** 40-B:C, 5.5-lb (2.5-kg) **OR** 60-B:C, 10-lb (4.5-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with sodium bicarbonate-based dry chemical in enameled-aluminum container.
11. Regular Dry-Chemical Type in Brass Container: UL-rated 40-B:C, 6-lb (2.7-kg) **OR** 60-B:C, 10-lb (4.5-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with sodium bicarbonate-based dry chemical in chrome-plated brass container.
12. Multipurpose Dry-Chemical Type: UL-rated <Insert capacity> nominal capacity, with monoammonium phosphate-based dry chemical in manufacturer's standard enameled container.
13. Multipurpose Dry-Chemical Type in Steel Container: UL-rated 1-A:10-B:C, 2.5-lb (1.1-kg) **OR** 2-A:10-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 6-lb (2.7-kg) **OR** 4-A:60-B:C, 10-lb (4.5-kg) **OR** 20-A:120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with monoammonium phosphate-based dry chemical in enameled-steel container.
14. Multipurpose Dry-Chemical Type in Aluminum Container: UL-rated 1-A:10-B:C, 2.5-lb (1.1-kg) **OR** 2-A:10-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 6-lb (2.7-kg) **OR** 4-A:60-B:C, 10-lb (4.5-kg) **OR** 20-A:120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with monoammonium phosphate-based dry chemical in enameled-aluminum container.
15. Multipurpose Dry-Chemical Type in Brass Container: UL-rated 2-A:10-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 6-lb (2.7-kg) **OR** 4-A:60-B:C, 10-lb (4.5-kg) **OR** 4-A:80-B:C, 10-lb (4.5-kg) **OR** 20-A:120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with monoammonium phosphate-based dry chemical in chrome-plated brass container.
16. Purple-K Dry-Chemical Type in Aluminum Container: UL-rated 10-B:C, 2.5-lb (1.1-kg) **OR** 30-B:C, 5-lb (2.3-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with potassium bicarbonate-based dry chemical in enameled-aluminum container.
17. Purple-K Dry-Chemical Type in Brass Container: UL-rated 80-B:C, 10-lb (4.5-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with potassium bicarbonate-based dry chemical in chrome-plated brass container.
18. Carbon Dioxide Type: UL-rated 5-B:C, 5-lb (2.3-kg) **OR** 10-B:C, 10-lb (4.5-kg) **OR** 10-B:C, 15-lb (6.8-kg) **OR** 10-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with carbon dioxide in manufacturer's standard enameled-metal **OR** enameled-steel **OR** enameled-aluminum, **as directed** container.
19. Dry-Powder Type: FMG-approved, **as directed**, UL-rated Class D, 30-lb (13.6-kg) nominal capacity, with sodium chloride-based **OR** copper-based, **as directed**, powder in enameled-steel container; with pressure-indicating gage.
20. Halon Type: UL-rated 5-B:C, 2.5-lb (1.1-kg) **OR** 10-B:C, 5-lb (2.3-kg), **as directed**, nominal capacity, in enameled-steel container; with pressure-indicating gage.
21. Clean-Agent Type in Aluminum Container: UL-rated 1-B:C, 1.4-lb (0.6-kg) **OR** 2-B:C, 2.5-lb (1.1-kg) **OR** 5-B:C, 5-lb (2.3-kg), **as directed**, nominal capacity, with HCFC Blend B agent and inert material in enameled-aluminum container; with pressure-indicating gage.



22. Clean-Agent Type in Brass Container: UL-rated 1-A:10-B:C, 11-lb (5-kg) **OR** 2-A:10-B:C, 15.5-lb (7-kg), **as directed**, nominal capacity, with HCFC Blend B agent and inert material in chrome-plated brass container; with pressure-indicating gage.
23. Clean-Agent Type in Steel Container: UL-rated 5-B:C, 4.75-lb (2.2-kg) **OR** 1-A:10-B:C, 10-lb (4.5-kg) **OR** 2-A:10-B:C, 14-lb (6.4-kg), **as directed**, nominal capacity, with HFC blend agent and inert material in enameled-steel container; with pressure-indicating gage.

B. Mounting Brackets

1. Mounting Brackets: Manufacturer's standard galvanized, **as directed**, steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or red **OR** black, **as directed**, baked-enamel finish.
2. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location.
 - a. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.
 - 1) Orientation: Vertical **OR** Horizontal, **as directed**.

C. Wheeled Fire Extinguishers

1. Wheeled Fire Extinguishers: Type, size, and capacity for locations indicated, complete with carriage.
 - a. Carriage: Fabricated from enameled-steel pipe, complete with hanger assembly, long-range nozzle, hose, and semipneumatic solid-rubber tires **OR** wide-rim wheels, **as directed**.
 - 1) Hose: 15 feet (4.6 m) **OR** 50 feet (15.2 m) **OR** 100 feet (30.5 m), **as directed**.
2. Pressurized, FFFP-Foam Type: UL-rated 20-A:160-B, 33-gal. (125-L) nominal capacity, with FFFP foam in stainless-steel container.
3. Regular Dry-Chemical Type: UL-rated 160-B:C, 50-lb (23-kg) **OR** 240-B:C, 150-lb (68-kg) **OR** 160-B:C, 250-lb (113-kg), **as directed**, nominal capacity, with sodium bicarbonate-based dry chemical in regulated-pressure **OR** stored-pressure **OR** direct-pressure, **as directed**, enameled-steel container.
4. Multipurpose Dry-Chemical Type: UL-rated 20-A:160-B:C, 30-lb (13.6-kg) **OR** 30-A:160-B:C, 50-lb (23-kg) **OR** 40-A:240-B:C, 125-lb (57-kg) **OR** 40-A:160-B:C, 250-lb (113-kg), **as directed**, nominal capacity, with monoammonium phosphate-based dry chemical in regulated-pressure **OR** stored-pressure **OR** direct-pressure, **as directed**, enameled-steel **OR** enameled-aluminum, **as directed**, container.
5. Purple-K Dry-Chemical Type: UL-rated 160-B:C, 50-lb (23-kg) **OR** 320-B:C, 125-lb (57-kg) **OR** 160-B:C, 250-lb (113-kg), **as directed**, nominal capacity, with potassium bicarbonate-based dry chemical in regulated-pressure **OR** stored-pressure **OR** direct-pressure, **as directed**, enameled-steel container.
6. Carbon Dioxide Type: UL-rated 20-B:C, 50-lb (23-kg) **OR** 20-B:C, 100-lb (45-kg), **as directed**, nominal capacity, with carbon dioxide in manufacturer's standard enameled-metal **OR** enameled-steel **OR** enameled-aluminum, **as directed**, container.
7. Dry-Powder Type: FMG-approved, **as directed**, UL-rated Class D, sodium chloride-based powder, 150-lb (68-kg) **OR** copper-based powder, 250-lb (113-kg), **as directed**, nominal capacity, in regulated-pressure, enameled-steel container; with pressure-indicating gage.
8. Clean-Agent Type: UL-rated 4-A:40-B:C, 65-lb (29-kg) **OR** 10-A:80-B:C, 150-lb (68-kg), **as directed**, nominal capacity, with HCFC Blend B agent and inert material in stored-pressure, enameled-steel container; with pressure-indicating gage.

1.3 EXECUTION

A. Installation

1. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.



-
- a. Mounting Brackets: 54 inches (1372 mm) above finished floor to top of fire extinguisher. If NFPA 10 is the governing code, maximum mounting height for fire extinguishers weighing 40 lb (18 kg) or less shall be 60 inches (1524 mm); for those weighing more, maximum mounting height shall be 42 inches (1067 mm).
 2. Mounting Brackets: Fasten mounting brackets to surfaces, square and plumb, at locations indicated.

END OF SECTION 10 44 16 13



Task	Specification	Specification Description
10 44 16 13	01 22 16 00	No Specification Required



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**SECTION 11 21 63 00 - FOOD SERVICE EQUIPMENT**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for food service equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Fabricated equipment.
 - b. Food waste machines.
 - c. Cooking equipment.
 - d. Self-contained refrigeration equipment.
 - e. Walk-in refrigeration equipment.
 - f. Powered food-preparation equipment.
 - g. Warewashing equipment.
 - h. Serving equipment.
 - i. Utility distribution systems.
2. Owner-Furnished Equipment: Where indicated, the Owner will furnish equipment for installation by Contractor.

C. Submittals

1. Product Data: For each type of product indicated. Include the following:
 - a. Manufacturer's model number.
 - b. Accessories and components that will be included for Project.
 - c. Clearance requirements for access and maintenance.
 - d. Utility service connections for water, drainage, power, and fuel; include roughing-in dimensions.
2. Shop Drawings: For fabricated equipment. Include plans, elevations, sections, roughing-in dimensions, fabrication details, utility service requirements, and attachments to other work.
3. Samples: For each factory-applied color finish required, in manufacturer's standard sizes.
4. Coordination Drawings: For foodservice facilities.
 - a. Indicate locations of foodservice equipment and connections to utilities.
 - b. Key equipment using same designations as indicated on Drawings.
 - c. Include plans and elevations; clearance requirements for equipment access and maintenance; details of equipment supports; and utility service characteristics.
 - d. Include details of seismic bracing for equipment.
5. Operation and Maintenance Data: For foodservice equipment to include in emergency, operation, and maintenance manuals. Include the following:
 - a. Product Schedule: For each foodservice equipment item, include the following:
 - 1) Designation indicated on Drawings.
 - 2) Manufacturer's name and model number.
 - 3) List of factory-authorized service agencies including addresses and telephone numbers.
6. Warranty: Samples of special warranty.

D. Quality Assurance

1. NSF Standards: Provide equipment that bears NSF Certification Mark or UL Classification Mark certifying compliance with applicable NSF standards.
2. BISSC Standards: Provide bakery equipment that complies with BISSC/Z50.2.



- a. Provide BISSC-certified equipment, with certification verified by a third-party agency, **as directed**.
 3. UL Certification: Provide electric and fuel-burning equipment and components that are evaluated by UL for fire, electric shock, and casualty hazards according to applicable safety standards, and that are UL certified for compliance and labeled for intended use.
 4. Steam Equipment: Provide steam-generating and direct-steam heating equipment that is fabricated and labeled to comply with ASME Boiler and Pressure Vessel Code.
 5. Regulatory Requirements: Install equipment to comply with the following:
 - a. ASHRAE 15, "Safety Code for Mechanical Refrigeration."
 - b. NFPA 54, "National Fuel Gas Code."
 - c. NFPA 70, "National Electrical Code."
 - d. NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations."
 6. Seismic Restraints: Comply with SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines," Appendix A, "Seismic Restraint Details," unless otherwise indicated.
 7. Preinstallation Conference: Conduct conference at Project site.
- E. Project Conditions
1. Field Measurements: Verify actual dimensions of construction contiguous with foodservice equipment by field measurements before fabrication. Indicate measurements on Coordination Drawings.
- F. Coordination
1. Coordinate foodservice equipment layout and installation with other work, including layout and installation of lighting fixtures, HVAC equipment, and fire-suppression system components.
 2. Coordinate locations and requirements of utility service connections.
 3. Coordinate sizes, locations, and requirements of the following:
 - a. Overhead equipment supports.
 - b. Equipment bases.
 - c. Floor depressions.
 - d. Insulated floors.
 - e. Floor areas with positive slopes to drains.
 - f. Floor sinks and drains serving foodservice equipment.
 - g. Roof curbs, equipment supports, and penetrations.
- G. Warranty
1. Refrigeration Compressor Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace compressors that fail in materials or workmanship within specified warranty period.
 - a. Failure includes, but is not limited to, inability to maintain set temperature.
 - b. Warranty Period: Five years from date of Final Completion.
- 1.2 PRODUCTS
- A. Fabricated Equipment
1. Stainless-Steel Sinks:
 - a. Description: One **OR** Two **OR** Three **OR** Four, **as directed**,-compartment sink(s). Fabricate units of welded stainless steel, sound deadened.
 - 1) Bowls: Stainless steel, Type 304, 0.078 inch (1.98 mm) **OR** 0.062 inch (1.59 mm), **as directed**, thick.
 - 2) Integral Drainboards: Stainless steel, Type 304, 0.078 inch (1.98 mm) **OR** 0.062 inch (1.59 mm), **as directed**, thick.
 - 3) Body: Stainless steel, Type 304, 0.078 inch (1.98 mm) **OR** Type 304, 0.062 inch (1.59 mm) **OR** Type 430, 0.062 inch (1.59 mm), **as directed**, thick.



- a) Back Splash: Manufacturer's standard height **OR** 13 inches (330 mm) **OR** 18 inches (457 mm), **as directed**.
 - b) Side Splash: Manufacturer's standard height **OR** 13 inches (330 mm) **OR** 18 inches (457 mm), **as directed**.
 - 4) Legs and Feet: Stainless-steel tubing legs with adjustable bullet feet.
 - 5) Accessories:
 - a) Faucets and Spouts: as directed by the Owner.
 - b) Prerinse Faucet: as directed by the Owner.
 - c) Vacuum breaker.
 - d) Lever waste with **OR** without, **as directed**, overflow.
 - e) Basket strainer.
 - f) Continuous waste.
 - g) Scrap trough.
 - h) Control bracket for food waste disposer controls.
 - i) Scrap block and hole.
 - j) Stainless-steel pot rack.
 - b. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
 - c. Fabrication: Prepare sink for installation of the following equipment items:
 - 1) Water heater.
 - 2) Food waste disposer; weld disposer cone or collar into sink.
 - 3) Undercounter dishwasher.
 - d. Stainless-Steel Finish: Directional satin finish, No. 4.
2. Stainless-Steel Tables:
- a. Description: Flat-countertop **OR** Prep **OR** Equipment-stand **OR** Mixer-stand **OR** Dish, **as directed**, table.
 - 1) Tops: Stainless steel, Type 304, 0.078 inch (1.98 mm) **OR** Type 304, 0.062 inch (1.59 mm) **OR** Type 430, 0.062 inch (1.59 mm), **as directed**, thick, reinforced and sound deadened.
 - a) Back Splash: Manufacturer's standard height **OR** 1-1/2 inches (38 mm) **OR** 5 inches (127 mm), **as directed**.
 - b) Edge: Bullnose on four sides **OR** Bullnose on front edge, straight on sides and back **OR** Marine edge, **as directed**.
 - 2) Welded **OR** Adjustable, **as directed**, Undershelf: Stainless steel, Type 304, 0.050 inch (1.27 mm) thick **OR** Metallic-coated steel, 0.052-inch (1.32-mm) nominal thickness, **as directed**.
 - 3) Crossbracing: Stainless-steel **OR** Metallic-coated steel, **as directed**, tubing, bolted **OR** welded, **as directed**, to legs.
 - 4) Cabinet:
 - a) Body: Stainless steel, Type 430, 0.050 inch (1.27 mm) thick.
 - b) Doors: Sliding **OR** Hinged, **as directed**, stainless steel, Type 304, 0.038 inch (0.95 mm) thick.
 - c) Drawers: Stainless-steel drawer and faceplate **OR** Galvanized-steel drawer and stainless-steel faceplate **OR** Stainless-steel front and liner **OR** Stainless-steel front and galvanized-steel liner, **as directed**.
 - 5) Sink: Stainless steel, Type 304, 0.078 inch (1.98 mm) thick, welded into tabletop and including the following:
 - a) Faucet and Spout: as directed by the Owner.
 - b) Vacuum breaker.
 - c) Leverwaste with **OR** without, **as directed**, overflow.
 - d) Basket strainer.
 - e) Tail piece.
 - 6) Legs: Stainless-steel **OR** Metallic-coated steel, **as directed**, tubing.
 - 7) Feet: Stainless-steel adjustable bullets **OR** Plastic adjustable bullets **OR** Stainless-steel, flanged, adjustable bullets **OR** Casters, **as directed**.
 - 8) Accessories:
 - a) Control panel.



- b) Control bracket for food waste disposer controls.
 - c) Aluminum pan rack slides, six **OR** three, **as directed**, slides each.
 - d) Urn trough.
 - e) Spice bins.
- b. Materials:
- 1) Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
 - 2) Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum G90 (Z275) coating.
- c. Fabrication: Prepare table for installation of the following equipment items:
- 1) Food waste disposer; weld disposer cone or collar into sink.
 - 2) Heat lamp.
- d. Stainless-Steel Finish: Directional satin finish, No. 4.
3. Stainless-Steel Shelf Units:
- a. Description: Table mounted, single deck **OR** Table mounted, double deck **OR** Wall mounted, **as directed**. Fabricate units of stainless steel, Type 304, 0.062 inch (1.59 mm) **OR** Type 304, 0.050 inch (1.27 mm) **OR** Type 430, 0.050 inch (1.27 mm), **as directed**, thick.
 - b. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
 - c. Stainless-Steel Finish: Directional satin finish, No. 4.
4. Pot Racks:
- a. Description: Wall mounted **OR** Ceiling hung **OR** Corner, **as directed**. Fabricate units of stainless steel **OR** painted, cold-rolled steel, **as directed**.
 - 1) Bars: Double **OR** Single, **as directed**.
 - 2) Hooks: 18 per unit.
 - b. Materials:
 - 1) Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, Type 304.
 - 2) Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.
 - c. Finishes:
 - 1) Stainless Steel: Directional satin finish, No. 4.
 - 2) Cold-Rolled Steel: Powder-coat painted finish.
5. Stainless-Steel Hand Sinks:
- a. Description: Lavatory sink. Fabricate units of stainless steel, Type 304, 0.050 inch (1.27 mm) **OR** 0.038 inch (0.95 mm), **as directed**, thick.
 - 1) Operation: Electronic **OR** Knee valve **OR** Foot pedal **OR** Wrist handle **OR** Handle, **as directed**.
 - 2) Faucet and Spout: as directed by the Owner.
 - 3) Accessories:
 - a) Chrome-plated tail piece and P trap, NPS 1-1/2 (DN 40), with 0.045-inch (1.1-mm) minimum wall thickness.
 - b) Strainer basket with metal post.
 - c) Liquid soap dispenser, splash **OR** deck, **as directed**, mounted.
 - d) Liquid soap and towel dispenser.
 - e) Towel dispenser.
 - f) Tubular wall supports.
 - g) Skirt assembly for support.
 - h) Side splashes.
 - b. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
 - c. Stainless-Steel Finish: Directional satin finish, No. 4.
6. Floor Troughs **OR** Water Receptacles, **as directed**:
- a. Description: 4-inch (102-mm) **OR** 2-inch (50-mm), **as directed**, nominal depth excluding tailpiece.
 - 1) Body: Stainless steel, Type 304, 0.078 inch (1.98 mm) thick.
 - 2) Grate: Stainless-steel bar, Type 304 **OR** Fiberglass, **as directed**.



- 3) Waste Connection: NPS 3 (DN 80).
 - b. Materials:
 - 1) Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
 - 2) Stainless-Steel Bars: ASTM A 276, austenitic stainless steel, type as indicated.
 - c. Stainless-Steel Finish: Directional satin finish, No. 4.
- B. Food Waste Machines
1. Food Waste Disposer Units:
 - a. Description: 3 **OR** 5 **OR** 7, **as directed**, hp, with dual-direction shredding elements, and the following:
 - 1) Stainless-steel **OR** Corrosion-resistant, **as directed**, housing.
 - 2) Flow control.
 - 3) Solenoid valve.
 - 4) Vacuum breaker.
 - 5) Fixed nozzle.
 - 6) Control Panel:
 - a) Autoreversing and internal timed water flush.
 - b) Stainless-steel mounting bracket.
 - 7) Prerinse: Backsplash mounted with hot- and cold-water mixing valve and with stainless-steel **OR** corrosion-resistant, **as directed**, exposed metal parts and the following:
 - a) Wall support bracket.
 - b) Flexible, 3/8-inch (10-mm) metal-encased hose with a minimum length of 29 inches (737 mm) and supported by spiral spring.
 - c) Spray-head assembly with lockable lever handle.
 - 8) Accessories:
 - a) Collar adaptor for sink **OR** trough, **as directed**.
 - b) Cone with adaptor ring.
 - i. Size: 12 inches (305 mm) **OR** 15 inches (381 mm) **OR** 18 inches (457 mm), **as directed**.
 - c) Cone cover in size that matches cone.
 - d) Silver accumulator.
 - 9) Electrical Service: Equip unit for connection to service indicated on Drawings.
 2. Food Waste Pulper and Water Extractor Systems:
 - a. Description: Stainless-steel pulper unit, extractor unit, and control panel with water-level control and push-button start.
 - 1) Capacity: Not less than 600 lb (272 kg) **OR** 700 lb (318 kg) **OR** 900 lb (408 kg), **as directed**, of waste per hour.
 - 2) Accessories:
 - a) Feed trough connection.
 - b) Feed tray.
 - c) Feed hood assembly.
 - d) Under-dish-table lid.
 - e) Remote Water Extractor:
 - i. Dam, to prevent siphoning of water from pulper tank.
 - ii. Remote piping system, overhead **OR** below floor, **as directed**.
 - 3) Electrical Service: Equip unit for connection to service indicated on Drawings.
 3. Food Waste Grinder and Water Extractor Systems:
 - a. Description: Stainless-steel construction; with off and on controls on unit, food waste hopper, silver saver, internal disposer, removable water extraction auger with internal water sprays, and discharge chute.
 - 1) Capacity: Not less than 600 lb (272 kg) **OR** 700 lb (318 kg), **as directed**, of waste per hour.
 - 2) Accessories:
 - a) Reel rinse unit with spray valve.



- b) Recirculation water pump.
 - c) Trough mount.
 - 3) Electrical Service: Equip unit for connection to service indicated on Drawings.
 - 4. Undercounter Food Waste Grinder and Water Extractors:
 - a. Description: Stainless-steel, undercounter, cleanable assembly including the following:
 - 1) Capacity: Not less than 600 lb (272 kg) **OR** 700 lb (318 kg), **as directed**, of waste per hour.
 - 2) Separate water-extractor and disposer units.
 - a) Disposer: Corrosion-resistant housing, dual-direction shredding elements.
 - 3) Piping between disposer and water extractor.
 - 4) Vacuum breaker.
 - 5) Solenoid valve.
 - 6) Flow control.
 - 7) Time-delayed relay.
 - 8) Control Panel:
 - a) Autoreversing and internal timed water flush.
 - b) Stainless-steel mounting bracket.
 - 9) Prerinse: Backsplash mounted with hot- and cold-water mixing valve and with stainless-steel **OR** corrosion-resistant, **as directed**, exposed metal parts and the following:
 - a) Wall support bracket.
 - b) Flexible, 3/8-inch (10-mm) metal-encased hose with a minimum length of 29 inches (737 mm) and supported by spiral spring.
 - c) Spray-head assembly with lockable lever handle.
 - 10) Accessories:
 - a) Cone with adaptor ring.
 - i. Size: 12 inches (305 mm) **OR** 15 inches (381 mm) **OR** 18 inches (457 mm), **as directed**.
 - b) Cone cover in size that matches cone.
 - c) Silver sorter.
 - d) Trough collar connection.
 - 11) Electrical Service: Equip unit for connection to service indicated on Drawings.
- C. Cooking Equipment
 - 1. Ranges:
 - a. Description:
 - 1) Top Configuration:
 - a) Open-Burner Unit:
 - i. Standard Burners: Four **OR** Six **OR** Eight **OR** Four, step-up type, **as directed**.
 - ii. Wok **OR** Saute, **as directed**, Head: as directed by the Owner.
 - b) Griddle: Flat **OR** Raised, **as directed**.
 - c) Radiant Broiler: as directed by the Owner.
 - 2) Base Configuration:
 - a) Standard Oven(s): One **OR** Two, **as directed**.
 - b) Convection Oven(s): One **OR** Two, **as directed**.
 - c) Storage Base: One.
 - 3) Accessories:
 - a) High **OR** Double-deck, **as directed**, back shelf.
 - b) Stainless-steel sides.
 - c) Stainless-steel back.
 - d) Legs for curb base.
 - e) Toe Base: 4 inches (102 mm) high.
 - f) Casters: as directed by the Owner.
 - g) Oven Rack(s): One for each oven.



- 4) Electrical Service: Equip unit for connection to service indicated on Drawings.
 - 5) Gas Service: Natural **OR** Liquefied propane, **as directed**, gas.
2. Deep Fat Fryers:
- a. Description: Electric fryer, solid-state controls **OR** Electric, programmable computer controls **OR** Gas fryer, **as directed**.
 - 1) Oil Capacity: 40 lb (18 kg) **OR** 85 lb (39 kg), **as directed**.
 - 2) Accessories:
 - a) Stainless-steel sides.
 - b) Stainless-steel fry tank.
 - c) Stainless-steel fry tank cover.
 - d) Casters: as directed by the Owner.
 - e) Automatic basket lifts.
 - f) Single Fry Baskets: as directed by the Owner.
 - g) Twin Fry Baskets: as directed by the Owner.
 - h) Triple Fry Baskets: as directed by the Owner.
 - i) Quick gas-service disconnect and flexible hose.
 - 3) Electrical Service: Equip unit for connection to service indicated on Drawings.
 - 4) Gas Service: Natural **OR** Liquefied propane, **as directed**, gas.
3. Steam Jacketed Kettles:
- a. Description: Stainless steel, Type 304.
 - 1) Type: Stationary **OR** Tilting, **as directed**.
 - 2) Steam Source: Electrically heated, self-contained **OR** Direct, **as directed**.
 - a) Maximum **OR** Operating, **as directed**, Steam Pressure: 50 psig (345 kPa) **OR** 25 psig (172 kPa), **as directed**.
 - 3) Capacity: 10 quarts (9.5 L) **OR** 20 gal. (76 L), **as directed**.
 - 4) Accessories:
 - a) Basket insert.
 - b) Lift-off cover.
 - c) Single **OR** Double, **as directed**, -pantry water filler.
 - d) Tangent Drawoff: 2 inches (50 mm) **OR** 3 inches (76 mm), **as directed**.
 - e) Disc Strainer: 1/8 inch (3 mm), perforated **OR** solid, **as directed**.
 - f) Interior Finish: Manufacturer's standard **OR** Stainless steel, Type 316, **as directed**.
 - g) Cold-water jacket cooling.
 - h) Steam trap assemblies.
 - i) Kettle brush kit.
 - 5) Electrical Service: Equip unit for connection to service indicated on Drawings.
 - b. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
 - c. Stainless-Steel Finish: Directional satin finish, No. 4.
4. Ovens:
- a. Description: Electric convection **OR** Gas convection **OR** Rotisserie, **as directed**.
 - 1) Single deck **OR** Double deck **OR** Single deck with open stand, **as directed**.
 - 2) Accessories:
 - a) Oven Rack(s): One per oven chamber.
 - b) Stainless-steel drip pan.
 - c) Down-draft flue diverter.
 - d) Stacking kit.
 - 3) Electrical Service: Equip unit for connection to service indicated on Drawings.
 - 4) Gas Service: Natural **OR** Liquefied propane, **as directed**, gas.
5. Microwave Ovens:
- a. Description: 1200-W cooking power.
 - 1) Electrical Service: Equip unit with plug and cord for 120-V service.
6. Coffee Urns:
- a. Description: Single **OR** Twin **OR** Triple, **as directed**, urn.
 - 1) Capacity: 3 gal. (11 L) **OR** 6 gal. (23 L) **OR** 10 gal. (38 L), **as directed**, per liner.
 - 2) Type: Electric **OR** Gas **OR** Steam, **as directed**, heated.



- 3) Agitator: Automatic **OR** Push button, **as directed**.
- 4) Spray Arm: With **OR** Without, **as directed**, bypass.
- 5) Timer: Digital **OR** Electromechanical, **as directed**.
- 6) Accessories:
 - a) Fill/Dispense: as directed by the Owner.
 - b) Multiple Faucet: as directed by the Owner.
 - c) Filtering: Permanent, stainless-steel, woven-wire cloth **OR** Disposable filter paper, **as directed**.
 - d) Finish: Manufacturer's standard **OR** Brass body and trim **OR** Copper body and brass trim, **as directed**.
- b. Electrical Service: Equip unit for connection to service indicated on Drawings.
- c. Gas Service: Natural **OR** Liquefied propane, **as directed**, gas.
- d. Operating Steam Pressure: As indicated on Drawings **OR** As directed.

D. Self-Contained Refrigeration Equipment

1. Refrigerators **OR** Freezers, **as directed**:

- a. Description: Reach-in **OR** Roll-in **OR** Pass-through, **as directed**, type.
 - 1) Exterior Finish: Stainless steel.
 - 2) Interior Finish: Stainless steel **OR** Manufacturer's standard, **as directed**.
 - 3) Doors: Full length **OR** Half length **OR** In configuration shown on Drawings, **as directed**.
 - 4) Accessories:
 - a) Casters.
 - b) Stainless-steel back with rear louvers.
 - c) Re-hinging feature for doors.
 - d) Hinged glass doors and fluorescent fixtures.
 - e) Tray Slides: For sheet pans.
 - f) Chrome-Plated **OR** Stainless-Steel, **as directed**, Shelves: Quantity, as directed by the Owner.
 - g) Loading Rack: as directed by the Owner.
 - h) Transfer Carriage: as directed by the Owner.
 - 5) Electrical Service: Equip unit with plug and cord for service indicated on Drawings.

2. Undercounter Refrigerators **OR** Freezers, **as directed**:

- a. Description: Compact unit with rear-mounted, self-contained refrigeration system.
 - 1) Accessories:
 - a) Stainless-steel top with backsplash.
 - b) Stainless-steel back panel.
 - c) Casters: 6 inches (152 mm) **OR** 4 inches (102 mm) **OR** 3-1/2 inches (89 mm), **as directed**, high.
 - d) Utility Base: 6 inches (152 mm) high.
 - e) Shelves: Description and quantity, as directed by the Owner.
 - f) Stacking kit.
 - 2) Electrical Service: Equip unit with plug and cord for service indicated on Drawings.

3. Merchandiser Refrigeration Units:

- a. Description: Curved-glass, self-contained refrigerator **OR** Sliding-glass, self-contained refrigerator **OR** Sliding-glass, self-contained freezer, **as directed**.
 - 1) Exterior Finish: Manufacturer's standard **OR** Stainless steel, **as directed**.
 - 2) Interior Finish: Manufacturer's standard **OR** Stainless steel **OR** White, **as directed**.
 - 3) Accessories:
 - a) Door locks.
 - b) Fluorescent Light Fixtures: Quantity, as directed by the Owner.
 - c) Base: as directed by the Owner.
 - d) Casters: as directed by the Owner.
 - e) Legs: as directed by the Owner.
 - f) Chrome-Plated Shelves: Quantity, as directed by the Owner.



- 4) Electrical Service: Equip unit with plug and cord for service indicated on Drawings.
4. Ice-Making Machine:
 - a. Description: Undercounter **OR** Freestanding, **as directed**, units.
 - 1) Production: Ice cubes **OR** cubes, dice **OR** cubes, half dice **OR** flakes **OR** chiplets (compacted flake ice), **as directed**.
 - 2) Capacity: as directed by The Owner per 24-hour period.
 - 3) Accessories:
 - a) Storage Bin: as directed by the Owner..
 - i. Stainless-steel stand and legs.
 - b) Water filter.
 - 4) Electrical Service: Equip unit for connection to service indicated on Drawings.
- E. Walk-In Refrigeration Equipment
 1. Walk-in Refrigeration Units:
 - a. Description: Cooler **OR** Freezer **OR** Two-compartment unit, with cooler and freezer compartments, **as directed**.
 - 1) Wall and Ceiling Panels: Interlocking insulating panels.
 - 2) Floors: Insulated floor panels **OR** Field installed; provide manufacturer's standard insulated floor screed, **as directed**.
 - 3) Doors:
 - a) Hinges: Two per door **OR** Self-closing and spring loaded; three per door, **As directed**.
 - b) Latch: Edge-mounted, positive-type latch with cylinder lock.
 - c) Include safety-release handle that opens door from inside when door is locked.
 - 4) Door Accessories:
 - a) Vision port.
 - b) Pressure relief port.
 - c) Threshold: Stainless steel, factory installed.
 - d) Anticondensate heater at freezer doors.
 - 5) Vaporproof Lighting Fixtures: Incandescent fixture with 100-W lamp.
 - a) Control: Neon pilot light and toggle switch located on exterior of door panel.
 - b) Quantity: One per compartment, located on door panel.
 - 6) Refrigeration System: Self-contained, mounted on unit **OR** Remote system with preassembled condensing unit and evaporator assemblies.
 - a) Exterior Condensing Units: Include winter control, crankcase heater, and enclosed weatherproof housing.
 - b) Operating Temperature: as directed by the Owner.
 - 7) Temperature Monitoring System: Electronic monitoring and remote audible alarm system that warns when temperatures register 10 deg F (6 deg C) above or below set temperature.
 - 8) Closure Panels and Trim: Include closure panels and trim.
 - 9) Electrical Service: Equip unit for connection to service indicated on Drawings.
 - b. Finishes:
 - 1) Exposed Exterior Finish: Stucco-patterned aluminum **OR** Smooth, mill-finished aluminum **OR** White-painted aluminum, **as directed**.
 - 2) Unexposed Exterior Finish: Stucco-patterned, metallic-coated steel.
 - 3) Interior Finish: Stucco-patterned aluminum **OR** Smooth, mill-finished aluminum **OR** White-painted aluminum, **as directed**.
 - 4) Closure Panels and Trim: Matched to exposed exterior finish of panels.
- F. Powered Food-Preparation Equipment
 1. Mixers **OR** Slicers **OR** Meat Saws **OR** Peelers, **as directed**:
 - a. Description: as directed by the Owner.
 - b. Accessories: as directed by the Owner.
 - c. Electrical Service: Equip unit with plug and cord for service indicated on Drawings.

**G. Warewashing Equipment****1. Warewashing Machines:**

- a. Description: Dishwashing, single tank **OR** Dishwashing, double tank **OR** Dishwashing, rackless conveyor **OR** Dishwashing, with circular conveyor table **OR** Pot and pan washing, two racks **OR OR** Pot and pan washing, one rack, **as directed**.
 - 1) Capacity: as directed by the Owner.
 - 2) Accessories: as directed by the Owner.
 - 3) Electrical Service: Equip unit for connection to service indicated on Drawings.

H. Serving Equipment**1. Modular Counters:**

- a. Description: Hot food **OR** Refrigerated salad **OR** Ice-cooled salad **OR** Sliding-glass door refrigerated **OR** Frost-top **OR** Sandwich **OR** Pizza **OR** Refrigerated-chest **OR** Dual-temperature **OR** Tray-starter **OR** Storage **OR** Cashier, **as directed**, module.
 - 1) Cabinet Face Panels: Manufacturer's standard.
 - 2) Accessories:
 - a) Tray slide.
 - b) Work shelf.
 - c) Casters.
 - d) Electrical receptacle.
 - e) Cam-action latch locks with trigger release to mate with adjoining modular counters.
 - f) Tempered-glass, food-protector shield.
 - 3) Electrical Service: Equip unit for connection to service indicated on Drawings.
 - 4) Color: As selected from manufacturer's full range.

I. Utility Distribution Systems**1. Utility Distribution Systems:**

- a. Description: Overhead **OR** Counter **OR** Island **OR** Tray-slide **OR** Steam **OR** Wall-mounted, **as directed**, system.
- b. Accessories: as directed by the Owner.

J. Miscellaneous Materials

1. Installation Accessories, General: NSF certified for end-use application indicated.
2. Elastomeric Joint Sealant: ASTM C 920; silicone **OR** urethane, **as directed**. Type S (single component), Grade NS (nonsag), Class 25, Use NT (nontraffic) related to exposure, and Use M, G, A, or O as applicable to joint substrates indicated.
 - a. Public Health and Safety Requirements:
 - 1) Sealant is certified for compliance with NSF standards for end-use application indicated.
 - 2) Washed and cured sealant complies with the FDA's regulations for use in areas that come in contact with food.
 - b. Cylindrical Sealant Backing: ASTM C 1330, Type C, closed-cell polyethylene, in diameter greater than joint width.

K. Finishes**1. Stainless-Steel Finishes:**

- a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- b. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1) Run grain of directional finishes with long dimension of each piece.
 - 2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.



2. Powder-Coat Finishes: Immediately after cleaning and pretreating, electrostatically apply manufacturer's standard, baked-polymer, thermosetting powder finish. Comply with resin manufacturer's written instructions for application, baking, and minimum dry film thickness.

1.3 EXECUTION

A. Installation

1. Install foodservice equipment level and plumb, according to manufacturer's written instructions.
 - a. Connect equipment to utilities.
 - b. Provide cutouts in equipment, neatly formed, where required to run service lines through equipment to make final connections.
2. Complete equipment assembly where field assembly is required.
 - a. Provide closed butt and contact joints that do not require a filler.
 - b. Grind field welds on stainless-steel equipment until smooth and polish to match adjacent finish.
3. Install equipment with access and maintenance clearances that comply with manufacturer's written installation instructions and with requirements of authorities having jurisdiction.
4. Install cabinets and similar equipment on bases in a bed of sealant.
5. Install closure-trim strips and similar items requiring fasteners in a bed of sealant.
6. Install joint sealant in joints between equipment and abutting surfaces with continuous joint backing unless otherwise indicated. Produce airtight, watertight, vermin-proof, sanitary joints.

B. Cleaning And Protecting

1. After completing installation of equipment, repair damaged finishes.
2. Clean and adjust equipment as required to produce ready-for-use condition.
3. Protect equipment from damage during remainder of the construction period.

C. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain foodservice equipment.

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**SECTION 11 32 13 00 - UNIT KITCHENS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for unit kitchens. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes factory-fabricated and -assembled unit kitchens with metal, laminate-clad and wood cabinets, countertops, fixtures, appliances, and accessories.

C. Submittals

1. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, finishes, furnished specialties, and accessories. Include rated capacities, operating characteristics, and utility requirements of appliances.
2. LEED Submittals:
 - a. Product Data for Credit EQ 4.4: For composite wood products, documentation indicating that product contains no urea formaldehyde.
 - b. Certificates for Credit MR 7: Chain-of-custody certificates certifying that cabinets and countertops comply with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body. Include statement indicating costs for each certified wood product.
 - c. Product Data for Credit EA 1.4: For appliances, documentation indicating that products are ENERGY STAR rated.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. Wiring Diagrams: For power, signal, and control wiring.
4. Samples: For each type of exposed finish required, prepared on Samples of size indicated below:
 - a. Metal finish for cabinets and countertops, 8 by 10 inches (200 by 250 mm).
 - b. Wood finish for cabinets, 8 by 10 inches (200 by 250 mm).
 - c. Plastic laminate for cabinets and countertops, 8 by 10 inches (200 by 250 mm).
 - d. Solid surfacing for countertops, 6 inches (150 mm) square.
 - e. One full-size unit of each type of exposed hardware.
5. Product Certificates: For each type of unit kitchen, from manufacturer.
6. Manufacturer Certificate: Signed by manufacturer certifying that units comply with requirements.
7. Maintenance Data: For unit kitchen appliances to include in maintenance manuals.
8. Warranty: Sample of special warranty.

D. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer that fabricates unit kitchens and their components.
2. Source Limitations: Obtain unit kitchens from single source from single manufacturer.
3. Regulatory Requirements: Where unit kitchens are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines, ICC/ANSI A117.1 and HUD's "Fair Housing Accessibility Guidelines".
4. Forest Certification: Provide cabinets and countertops made from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.



- a. Built-in Refrigerators: Listed and labeled for recessed installation. Mount label to be visible after installation of unit; include electrical rating, type of refrigerant, and minimum installation clearances.
- b. Refrigerated Unit Kitchens and Wet Bars: Listed and labeled for entire unit as a single integrated system. Mount label to be visible after installation of unit; include electrical rating, type of refrigerant, and minimum installation clearances.
6. Wood and Laminate-Clad Cabinet Fabrication Standard:
 - a. KCMA A161.1. Provide cabinets with KCMA's "Certified Cabinet" seal affixed to a semiexposed location of each unit and showing compliance with standard.
 - b. AWI 400B, Custom grade.
 - c. Either fabrication standard above.
7. Appliance Standards:
 - a. Refrigerators and Freezers: UL 250 or AHAM ER-1.
 - b. Electric Ranges: UL 858 or AHAM HRF-1.
 - c. Microwave Ovens: UL 923.
 - d. Gas-Burning Appliances: ANSI Z21 Series, and certified by CSA International, UL, or another testing and inspecting agency acceptable to authorities having jurisdiction.
8. ENERGY STAR Rating: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.

E. Delivery, Storage, And Handling

1. Deliver factory-assembled units, individually factory packaged and protected. Label with manufacturer's name, product name, and model number.

F. Project Conditions

1. Environmental Limitations: Do not deliver or install unit kitchens until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Field Measurements: Verify actual dimensions of construction contiguous with unit kitchens by field measurements before fabrication.

G. Coordination

1. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of work specified in other Sections to ensure that unit kitchens can be supported and installed as indicated.
2. Coordinate wiring requirements and current characteristics of unit kitchens with building electrical system. See Division 22.
3. Coordinate layout and installation of plumbing, mechanical, and electrical services for unit kitchens.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace hermetically sealed refrigerator compressor system of unit kitchens that fail within specified warranty period.
 - a. Warranty Period: Five years from date of Final Completion.

1.2 PRODUCTS

A. Materials

1. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.



2. Porcelain-Enamel-Finished Steel Sheet: ASTM A 424, enameling-grade steel, uncoated thickness indicated; with exposed face and edges coated with primer, ground coat, and color cover coat; and concealed face coated with primer and ground coat; acid resistant.
3. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.
4. Medium-Density Fiberboard: ANSI A208.2, Grade 130, made with binder containing no urea-formaldehyde resin.
5. Particleboard: ANSI A208.1, Grade M-2 **OR** Grade M-2-Exterior Glue **OR** Grade M-2, made with binder containing no urea-formaldehyde resin, **as directed**.
6. Veneer-Faced Panel Products (Hardwood Plywood): HPVA HP-1, Type I, made with adhesive containing no urea formaldehyde.
7. Solid Wood: Clear hardwood lumber of species indicated, free of defects, selected for compatible grain and color, and kiln dried to 7 percent moisture content.
8. High-Pressure Decorative Laminate: NEMA LD 3.
9. Solid-Surfacing Material: Homogenous solid sheets fabricated from reacted monomers and resins, mineral fillers, and pigments; in thickness indicated; complying with ISSFA-2.
10. Adhesives: Do not use adhesives that contain urea formaldehyde.

B. Metal Cabinets

1. Steel Base Cabinets: Fabricate frames and sides from 0.036-inch (0.91-mm) **OR** 0.030-inch (0.76-mm), **as directed**, nominal-thickness, cold-rolled steel sheet; welded and reinforced with internal gussets and bracing; with baked-enamel finish.
 - a. Door and Drawer Fronts: 0.036-inch (0.91-mm) **OR** 0.030-inch (0.76-mm), **as directed**, nominal-thickness, cold-rolled steel sheet, textured or smooth; welded, reinforced, and sound-deadened; with baked-enamel finish.
OR
Door and Drawer Fronts: 0.038-inch- (0.95-mm-) thick, stainless-steel sheet; welded, reinforced, and sound deadened.
2. Stainless-Steel Base Cabinets: Fabricate frames and sides from 0.038-inch- (0.95-mm-) thick, stainless-steel sheet; welded and reinforced with internal gussets and bracing.
 - a. Door and Drawer Fronts: 0.038-inch- (0.95-mm-) thick, stainless-steel sheet; welded, reinforced, and sound deadened.
3. Undercounter Storage Cabinet: Same material and finish as base cabinets, with adjustable shelf and drawer or with two drawers.
4. Wall Cabinets: Same material and finish as base cabinets, with flush double bottoms and adjustable shelves.
 - a. Wall Shields: Fabricated from textured, cold-rolled steel sheet with baked-enamel finish, color to match cabinets **OR** textured, cold-rolled steel sheet with baked-enamel finish, color to match countertop **OR** stainless-steel sheet, **as directed**. Provide wall shields for back wall and side walls, **as directed**, between countertop splash and wall cabinets.
5. Shelves: Manufacturer's standard rolled-front shelves, fixed **OR** adjustable, **as directed**, of same material and finish as cabinets.
6. Wire Pulls: Brushed-chrome **OR** Polished-chrome **OR** Brushed-brass **OR** Polished-brass, **as directed**, finish.

C. Laminate-Clad Cabinets

1. Framed-Style Base Cabinets:
 - a. Face Frames: 3/4-inch- (19-mm-) thick plywood or solid wood.
 - b. Back Panels: 3/8-inch- (10-mm-) thick particleboard with melamine bonded to inside surface.
 - c. Top, Bottom, and End Panels: 3/8-inch- (10-mm-) thick particleboard with melamine bonded to both sides.
 - d. Door and Drawer Fronts: 3/4-inch- (19-mm-) thick, medium-density fiberboard with 16-mil- (0.4-mm-) thick vinyl film (Thermofoil) bonded to exposed surfaces and melamine bonded to inside surfaces.
OR



- Door and Drawer Fronts: 5/8-inch- (16-mm-) thick particleboard with melamine bonded to both sides.
- e. Drawers: Four sided, with 1/2-inch- (13-mm-) thick particleboard fronts, backs, and sides, and 1/4-inch- (6-mm-) thick particleboard bottom.
 - f. Shelves: 5/8-inch- (16-mm-) thick particleboard with melamine bonded to both sides and PVC edges.
2. Frameless-Style Base Cabinets:
- a. Back Panels: 1/4-inch- (6-mm-) thick plywood or particleboard with melamine bonded to inside surface.
 - b. Top and Bottom Panels: 3/4-inch- (19-mm-) thick particleboard with melamine bonded to both sides.
 - c. End Panels: 5/8-inch- (16-mm-) thick particleboard with melamine bonded to both sides.
 - d. Door and Drawer Fronts: 3/4-inch- (19-mm-) thick plywood with Grade HGS high-pressure decorative laminate bonded to front and edges, and Grade CLS high-pressure decorative laminate bonded to inside surface.
- OR**
- Door and Drawer Fronts: 5/8-inch- (16-mm-) thick particleboard with melamine bonded to both sides.
- OR**
- Door and Drawer Fronts: 5/8-inch- (16-mm-) thick particleboard with melamine bonded to both sides. Provide continuous bevel edge at tops and bottoms of doors and bottom of drawer fronts in wood-grain laminate **OR** solid wood, **as directed**.
- e. Drawers: Four sided, with 1/2-inch- (13-mm-) thick particleboard fronts, backs, and sides, and 1/4-inch- (6-mm-) thick particleboard bottom.
 - f. Shelves: 3/4-inch- (19-mm-) thick particleboard with melamine bonded to both sides and PVC edges.
3. Wall Cabinets: Same material and finish as base cabinets, with adjustable shelves.
- a. Wall Shields: Fabricated from high-pressure decorative laminate of grade and color to match cabinets **OR** high-pressure decorative laminate of grade and color to match countertop **OR** stainless-steel sheet, **as directed**. Provide wall shields for back wall and side walls, **as directed**, between countertop splash and wall cabinets.
4. Scribe Strips for Recessed Cabinets: Same material, finish, and color as cabinet.
5. Wire Pulls: Brushed-chrome **OR** Polished-chrome **OR** Brushed-brass **OR** Polished-brass, **as directed**, finish.
- D. Wood Cabinets
1. Base Cabinets: Birch **OR** Maple **OR** Oak **OR** Cherry **OR** Ash, **as directed**.
 - a. Face Frames: 3/4-inch- (19-mm-) thick, hardwood-veneer plywood or solid wood.
 - b. Back Panels: 3/8-inch- (10-mm-) thick particleboard with melamine bonded to inside surface.
 - c. Top, Bottom, and End Panels: 3/8-inch- (10-mm-) thick particleboard with melamine bonded to both sides.
 - d. Shelves: 5/8-inch- (16-mm-) thick particleboard with melamine bonded to both sides and PVC edges.
 - e. Door and Drawer Fronts: 5/8-inch- (16-mm-) thick, hardwood-veneer plywood with matching hardwood edges.

OR

Door and Drawer Fronts: 3/4-inch- (19-mm-) thick, solid wood stiles and rails, with solid wood center panels.
2. Wall Cabinets: Same material and finish as base cabinets, with adjustable shelves.
 - a. Wall Shields: Fabricated from high-pressure decorative laminate of grade and color to match countertop **OR** stainless-steel sheet, **as directed**. Provide wall shields for back wall and side walls, **as directed**, between countertop splash and wall cabinets.
 3. Scribe Strips for Recessed Cabinets: Same material, finish, and color as cabinet.



4. Wire Pulls: Brushed-chrome **OR** Polished-chrome **OR** Brushed-brass **OR** Polished-brass, **as directed**, finish.
- E. Countertops
1. Countertop and Integral Sink: Seamless, one-piece countertop and sink with integral embossed drainboard and backsplash and side splashes, **as directed**.
 - a. Stainless Steel: 0.038-inch- (0.95-mm-) thick sheet bonded to 3/4-inch (19-mm) plywood.
 - b. Porcelain-Enamel-Finished Steel: 0.0677 inch (1.7 mm) thick.
 - c. Solid-Surfacing Material: Minimum 1/2 inch (13 mm) thick.
 2. Countertop **OR** Countertop for Drop-in Sink, **as directed**: Seamless, one-piece countertop with integral backsplash and side splashes, **as directed**.
 - a. Stainless Steel: 0.038-inch- (0.95-mm-) thick sheet bonded to 3/4-inch (19-mm) plywood.
 - b. High-Pressure Decorative Laminate: Grade HGS, bonded to 3/4-inch (19-mm) plywood.
OR
High-Pressure Decorative Laminate: Grade HGP, post formed, bonded to 3/4-inch (19-mm) particleboard with Grade BKL unfinished backing sheet bonded to reverse side.
 3. Countertop **OR** Countertop for Undercounter-Mounted Sink, **as directed**: Seamless, one-piece countertop with integral backsplash and side splashes, **as directed**; fabricated from 1/2-inch- (13-mm-) thick, solid-surfacing material.
- F. Fixtures
1. Stainless-Steel Drop-in Sinks: 0.050 inch (1.27 mm) **OR** 0.038 inch (0.95 mm), **as directed**, thick; seamless; single compartment.
 2. Porcelain-Enamel-Finished Steel Drop-in Sinks: 0.043 inch (1.09 mm) thick; seamless; single compartment.
 3. Undercounter-Mounted Sinks: Solid-surfacing material; seamless; single compartment.
 4. Supplies: NPS 3/8 (DN 12) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated copper with stops.
 5. Sink Faucet: Single-lever control; polished chrome-plated mixing **OR** European-style, pull-out spray, **as directed**, faucet with limited-swing spout and aerator.
OR
Sink Faucet: Separate hot and cold controls with wrist-blade handles, **as directed**; polished chrome-plated mixing faucet with limited-swing spout **OR** gooseneck spout, **as directed**, and aerator.
 6. Sink Outlet with Disposer: 3-1/2-inch- (89-mm-) diameter outlet.
 7. Sink Outlet without Disposer: 3-1/2-inch- (89-mm-) diameter outlet with stainless-steel cup strainer and 1-1/2-inch- (38-mm-) diameter tailpiece.
 8. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated cast-brass trap, tubular brass waste to wall, and wall escutcheon.
 9. Bar Sink Outlet: 2-inch- (51-mm-) diameter outlet with stainless-steel grid strainer.
 10. Disposers: Continuous-feed, household, food-waste disposers. Include 115-V ac, 1725-rpm, 1/2-hp motor with overload protection and reset button; three-conductor, grounded power cord; wall switch; corrosion-resistant chamber with jam-resistant, cutlery- or stainless-steel grinder or shredder; NPS 1-1/2 (DN 40) outlet; quick-mounting, stainless-steel sink flange; antisplash guard; and combination cover/stopper.
 11. Hot-Water Dispensers: Household type with instant on-off control; insulated, corrosion-resistant-metal storage tank that is open to atmosphere; electric, 115-V ac, heating element; three-conductor, grounded power cord; chrome-plated faucet or spout; removable strainer; thermostat control for water temperature up to 190 deg F (88 deg C); thermal-overload protection; and minimum 1/2-gal. (1.9-L) tank capacity dispensing approximately 60 cups (240 mL) of water per hour.
- G. Appliances
1. Built-in Refrigerators: Fabricated with one-piece seamless steel or ABS plastic inner liner; refrigerator compartment with slide-out or removable shelves and meat tray; adjustable automatic temperature control; door with magnetic gaskets and storage shelves; interior light; closed



- compartment for 25-lb (11-kg) minimum storage of prefrozen food and two ice cube trays; 115-V ac.
- a. Minimum Capacity: 3.2 cu. ft. (0.091 cu. m) **OR** 5.5 cu. ft. (0.156 cu. m) **OR** 6.0 cu. ft. (0.169 cu. m), **as directed**.
 - b. Defrost System: Automatic defrost timer **OR** Push button or manual, **as directed**.
 - c. Compressor: Cushion-mounted, self-oiling, and hermetically sealed compressor; fan or gravity cooled.
 - d. Finish Panel: Manufacturer's standard door trim kit with filler panel or integral finish panel; match material and finish of base cabinets.
2. Freestanding, Upright Refrigerator-Freezers: Two-door combination unit with one-piece seamless steel or ABS plastic inner liner; automatic defrost; closed freezer compartment with two adjustable shelves and two ice cube trays, **as directed**; full-width vegetable crisper; dairy compartment; interior light; adjustable automatic temperature control; door with magnetic gaskets and storage shelves; 115-V ac, with three-conductor, grounded power cord.
 - a. Minimum Capacity: 12-cu. ft. (0.340-cu. m) refrigerator capacity with 100-lb (45-kg) freezer capacity **OR** 14-cu. ft. (0.396-cu. m) refrigerator capacity with 125-lb (57-kg) freezer capacity, **as directed**.
 - b. Icemaker: Built-in automatic unit, **as directed**.
 - c. Finish Panel: Manufacturer's standard door trim kit with filler panel or integral finish panel; match material and finish of base cabinets.
 3. Automatic Icemakers: Built-in undercounter unit; capable of producing 22 lb (10 kg) of ice per day; with 12-lb (5.4-kg) **OR** 35 lb (15.9 kg) of ice per day; with 26-lb (11.8-kg) **OR** 50 lb (22.6 kg) of ice per day; with 35-lb (15.9-kg), **as directed**, storage bin; 115-V ac, with three-conductor, grounded power cord; with plumbed water supply.
 4. Electric Cooktops: Porcelain-enamel-finished steel; coil-element burners with removable rings and reflector bowls, infinitely adjustable heating controls, and individual signal lights; with wiring terminated at factory-installed junction box.
 - a. Cooktop Burner: One element rated at 900 W; 115 **OR** 1250 W; 208/240, **as directed**, -V ac.
OR
Cooktop Burners: One element rated at 550 W and one element rated at 950 W; 115-V ac.
OR
Cooktop Burners: Two elements, each rated at 1250 W; 115 **OR** 208/240, **as directed**, -V ac.
OR
Cooktop Burners: Two elements rated at 1250 W and one element rated at 2100 W; 208/240-V ac.
 5. Built-in Electric Ovens: Porcelain-enamel-finished steel exterior surfaces; coil-element burners with removable rings and reflector bowls, infinitely adjustable heating controls, and individual signal lights. Oven interior fabricated from one-piece porcelain-enamel-finished steel with rounded corners, with "Bake" and "Broil" oven elements, automatic heat control, signal light, and removable wire oven rack; textured baked-enamel- or porcelain-enamel-finished steel oven door; 208/240-V ac, with wiring terminated at factory-installed junction box.
 - a. Cooktop Burners: Three elements, each rated at 1250 W.
 - b. Oven Elements: 1500 W bake; 2000 W broil **OR** Manufacturer's standard, **as directed**.
 6. Freestanding Electric Ranges: Porcelain-enamel-finished steel exterior surfaces; coil-element burners with removable rings and reflector bowls, infinitely adjustable heating controls, and individual signal lights; anti-tip anchors. Oven interior fabricated from one-piece porcelain-enamel-finished steel with rounded corners, with "Bake" and "Broil" oven elements, automatic heat control, signal light, two removable wire oven racks, and porcelain-on-steel broiler pan; textured baked-enamel- or porcelain-enamel-finished steel oven door; 208/240-V ac, with wiring terminated at factory-installed junction box.
 - a. Cooktop Burners: Three elements, each rated at 1250 W, and one element rated at 2100 W.
 - b. Oven Elements: Manufacturer's standard.



7. Gas Cooktops: Porcelain-enamel-finished steel; surface burners with removable cast-iron grates, lift-out burner bowls, and 115-V ac electronic ignition; with wiring terminated at factory-installed junction box, and burner control panel mounted at front of unit.
 - a. Cooktop Burners: Two elements, each rated at 8000 Btu/h (8440 kJ) **OR** 10,000 Btu/h (10 550 kJ), **as directed**, for natural gas.
8. Built-in Gas Ovens: Stainless-steel **OR** Porcelain-enamel-finished steel, **as directed**, exterior surfaces; surface burners with removable cast-iron grates, lift-out burner bowls, and 115-V ac electronic ignition; with wiring terminated at factory-installed junction box. Oven interior fabricated from porcelain-enamel-finished steel with rounded corners; removable wire oven rack, automatic heat control, and combination surface burner and oven control panel mounted above oven door at front of unit.
 - a. Cooktop Burners: Three elements, each rated at 5000 Btu/h (5275 kJ) for natural gas.
OR
Cooktop Burners: Four elements, each rated at 9000 Btu/h (9495 kJ) for natural gas.
 - b. Oven Burner: Rated at 9000 Btu/h (9495 kJ) **OR** 18,000 Btu/h (18 990 kJ), **as directed**, for natural gas.
9. Freestanding Gas Ranges: Porcelain-enamel-finished steel exterior surfaces; surface burners with removable grates, lift-out burner bowls, and 115-V ac electronic ignition; with three-conductor, grounded power cord; anti-tip anchors. Oven interior fabricated from porcelain-enamel-finished steel with rounded corners; two removable wire oven racks, porcelain-on-steel broiler pan, automatic heat control, and combination surface burner and oven control panel mounted above oven door at front of unit.
 - a. Cooktop Burners: Four elements, each rated at 9000 Btu/h (9495 kJ) for natural gas.
 - b. Oven Burner: Rated at 18,000 Btu/h (18 990 kJ) for natural gas.
10. Freestanding Microwave Ovens: 0.7-cu. ft. (0.020-cu. m) capacity with 600 W **OR** 0.8-cu. ft. (0.023-cu. m) capacity with 700 W, **as directed**, cooking power; electronic touch controls, variable power control, digital clock timer, interior light, turntable, and tempered glass door; 115-V ac, with three-conductor, grounded power cord.
11. Built-in Microwave Ovens with Exhaust Hood: Undercabinet mounted, minimum 1.0-cu. ft. (0.028-cu. m) capacity with 800-W cooking power; electronic touch controls, variable power control, digital clock timer, interior light, turntable, tempered glass door, and exhaust hood with integral light and two-speed fan control; 115-V ac, with three-conductor, grounded power cord.
 - a. Exhaust Hood: Recirculating, nonventing type, with replaceable charcoal filter.
OR
Exhaust Hood: Ventilating type, with permanent washable filter. Provide exhaust duct and wall **OR** roof, **as directed**, cap and shutter. See Division 23 Section "Metal Ducts".
12. Built-in Microwave/Convection Ovens with Exhaust Hood: Undercabinet mounted, minimum 1.0-cu. ft. (0.028-cu. m) capacity with 800-W cooking power; electronic touch controls, variable power control, digital clock timer, interior light, turntable, convection rack, tempered glass door, and exhaust hood with integral light and two-speed fan control; 115-V ac, with three-conductor, grounded power cord.
 - a. Exhaust Hood: Recirculating, nonventing type, with replaceable charcoal filter.
 - b. Exhaust Hood: Ventilating type, with permanent washable filter. Provide exhaust duct and wall **OR** roof, **as directed**, cap and shutter. See Division 23 Section "Metal Ducts".
13. Ventilating Exhaust Hoods: Undercabinet mounted, 24 inches (610 mm) wide, stainless **OR** baked-enamel, **as directed**, steel; two-speed fan control, permanent washable filter, and built-in lighting; 115-V ac, with wiring terminated at factory-installed junction box.
 - a. Provide exhaust duct and wall **OR** roof, **as directed**, cap and shutter. See Division 23 Section "Metal Ducts".
14. Recirculating, Nonventing Exhaust Hoods: Undercabinet mounted, 24 inches (610 mm) wide, stainless **OR** baked-enamel, **as directed**, steel; two-speed fan control, replaceable charcoal filter, and built-in lighting; 115-V ac, with wiring terminated at factory-installed junction box.
15. Dishwashers: Built-in undercounter unit, 18 inches (457 mm) wide **OR** 24 inches (610 mm) wide **OR** width as indicated, **as directed**; multiple wash cycles, coated roll-out racks, detergent dispenser, and insulated cavity walls and door; 115-V ac, with wiring terminated at factory-installed junction box.



16. Automatic Coffeemakers: Stainless steel, with capacity for three pots of coffee; automatic brewing, nonstick warmer plates, and lighted on-off switch; 115-V ac, with three-conductor, grounded power cord; designed for permanent installation in countertop, with plumbed water supply. Provide glass coffee decanters in number to match capacity.

H. Accessories

1. Locks: Brass-cylinder type; furnish two keys per lock. Provide where indicated **OR** on base cabinet doors **OR** on refrigerator, **as directed**.
2. Fluorescent Light Fixtures: Surface mounted to underside of overhead cabinet; with 15-W lamp, on-off switch, grounded convenience receptacle, and translucent plastic lens.
3. Cutlery Drawers: Concealed drawer in undercounter storage compartment with pull-out divided tray.
4. Cutting Boards: Pull-out hardwood board.
5. Heat Shields: Minimum 12 inches high by 24 inches (305 mm high by 610 mm) wide, 0.025-inch- (0.64-mm-) thick stainless steel over 1/4-inch- (6-mm-) thick board insulation.

I. Fabrication

1. General: Factory fabricate and assemble unit kitchens, with base cabinets, sink **OR** refrigerator, **as directed**, and countertop shipping as a one-piece assembly. Securely fasten components, fixtures, and appliances together.
 - a. Provide manufacturer's standard hardware including concealed, adjustable plated-steel hinges; steel drawer slides with nylon rollers; and catches and rubber bumpers on doors and drawers. Unless otherwise indicated, provide chromium-plated metal or satin-finished stainless steel for exposed hardware.
2. Accessible Units: Fabricate unit kitchens to comply with accessibility regulations as follows:
 - a. Standard, Accessible Countertops: Fabricate unit kitchens with one-piece countertop located at height of 34 inches (864 mm) above floor.

OR

 Adjustable, Accessible Countertops: Fabricate unit kitchens with two-piece countertop that allows countertop over sink, including backsplash, side splashes, and sink assembly, to be adjusted between 29 and 36 inches (735 and 915 mm) above finished floor.
 - b. Removable, Accessible Cabinets: Fabricate cabinet under sink to allow removal for future accessibility conversion. Fabricate cabinet to allow access to plumbing and electrical connections after conversion.
 - c. Knee and Toe Clearance: Provide minimum 30-inch- (760-mm-) wide open space beneath countertop with a minimum clear height of 27 inches (685 mm) above floor for first 8 inches (205 mm) of depth, then reduce clearance at a rate of 1 inch (25 mm) in depth for each 6 inches (150 mm) in height, to a minimum clear height of 9 inches (230 mm) above floor at a depth of 11 inches (280 mm).
 - d. Pipe Enclosure Panels: Provide manufacturer's standard panels to enclose plumbing under countertop, of same material and finish as cabinets. Install panel to prevent exposure of sharp or abrasive surfaces under countertop.
 - e. Operable Parts: Locate operable parts no higher than 48 inches (1219 mm) and no lower than 15 inches (380 mm) above floor. Provide operable parts that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf (22.2 N).
 - f. Range or Cooktop: Provide top surface 34 inches (865 mm) above floor, with controls that do not require reaching across burners. Provide knee and toe clearance beneath range or cooktop; insulate underside of cooktop to prevent burns, shocks, or abrasions.
 - g. Refrigerator/Freezer: Provide 50 percent of freezer space no higher than 54 inches (1370 mm) off floor.
 - h. Oven: Provide work surface adjacent to one side of bottom-hinged doors. Locate controls on front panel.

J. General Finish Requirements



1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

K. Finishes

1. Stainless-Steel Finishes: Remove tool and die marks and stretch lines, or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - a. Bright, Directional Polish: No. 4 finish.
2. Wood Finishes: Factory finished with manufacturer's standard stain, sealer, and clear finish coat. Defer only final touchup until after installation.

1.3 EXECUTION

A. Examination

1. Examine walls and floors, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
2. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
3. Examine walls and partitions for proper backing for unit kitchens.
4. Examine roughing-in for electrical power plumbing and mechanical system(s) to verify actual locations of connections before installation of unit kitchens.
5. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. General: Install level, plumb, and true; shim as required, using concealed shims. Provide fasteners, clips, backing materials, brackets, anchors, fillers, scribes, trim, and accessories necessary for complete installation.
 - a. Anchor unit kitchens at ends and at intervals recommended by manufacturer, but not more than 36 inches (910 mm) o.c. Install anchors through backup reinforcing plates, channels, or blocking as required to prevent material distortion; use concealed fasteners.
 - b. Freestanding Ranges: Install anti-tip anchors at locations recommended by manufacturer.
2. Comply with requirements specified in Division 14 AND Division 21 for connecting unit kitchens to plumbing and mechanical system(s).
3. Comply with requirements specified in Division 22 for connecting unit kitchens to electrical power system.

C. Adjusting And Cleaning

1. Test, adjust, and verify operation of each appliance, plumbing fixture, and component of unit kitchens. Repair or replace items found to be defective or operating below rated capacity.
2. Verify that operating parts work freely and fit neatly and that clearances are adequate to properly and freely operate appliances.
3. Clean, lubricate, and adjust hardware. Adjust doors and latches to operate easily without binding. Verify that locking devices operate properly.
4. After completing unit kitchen installation, remove protective coverings if any.
5. Repair or replace damaged parts, dents, buckles, abrasions, and other defects affecting appearance or serviceability. Touch up factory-applied finishes to restore damaged or soiled areas.

END OF SECTION 11 32 13 00



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Task	Specification	Specification Description
11 41 13 00	11 21 63 00	Food Service Equipment
11 41 23 00	11 21 63 00	Food Service Equipment
11 41 31 00	11 21 63 00	Food Service Equipment



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SECTION 11 41 33 00 - RESIDENTIAL CASEWORK

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for residential casework. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Kitchen cabinets.
 - b. Vanity cabinets.
 - c. Plastic-laminate countertops and backsplashes.
 - d. Solid-surfacing-material countertops and backsplashes.

C. Definitions

1. Exposed Surfaces of Cabinets: Surfaces visible when doors and drawers are closed, including visible surfaces in open cabinets or behind glass doors.
2. Semiexposed Surfaces of Cabinets: Surfaces behind opaque doors or drawer fronts, including interior faces of doors and interiors and sides of drawers. Bottoms of wall cabinets are defined as "semiexposed."
3. Concealed Surfaces of Cabinets: Surfaces not usually visible after installation, including sleepers, web frames, dust panels, bottoms of drawers, and ends of cabinets installed directly against and completely concealed by walls or other cabinets. Tops of wall cabinets and utility cabinets are defined as "concealed."

D. Submittals

1. Product Data: For cabinets, countertop material, and cabinet hardware.
2. Shop Drawings: For cabinets and countertops. Include plans, elevations, details, and attachments to other work. Show materials, finishes, filler panels, hardware, edge and backsplash profiles, methods of joining countertops, and cutouts for plumbing fixtures.
3. Samples: For each type of material exposed to view.
4. LEED Submittals:
 - a. Product Data for Credit EQ 4.4: For adhesives and composite wood products, documentation indicating that product contains no urea formaldehyde.
 - b. Product Data for Credit MR 4.1 and MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
 - c. Certificates for Credit MR 7: Chain-of-custody certificates certifying that wood used to produce cabinets and countertops complies with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.
 - 1) Include statement indicating costs for each certified wood product.

E. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer that is certified for chain of custody by an FSC-accredited certification body.
2. Quality Standards: Unless otherwise indicated, comply with the following standards:
 - a. Cabinets: KCMA A161.1.



- 1) KCMA Certification: Provide cabinets with KCMA's "Certified Cabinet" seal affixed in a semiexposed location of each unit and showing compliance with the above standard.
- b. Plastic-Laminate Countertops: KCMA A161.2.

1.2 PRODUCTS

A. Cabinet Materials

1. General:
 - a. Certified Wood Materials: Fabricate cabinets with wood and wood-based products produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
 - b. Adhesives: Do not use adhesives that contain urea formaldehyde.
 - c. Hardwood Lumber: Kiln dried to 7 percent moisture content.
 - d. Softwood Lumber: Kiln dried to 10 percent moisture content.
 - e. Hardwood Plywood: HPVA HP-1, made with adhesive containing no urea formaldehyde.
 - f. Particleboard: ANSI A208.1, Grade M-2, made with binder containing no urea formaldehyde.
OR
Particleboard: Straw-based particleboard complying with requirements of ANSI A208.1, Grade M-2, except for density.
 - g. Medium-Density Fiberboard: ANSI A208.2, Grade MD, made with binder containing no urea formaldehyde.
 - h. Hardboard: AHA A135.4, Class 1 Tempered.
2. Exposed Materials:
 - a. Exposed Wood Species: Oak **OR** Maple **OR** Alder **OR** Birch **OR** Hickory **OR** Cherry **OR** Manufacturer's standard domestic hardwood species, **as directed**.
 - 1) Select materials for compatible color and grain. Do not use two adjacent exposed surfaces that are noticeably dissimilar in color, grain, figure, or natural character markings.
 - 2) Staining and Finish: As selected from manufacturer's full range.
 - b. Solid Wood: Clear hardwood lumber of species indicated, free of defects.
 - c. Plywood: Hardwood plywood with face veneer of species indicated, with Grade A faces and Grade C backs of same species as faces.
 - 1) Edge band exposed edges with minimum 1/8-inch- (3-mm-) thick, solid-wood edging of same species as face veneer.
 - d. Plastic Laminate: Particleboard faced with high-pressure decorative laminate complying with NEMA LD 3, Grade VGS **OR** HGL, **as directed**.
 - 1) Where edges of solid-color plastic-laminate sheets will be visible after fabrication, provide through-color plastic laminate.
 - 2) For doors and drawer fronts faced with plastic laminate, provide plastic-laminate edges of same grade, pattern, color, and texture of plastic laminate as for faces.
 - 3) Colors, Textures, and Patterns: As selected from cabinet manufacturer's full range.
 - e. Thermoset Decorative Panels: Particleboard or medium-density fiberboard finished with thermally fused, melamine-impregnated decorative paper complying with LMA SAT-1.
 - 1) Provide material finished on both sides for doors and drawer fronts.
 - 2) Provide PVC or polyester edge banding complying with LMA EDG-1 on components with exposed or semiexposed edges.
 - 3) Colors: As selected from cabinet manufacturer's full range.
 - f. Thermoformed Vinyl-Faced Panels: Medium-density fiberboard, milled to required shapes, with a thermoformed vinyl overlay applied in a vacuum or membrane press.
 - 1) Color: As selected from cabinet manufacturer's full range.
 - g. PVC Edge Molding: Rigid PVC extrusions, through color with satin finish, 3 mm thick at doors and drawer fronts, and 1 mm thick elsewhere.



- 1) Color: As selected from cabinet manufacturer's full range.
 3. Semiexposed Materials: Unless otherwise indicated, provide the following:
 - a. Solid Wood: Sound hardwood lumber, selected to eliminate appearance defects. Same species as exposed surfaces or stained to be compatible with exposed surfaces.
 - b. Plywood: Hardwood plywood with Grade C faces and not less than Grade 3 backs of same species as faces. Face veneers of same species as exposed surfaces or stained to be compatible with exposed surfaces.
 - c. Plastic Laminate: Particleboard faced with high-pressure decorative laminate complying with NEMA LD 3, Grade VGS **OR** CLS, **as directed**.
 - 1) For backs of doors and drawer fronts faced with plastic laminate, provide same grade, pattern, color, and texture of plastic laminate as for faces.
 - 2) For face frames faced with plastic laminate, provide plastic-laminate edges of same grade, pattern, color, and texture of plastic laminate as for faces.
 - 3) Colors, Textures, and Patterns: As selected from cabinet manufacturer's full range.
 - d. Thermoset Decorative Panels: Particleboard or medium-density fiberboard finished with thermally fused, melamine-impregnated decorative paper complying with LMA SAT-1.
 - 1) Provide material finished on both sides for shelves, dividers, drawer bodies, and other components with two semiexposed surfaces.
 - 2) Provide PVC or polyester edge banding complying with LMA EDG-1 on components with semiexposed edges.
 - 3) Colors: As selected from cabinet manufacturer's full range.
 - e. Vinyl-Faced Particleboard: Medium-density particleboard with embossed, wood-grain-patterned, **as directed**, vinyl film adhesively bonded to particleboard.
 - 1) Provide vinyl film on both sides of shelves, dividers, drawer bodies, and other components with two semiexposed surfaces and on semiexposed edges.
 - 2) Colors, Textures, and Patterns: As selected from cabinet manufacturer's full range.
 4. Concealed Materials: Solid wood or plywood, of any hardwood or softwood species, with no defects affecting strength or utility; particleboard; medium-density fiberboard; or hardboard.
- B. Cabinet Hardware
1. General: Manufacturer's standard units complying with BHMA A156.9, of type, size, style, material, and finish as selected from manufacturer's full range.
 2. Pulls: Surface-mounted decorative pulls **OR** Back-mounted decorative pulls **OR** Back-mounted decorative pulls with backing plates **OR** Wire pulls **OR** Back-mounted Knobs **OR** Surface-mounted porcelain knobs, **as directed**.
 3. Hinges: Decorative full-surface hinges **OR** Concealed butt hinges **OR** Semiconcealed (wraparound) butt hinges for overlay doors **OR** Pivot (knife) hinges **OR** Concealed European-style self-closing hinges, **as directed**.
 4. Drawer Guides: Epoxy-coated-metal, self-closing drawer guides; designed to prevent rebound when drawers are closed; with nylon-tired, ball-bearing rollers; and complying with BHMA A156.9, Type B05011 or B05091.
- C. Countertop Materials
1. Plastic Laminate: High-pressure decorative laminate complying with NEMA LD 3.
 - a. Grade: HGS **OR** HGL **OR** HGP, **as directed**.
 - b. Provide through-color plastic laminate.
 - c. Grade for Backer Sheet: BKL.
 - d. Colors, Textures, and Patterns: As selected from countertop manufacturer's full range.
 2. Certified Wood Materials: Fabricate countertops with wood and wood-based products produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
 3. Particleboard: ANSI A208.1, Grade M-2 **OR** M-2-Exterior Glue, **as directed**.
OR
Particleboard: Straw-based particleboard complying with requirements of ANSI A208.1, Grade M-2, except for density.



4. Plywood: Exterior softwood plywood complying with DOC PS 1, Grade C-C Plugged, touch sanded.
5. Adhesives: Do not use adhesives that contain urea formaldehyde.
6. Solid-Surfacing Material: Homogeneous solid sheets of filled plastic resin complying with ISSFA-2.
 - a. Type: Provide Standard Type or Veneer Type made from material complying with requirements for Standard Type, as indicated, unless Special Purpose Type is indicated.
 - b. Integral Sink Bowls: Comply with ISSFA-2 and ANSI Z124.3, Type 5 or Type 6, without a precoated finish.
 - c. Colors and Patterns: As selected from manufacturer's full range.
7. Solid Wood Edges and Trim: Clear red oak **OR** white oak **OR** hard maple **OR** cherry, **as directed**, lumber, free of defects, selected for compatible grain and color, and kiln dried to 7 percent moisture content.

D. Cabinets

1. Face Style: Flush overlay; door and drawer faces cover cabinet fronts with only enough space between faces for operating clearance.
OR
Face Style: Reveal overlay; door and drawer faces partially cover cabinet fronts.
OR
Face Style: Lipped overlay; door and drawer faces are rabbeted and partially inset within cabinet fronts with the lip of the rabbet overlapping cabinet body members or face frames.
OR
Face Style: Flush inset; door and drawer faces are set within cabinet fronts, flush with face.
2. Cabinet Style: Face Frame **OR** Frameless, **as directed**.
3. Door and Drawer Fronts: Solid-wood stiles and rails, 5/8 inch (16 mm) thick, with 3/4-inch- (19-mm-) thick, solid-wood center panels.
OR
Door and Drawer Fronts: Solid-wood stiles and rails, 3/4 inch (19 mm) thick, with 1/4-inch- (6.4-mm-) thick, veneer-faced plywood center panels.
OR
Door and Drawer Fronts: 1/2-inch- (12.7-mm-) thick, veneer-faced plywood.

OR Door and Drawer Fronts: 1/2-inch- (12.7-mm-) thick plastic-laminate-faced particleboard, with continuous solid-wood pulls on one edge, **as directed**, with PVC edge banding, **as directed**.
OR
Door and Drawer Fronts: 1/2-inch- (12.7-mm-) thick thermoset decorative panels, with continuous solid-wood pulls on one edge, **as directed**.
OR
Door and Drawer Fronts: 1/2-inch- (12.7-mm-) thick, thermoformed-vinyl-faced panels with vinyl overlay on faces and edges and with thermoset decorative panel backs **OR** faces, backs, and edges, **as directed**.
4. Face Frames: 3/4-by-1-5/8-inch (19-by-41-mm) solid wood with glued mortise and tenon or doweled joints, **as directed**.
OR
Face Frames: 5/8-inch- (16-mm-) thick particleboard with plastic laminate on exposed and semiexposed surfaces.
OR
Face Frames: 5/8-inch- (16-mm-) thick thermoset-decorative-panel material.
OR
Face Frames: 1/2-inch- (12.7-mm-) thick, thermoformed-vinyl-faced panels with vinyl overlay on exposed and semiexposed surfaces.
5. Exposed Cabinet End Finish: Wood veneer **OR** Plastic laminate **OR** Thermoset decorative panels **OR** Thermoformed vinyl-faced panels, **as directed**.



6. Cabinet End Construction: 5/8-inch- (16-mm-) **OR** 1/2-inch- (12.7-mm-), **as directed**, thick particleboard or 1/2-inch- (12.7-mm-) **OR** 3/8-inch- (9.5-mm-), **as directed**, thick plywood.
 7. Cabinet Tops and Bottoms: 5/8-inch- (16-mm-) thick particleboard or 1/2-inch- (12.7-mm-) thick plywood, fully supported by and secured in rabbets in end panels, front frame (if any), and back rail.
OR
Cabinet Tops and Bottoms: 1/2-inch- (12.7-mm-) thick particleboard or 3/8-inch- (9.5-mm-) thick plywood, fully supported by and secured in rabbets in end panels, front frame, and back rail.
 8. Back, Top, and Bottom Rails: 3/4-by-2-1/2-inch (19-by-63-mm) solid wood, interlocking with end panels and rabbeted to receive top and bottom panels. Back rails secured under pressure with glue and with mechanical fasteners.
 9. Wall-Hung-Unit Back Panels: 3/16-inch- (4.8-mm-) thick plywood fastened to rear edge of end panels and to top and bottom rails.
 10. Base-Unit Back Panels: 3/16-inch- (4.8-mm-) thick plywood fastened to rear edge of end panels and to top and bottom rails.
 11. Base-Unit Back Panels: 1/8-inch- (3.2-mm-) thick hardboard fastened to rear edge of end panels and to top and bottom rails.
 12. Front Frame Drawer Rails: 3/4-by-1-1/4-inch (19-by-32-mm) solid wood mortised and fastened into face frame.
 13. Drawers: Fabricate with exposed fronts fastened to subfront with mounting screws from interior of body.
 - a. Join subfronts, backs, and sides with glued rabbeted joints supplemented by mechanical fasteners **OR** glued dovetail joints, **as directed**.
 - b. Subfronts, Backs, and Sides: 3/4-inch- (19-mm-) **OR** 1/2-inch- (12.7-mm-), **as directed**, thick solid wood.
OR
Subfronts, Backs, and Sides: 1/2-inch- (12.7-mm-) thick solid wood or 3/8-inch- (9.5-mm-) thick plywood.
OR
Subfronts, Backs, and Sides: 3/8-inch- (9.5-mm-) thick particleboard.
 - c. Bottoms: 1/4-inch- (6.4-mm-) **OR** 3/16-inch- (4.8-mm-), **as directed**, thick plywood.
OR
Bottoms: 1/4-inch- (6.4-mm-) thick hardboard **OR** particleboard, **as directed**.
 14. Shelves: 3/4-inch- (19-mm-) thick particleboard or 5/8-inch- (16-mm-) thick plywood.
OR
Shelves: 5/8-inch- (16-mm-) thick particleboard or 1/2-inch- (12.7-mm-) thick plywood.
 15. Joinery: Rabbet backs flush into end panels and secure with concealed mechanical fasteners. Connect tops and bottoms of wall cabinets and bottoms and stretchers of base cabinets to ends and dividers with mechanical fasteners. Rabbet tops, bottoms, and backs into end panels.
 16. Factory Finishing: Finish cabinets at factory. Defer only final touchup until after installation.
- E. Plastic-Laminate Countertops
1. Configuration: Provide countertops with the following front, cove (intersection of top with backsplash), backsplash, and endsplash style:
 - a. Front: No drip (raised marine edge with rolled front) **OR** Rolled **OR** Bevel **OR** Self-edge **OR** Wood-trimmed edge as indicated, **as directed**.
 - b. Cove: Cove molding (one-piece postformed laminate supported at junction of top and backsplash by wood cove molding) **OR** Applied (backsplash rests on top forming seam at inside corner), **as directed**.
 - c. Backsplash: Curved or waterfall shape with scribe **OR** Square edge without scribe **OR** Sloped top edge without scribe **OR** Square edge with scribe, **as directed**.
 - d. Endsplash: None **OR** Square edge without scribe **OR** Sloped top edge without scribe **OR** Square edge with scribe, **as directed**.
 2. Plastic-Laminate Substrate: Particleboard not less than 3/4 inch (19 mm) thick.
 - a. For countertops at sinks and lavatories, use Grade M-2-Exterior-Glue particleboard or exterior-grade plywood.



- b. Build up countertop thickness to 1-1/2 inches (38 mm) at front, back, and ends with additional layers of particleboard laminated to top.
3. Backer Sheet: Provide plastic-laminate backer sheet on underside of countertop substrate.
4. Paper Backing: Provide paper backing on underside of countertop substrate.

F. Solid-Surfacing-Material Countertops

1. Configuration: Provide countertops with the following front and backsplash style:
 - a. Front: Straight, slightly eased at top **OR** Bevel **OR** 3/4-inch (19-mm) bullnose **OR** Radius edge with apron, 2 inches (50 mm) high with 3/8-inch (9.5-mm) radius **OR** 1-1/2-inch (38-mm) laminated bullnose **OR** 1-inch (25-mm) laminated bullnose **OR** Wood-trimmed edge as indicated, **as directed**.
 - b. Backsplash: Straight, slightly eased at corner **OR** Bevel **OR** Radius edge with 3/8-inch (9.5-mm) radius, **as directed**.
 - c. Endsplash: Matching backsplash **OR** None, **as directed**.
2. Countertops: 1/2-inch- (12.7-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, thick, solid-surfacing material with wood-trimmed edges, **as directed**.
OR
 Countertops: 1/2-inch- (12.7-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, thick, solid-surfacing material with front edge built up with same material.
OR
 Countertops: 1/4-inch- (6.4-mm-) thick, solid-surfacing material laminated to 3/4-inch- (19-mm-) thick particleboard with wood-trimmed edges.
OR
 Countertops: 1/4-inch- (6.4-mm-) thick, solid-surfacing material laminated to 3/4-inch- (19-mm-) thick particleboard with front edge built up with 3/4-inch- (19-mm-) thick, solid-surfacing material.
3. Backsplashes: 1/2-inch- (12.7-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, thick, solid-surfacing material with wood-trimmed edges, **as directed**.
4. Fabrication: Fabricate tops in one piece with shop-applied edges and backsplashes, **as directed**, unless otherwise indicated. Comply with solid-surfacing-material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.
 - a. Fabricate with loose backsplashes for field assembly.
 - b. Install integral sink bowls in countertops in the shop.

1.3 EXECUTION

A. Installation

1. Install cabinets with no variations in flushness of adjoining surfaces; use concealed shims. Where cabinets abut other finished work, scribe and cut for accurate fit. Provide filler strips, scribe strips, and moldings in finish to match cabinet face.
2. Install cabinets without distortion so doors and drawers fit openings and are aligned. Complete installation of hardware and accessories as indicated.
3. Install cabinets and countertop level and plumb to a tolerance of 1/8 inch in 8 feet (3 mm in 2.4 m).
4. Fasten cabinets to adjacent units and to backing.
 - a. Fasten wall cabinets through back, near top and bottom, at ends and not less than 24 inches (600 mm) o.c. with No. 10 wafer-head screws sized for 1-inch (25-mm) penetration into wood framing, blocking, or hanging strips.
 - b. Fasten wall cabinets through back, near top and bottom, at ends and not less than 24 inches (600 mm) o.c., with toggle bolts through metal backing behind gypsum board.
5. Fasten plastic-laminate countertops by screwing through corner blocks of base units into underside of countertop. Form seams using splines to align adjacent surfaces, and secure with glue and concealed clamping devices designed for this purpose.
 - a. Provide cutouts for sinks and lavatories, including holes for faucets and accessories.
 - b. Seal edges of cutouts by saturating with varnish.



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6. Fasten solid-surfacing-material countertops by screwing through corner blocks of base units into underside of countertop. Align adjacent surfaces, and form seams to comply with manufacturer's written instructions using adhesive in color to match countertop. Carefully dress joints smooth, remove surface scratches, and clean entire surface.
 - a. Install backsplashes and endsplashes to comply with solid-surfacing-material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.
 - b. Seal edges of cutouts by saturating with varnish.

 - B. Adjusting And Cleaning
 1. Adjust cabinets and hardware so doors and drawers are centered in openings and operate smoothly without warp or bind. Lubricate operating hardware as recommended by manufacturer.
 2. Clean casework on exposed and semiexposed surfaces. Touch up factory-applied finishes to restore damaged or soiled areas.

END OF SECTION 11 41 33 00



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Task	Specification	Specification Description
11 41 33 00	11 21 63 00	Food Service Equipment
11 42 13 00	11 21 63 00	Food Service Equipment
11 42 16 00	11 21 63 00	Food Service Equipment
11 44 13 00	11 21 63 00	Food Service Equipment
11 44 16 00	11 21 63 00	Food Service Equipment



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SECTION 11 44 19 00 - RESIDENTIAL APPLIANCES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for residential appliances. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes:
 - a. Cooking appliances.
 - b. Kitchen exhaust ventilation.
 - c. Refrigeration appliances.
 - d. Cleaning appliances
 - e. Trash compactors.

C. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, dimensions, furnished accessories, and finishes for each appliance.
2. LEED Submittal:
 - a. Product Data for Credit EA 1.4 or LEED for Homes Credit EA9: For appliances, documentation indicating that products are ENERGY STAR rated.
3. Samples: For each exposed finish.
4. Product Schedule: For appliances; use same designations indicated on Drawings.
5. Qualification Data: For qualified Installer or manufacturer.
6. Product Certificates: For each type of appliance, from manufacturer.
7. Field quality-control reports.
8. Operation and Maintenance Data: For each residential appliance to include in operation and maintenance manuals.
9. Warranties: Special warranties specified in this Section.

D. Quality Assurance

1. Manufacturer Qualifications: Maintains a service center capable of providing training, parts, and emergency maintenance repairs.
2. Installer Qualifications: An employer of workers trained and approved by manufacturer for installation and maintenance of units required for this Project.
3. Source Limitations: Obtain residential appliances from single source and each type of residential appliance from single manufacturer.
4. High-Altitude and Propane Conversion: Provide gas-operated appliances with manufacturer's conversion kit installed by a qualified service agency according to manufacturer's written instructions for Project location and type of fuel.
5. Regulatory Requirements: Comply with the following:
 - a. NFPA: Provide electrical appliances listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 - b. ANSI: Provide gas-burning appliances that comply with ANSI Z21 Series standards.
6. Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1, " **as directed**."
7. Preinstallation Conference: Conduct conference at Project site.

E. Warranty



1. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace residential appliances or components that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period: Two **OR** Five years, **as directed**, from date of Final Completion.
2. Electric Cooktop **OR** Range: Full warranty including parts and labor **OR** Limited warranty including parts and labor for first year and parts thereafter for on-site service on surface-burner elements, **as directed**.
 - a. Warranty Period: Two **OR** Five years, **as directed**, from date of Final Completion.
3. Microwave Oven: Full warranty including parts and labor **OR** Limited warranty including parts and labor for first year and parts thereafter for on-site service on the magnetron tube, **as directed**.
 - a. Warranty Period: Two **OR** Five years, **as directed**, from date of Final Completion.
4. Refrigerator/Freezer **OR** Freezer **OR** Icemaker, Sealed System: Full warranty including parts and labor **OR** Limited warranty including parts and labor for first year and parts thereafter for on-site service on the product, **as directed**.
 - a. Warranty Period for Sealed Refrigeration System: Two **OR** Five years, **as directed**, from date of Final Completion.
 - b. Warranty Period for Other Components: Two years from date of Final Completion.
5. Dishwasher: Full warranty including parts and labor **OR** Limited warranty including parts and labor for first year and parts thereafter for on-site service on the product, **as directed**.
 - a. Warranty Period for Deterioration of Tub and Metal Door Liner: Three **OR** Five **OR** 10 years, **as directed**, from date of Final Completion.
 - b. Warranty Period for Other Components: Two years from date of Final Completion.
6. Clothes Washer: Full warranty including parts and labor **OR** Limited warranty including parts and labor for first year and parts thereafter for on-site service on the product, **as directed**.
 - a. Warranty Period: Two **OR** Three years, **as directed**, from date of Final Completion.

1.2 PRODUCTS

A. Cooktops:

1. Electric Cooktop:
 - a. Width: 12 inches (305 mm) **OR** 30 inches (762 mm) **OR** 36 inches (914 mm), **as directed**.
 - b. Electric Burner Elements: Two **OR** Four **OR** Six, **as directed**.
 - c. Coil Type: Manufacturer's standard **OR** Two 1200 W and two 2200 W **OR** One 1200 W, one 2200-W dual element, and two 2200 W, **as directed**.
 - d. Radiant Type: Two 1500 W and two 2000 W **OR** One 1200-W element, dual 1500-W/1500-W bridge element, and one 1200-W/2500-W expandable element **as directed**.
 - e. Induction Type: Manufacturer's standard **OR** Two 1200 W and two 1800 W **OR** One 1200 W, one 1800 W, one 2700 W, and one 3300 W, **as directed**.
 - f. Controls: Digital panel controls, located on front **OR** on left side **OR** on right side **OR** remotely, where indicated, **as directed**.
 - g. Downdraft Ventilation: Manufacturer's standard **OR** 550 cfm (260 L/s) **as directed**, built-in downdraft ventilation, with remote blower and exterior weatherproof wall cap.
 - h. Other Features: Grill **OR** deep fryer **OR** wok burner and wok ring, **as directed**.
 - i. Electric Power Supply: 240 V, 60 Hz, 1 phase, 30 A, **as directed**.
 - j. Top Material: Manufacturer's standard **OR** Ceramic glass **OR** Porcelain-enamel steel **OR** Stainless steel, **as directed**.
 - 1) Color/Finish: White **OR** Black, **as directed**.
2. Gas Cooktop
 - a. Width: 12 inches (300 mm) **OR** 30 inches (760 mm) **OR** 36 inches (915 mm), **as directed**.
 - b. Gas Burners: Two **OR** Four **OR** Six, **as directed**.
 - 1) Power Ratings: Manufacturer's standard **OR** One 5000 Btu/h (1500 W), two 9100 Btu/h (2700 W), and one 12,000 Btu/h (3500 W), **as directed**.
 - 2) Grates: Individual **OR** Continuous, **as directed**.



- c. Controls: Digital panel **OR** Manual-dial controls, located on front **OR** left side **OR** right side, **as directed**.
 - d. Downdraft Ventilation: Manufacturer's standard **OR** 550 cfm (260 L/s), **as directed**, with remote, **as directed**, blower and exterior weatherproof wall cap.
 - e. Other Features: Sealed burners **OR** Auto-reigniting **OR** Grill **OR** deep fryer **OR** wok burner and wok ring, **as directed**.
 - f. Electric Power Supply: 120 V, 60 Hz, 1 phase, 30 A, **as directed**.
 - g. Top Materials: Porcelain-enamel steel **OR** Ceramic glass **OR** glass **OR** Stainless steel **OR** Manufacturer's standard, **as directed**.
 - 1) Color/Finish: White **OR** Black, **as directed**.
- B. Range:
- 1. Electric Range: Freestanding **OR** Slide-in **OR** Drop-in range, **as directed**, with one **OR** two oven(s), **as directed** and complying with AHAM ER-1.
 - a. Width: 30 inch (762 mm) **OR** 36 inch (914 mm), **as directed**.
 - b. Electric Burner Elements: Four **OR** Six, **as directed**.
 - 1) Coil Type: Manufacturer's standard **OR** Two 1200 W and two 2200 W **OR** One 1200 W, one 2200-W dual element, and two 2200 W, **as directed**.
 - 2) Radiant Type: Two 1500 W and two 2000 W **OR** One 1200-W element, dual 1500-W/1500-W bridge element, and one 1200-W/2500-W expandable element, **as directed**.
 - 3) Induction Type: Manufacturer's standard **OR** Two 1200 W and two 1800 W **OR** One 1200 W, one 1800 W, one 2700 W, and one 3300 W, **as directed**.
 - 4) Controls: Digital panel controls, located on front **OR** left side **OR** right side **OR** splash panel at rear of rangetop, **as directed**.
 - c. Oven Features:
 - 1) Capacity: 3.3 cu. ft. (0.09 cu. m).
 - 2) Operation: Baking **OR** convection **as directed**, and self-cleaning.
 - 3) Broiler: Located in top of oven **OR** separate roll-out drawer on bottom **as directed**.
 - 4) Oven Door(s): Counterbalanced, removable, with observation window and full-width handle.
 - 5) Electric Power Rating:
 - a) Oven(s): Manufacturer's standard **OR** 2400 W **as directed**.
 - b) Broiler: Manufacturer's standard **OR** 3500 W **as directed**.
 - 6) Controls: Digital panel controls and timer display, located on front **OR** left side **OR** right side **OR** splash panel at rear of rangetop, **as directed**.
 - d. Anti-Tip Device: Manufacturer's standard.
 - e. Electric Power Supply: 240 V, 60 Hz, 1 phase, 30 A.
 - f. Material Porcelain-enamel **OR** Stainless, **as directed**, with manufacturer's standard, **as directed**, cooktop.
 - a) Color/Finish: White **OR** Black, **as directed**.
 - 2. Gas Range: Freestanding **OR** Slide-in range with one **OR** two ovens, **as directed**.
 - a. Width: 30 inch (762 mm) **OR** 36 inch (914 mm), **as directed**.
 - b. Gas Burners: Four **OR** Six, **as directed**.
 - 1) Power Ratings: Manufacturer's standard **OR** One 5000 Btu/h (1500 W), **as directed**, two 9100 Btu/h (2700 W), and one 12,000 Btu/h (3500 W).
 - 2) Controls: Digital panel **OR** Manual-dial controls, **as directed** located on front **OR** left side **OR** right side **OR** splash panel at rear of rangetop, **as directed**.
 - 3) Grates: Individual **OR** Continuous, **as directed**.
 - 4) Other Feature(s): Sealed burners **OR** auto-re-igniting burners, **as directed**, and grill.
 - c. Oven Features:
 - 1) Capacity: 3.3 cu. ft. (0.09 cu. m).
 - 2) Operation: Baking **OR** convection **as directed**, and self-cleaning.
 - 3) Broiler: Located in top of oven **OR** separate roll-out drawer on bottom **as directed**.



- 4) Oven Door(s): Counterbalanced, removable, with observation window and full-width handle.
 - 5) Electric Power Rating:
 - a) Oven(s): Manufacturer's standard **OR** 9100 Btu/h (2700 W) **as directed**.
 - b) Broiler: Manufacturer's standard **OR** 14,500 Btu/h (4200 W) **as directed**.
 - 6) Controls: Digital panel controls and timer display, located on front **OR** left side **OR** right side **OR** splash panel at rear of rangetop, **as directed**.
 - d. Anti-Tip Device: Manufacturer's standard.
 - e. Electric Power Supply: 240 V, 60 Hz, 1 phase, 15 A.
 - f. Material Porcelain-enamel **OR** Stainless, **as directed**, with manufacturer's standard, **as directed**, cooktop.
 - a) Color/Finish: White **OR** Black, **as directed**.
3. Dual Fuel Range Freestanding **OR** Slide-in range, **as directed**, with gas burners and one **OR** two electric ovens, **as directed**.
- a. Width: 30 inch (762 mm) **OR** 36 inch (914 mm), **as directed**.
 - b. Gas Burners: Four **OR** Six, **as directed**.
 - 1) Power Ratings: Manufacturer's standard **OR** One 5000 Btu/h (1500 W), **as directed**, two 9100 Btu/h (2700 W), and one 12,000 Btu/h (3500 W)
 - 2) Controls: Digital panel **OR** Manual-dial controls, **as directed** located on front **OR** left side **OR** right side **OR** splash panel at rear of rangetop, **as directed**.
 - 3) Grates: Individual **OR** Continuous, **as directed**.
 - 4) Other Feature(s): Sealed burners **OR** auto-re-igniting burners, **as directed**, and grill.
 - c. Oven Features:
 - 1) Capacity: 3.3 cu. ft. (0.09 cu. m).
 - 2) Operation: Baking **OR** convection **as directed**, and self-cleaning.
 - 3) Broiler: Located in top of oven **OR** separate roll-out drawer on bottom **as directed**.
 - 4) Oven Door(s): Counterbalanced, removable, with observation window and full-width handle.
 - 5) Electric Power Rating:
 - a) Oven(s): Manufacturer's standard **OR** 2400 W **as directed**.
 - b) Broiler: Manufacturer's standard **OR** 3500 W **as directed**.
 - 6) Controls: Digital panel controls and timer display, located on front **OR** left side **OR** right side **OR** splash panel at rear of rangetop, **as directed**.
 - d. Anti-Tip Device: Manufacturer's standard.
 - e. Electric Power Supply: 240 V, 60 Hz, 1 phase, 30 A.
 - f. Material Porcelain-enamel **OR** Stainless, **as directed**, with manufacturer's standard, **as directed**, cooktop.
 - 1) Color/Finish: White **OR** Black, **as directed**.
- C. Wall Oven:
1. Electric Wall Oven(s): One **OR** Two-oven unit, **as directed**.
 - a. Mounting: Built-in wall **OR** undercounter .
 - b. Capacity: 3.3 cu. ft. (0.09 cu. m).
 - c. Operation: Baking **OR** convection and self-cleaning, **as directed**.
 - d. Broiler: Located in top of oven **OR** separate roll-out drawer on bottom, **as directed**.
 - e. Oven Door(s): Counterbalanced, removable, with observation window and full-width handle.
 - f. Electric Power Rating:
 - 1) Oven(s): Manufacturer's standard **OR** 2400 W, **as directed**.
 - 2) Broiler: Manufacturer's standard **OR** 3500 W, **as directed**.
 - g. Electric Power Supply: 240 V, 60 Hz, 1 phase, 30 A
 - h. Controls: Digital panel **OR** Manual-dial controls and timer display, **as directed**.



- i. Material: Porcelain-enameled steel **OR** Stainless steel **OR** Manufacturer's standard, **as directed**.
 - 1) Color/Finish: White **OR** Black, **as directed**.
- 2. Gas Wall Oven(s): One **OR** Two-oven unit, **as directed**.
 - a. Mounting: Built-in wall **OR** undercounter .
 - b. Capacity: 3.3 cu. ft. (0.09 cu. m).
 - c. Operation: Baking **OR** convection and self-cleaning, **as directed**.
 - d. Broiler: Located in top of oven **OR** separate roll-out drawer on bottom, **as directed**.
 - e. Oven Door(s): Counterbalanced, removable, with observation window and full-width handle.
 - f. Electric Power Rating:
 - 1) Oven(s): Manufacturer's standard **OR** 9100 Btu/h (2700 W), **as directed**.
 - 2) Broiler: Manufacturer's standard **OR** 14,500 Btu/h (4200 W), **as directed**.
 - g. Electric Power Supply: 240 V, 60 Hz, 1 phase, 30 A
 - h. Controls: Digital panel **OR** Manual-dial controls and timer display, **as directed**.
 - i. Material: Porcelain-enameled steel **OR** Stainless steel **OR** Manufacturer's standard, **as directed**.
 - 1) Color/Finish: White **OR** Black, **as directed**.
- D. Microwave Oven:
 - 1. Microwave Oven(s):
 - a. Mounting: Undercabinet **OR** Wall cabinet, **as directed**.
 - b. Type: Conventional **OR** Convection, **as directed**.
 - c. Dimensions:
 - 1) Width: 24 inches (610 mm) **OR** 30 inches (762 mm), **as directed**.
 - 2) Depth: 19-1/2 inches (495 mm), **as directed**.
 - 3) Height: 14 inches (356 mm) **OR** 18 inches (457 mm), **as directed**.
 - d. Capacity: 1.5 cu. ft. (0.04 cu. m) **OR** 2.0 cu. ft. (0.06 cu. m), **as directed**.
 - e. Oven Door: Door with observation window and pull handle **OR** and push-button latch release, **as directed**.
 - f. Exhaust Fan: Variable **OR** Two **OR** Four-speed fan, , **as directed**, vented to outside **OR** nonvented, **as directed**, recirculating type with charcoal filter and with manufacturer's standard **OR** 300-cfm (140-L/s) capacity, **as directed**.
 - g. Microwave Power Rating: Manufacturer's standard **OR** 1000 W, **as directed**.
 - 1) Convection Element Power Rating: Manufacturer's standard **OR** 1450 W, **as directed**.
 - h. Electric Power Supply: 120 V, 60 Hz, 1 phase, 15 A.
 - i. Controls: Digital panel controls and timer display.
 - j. Other Features: Turntable **OR** temperature probe, **as directed**, and lock-out feature.
 - k. Material: Porcelain-enameled steel **OR** Stainless steel **OR** Manufacturer's standard, **as directed**.
 - 1) Color/Finish: White **OR** Black, **as directed**.
- E. Kitchen Exhaust Ventilation:
 - 1. Overhead Exhaust Hood
 - a. Type: Wall-mounted, **OR** Suspended-island-canopy, exhaust-hood system, **as directed**.
 - b. Dimensions:
 - 1) Width: 30 inches (762 mm) **OR** 36 inches (914 mm) **OR** 48 inches (1219 mm), **as directed**.
 - 2) Depth: 30 inches (762 mm) **OR** 36 inches (914 mm) **OR** 48 inches (1219 mm), **as directed**.
 - c. Exhaust Fan: Variable **OR** Two **OR** Three-speed fan, **as directed**, built into hood **OR** remotely located, , **as directed**, with separate housing and with manufacturer's standard **OR** 500-cfm (236-L/s) **OR** 900-cfm (425-L/s) capacity, **as directed**.
 - 1) Venting: Vented to outside through roof with weatherproof roof cap, backdraft damper, and rodent-proof screening **OR** Vented to outside through wall with



- weatherproof wall cap, backdraft damper, and rodent-proof screening **OR** Nonvented, recirculating type with charcoal filter, **as directed**.
- 2) Fan Control: Hood **OR** Wall-mounted touch-pad to control fan switch, with separate hood-light control switch, **as directed**.
- d. Duct Type: Manufacturer's standard **OR** 7-inch- (175-mm-) diameter round **OR** 3-1/4 by 10 inches (82 by 250 mm) rectangular, **as directed**.
 - e. Finish: Baked enamel **OR** Stainless steel, **as directed**.
 - 1) Color: White **OR as directed**.
 - f. Features:
 - 1) Permanent, washable aluminum mesh **OR** stainless-steel mesh **OR** baffle-type filter(s), **as directed**.
 - 2) Built-in halogen **OR** incandescent **OR** fluorescent lighting, **as directed**.
 - 3) Warming lamp socket(s).
2. Downdraft Exhaust:
 - a. Type: Retractable-downdraft exhaust system.
 - b. Width: 30 inches (762 mm) **OR** 36 inches (914 mm), **as directed**.
 - c. Exhaust Fan: Variable **OR** Two **OR** Three-speed fan built into cabinet below countertop **OR** remotely located, **as directed**, with separate housing and with manufacturer's standard **OR** 500-cfm (236-L/s) **OR** 900-cfm (425-L/s) capacity, **as directed**.
 - 1) Venting: Vented to outside through roof with weatherproof roof cap, backdraft damper, and rodent-proof screening **OR** Vented to outside through wall with weatherproof wall cap, backdraft damper, and rodent-proof screening **OR** Nonvented, recirculating type with charcoal filter, **as directed**.
 - 2) Fan Control: Countertop-mounted touch-pad to control fan switch.
 - d. Duct Type: Manufacturer's standard **OR** 7-inch- (175-mm-) diameter round **OR** 3-1/4 by 10 inches (82 by 250 mm) rectangular, **as directed**.
 - e. Finish: Baked enamel **OR** Stainless steel, **as directed**.
 - 1) Color: White **OR as directed**.
 - f. Features:
 - 1) Permanent, washable aluminum mesh **OR** stainless-steel mesh **OR** baffle-type filter(s), **as directed**.
- F. Refrigerator/Freezers
1. Refrigerator/Freezer One-door refrigerator with inside freezer compartment **OR** Two-door, side-by-side refrigerator/freezer **OR** Two-door refrigerator/freezer with freezer on top **OR** Two-door refrigerator/freezer with freezer on bottom, **as directed** and complying with AHAM HRF-1.
 - a. Type: Freestanding **OR** Built in **OR** Undercounter.
 - b. Dimensions:
 - 1) Width: 16 inches (406 mm) **OR** 24 inches (610 mm) **OR** 27 inches (686 mm) **OR** 30 inches (762 mm) **OR** 36 inches (914 mm) **OR** 42 inches (1067 mm) **OR** 48 inches (1220 mm), **as directed**.
 - 2) Depth: 24 inches (610 mm) **OR** 27 inches (686 mm) **OR** 33-1/4 inches (845 mm), **as directed**.
 - 3) Height: 34-1/2 inches (876 mm) **OR** 70 inches (1778 mm) **OR** 73 inches (1854 mm) **OR** 84 inches (2134 mm), **as directed**.
 - c. Storage Capacity:
 - 1) Refrigeration Compartment Volume: 15.6 cu. ft. (0.44 cu. m).
 - 2) Freezer Volume: 5.13 cu. ft. (0.15 cu. m).
 - 3) Shelf Area: Three adjustable wire **OR** glass shelves, **as directed**, 26 sq. ft. (2.42 sq. m).
 - d. General Features:
 - 1) Door Configuration: Framed **OR** Overlay.
 - 2) Revise first option in first subparagraph below if either crushed or cubed ice is required.
 - 3) Dispenser in door for ice and cold water dispenser lock.



- 4) Built-in water filtration system.
- 5) Dual refrigeration systems.
- 6) Separate touch-pad temperature controls for each compartment.
- e. Refrigerator Features:
 - 1) Interior light in refrigeration compartment.
 - 2) Compartment Storage: Wine racks **OR** vegetable crisper **OR** meat compartment, **as directed**.
 - 3) Door Storage: Glazed door without storage **OR** Modular compartments **OR** Gallon (3.8 L-) milk-container storage, **as directed**.
 - 4) Temperature-controlled meat/deli bin.
- f. Freezer Features: One **OR** Two freezer compartment(s) with door(s) **OR** configured as pull-out drawer(s), **as directed**.
 - 1) Automatic **OR** Manual defrost, **as directed**.
 - 2) Interior light in freezer compartment.
 - 3) Automatic icemaker and storage bin.
- g. Energy Performance, ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
- h. Front Panel(s): Manufacturer's standard **OR** Wood panel(s) to match kitchen cabinets **OR** Porcelain enamel **OR** Stainless steel **OR** Wood-panel insert(s) specified in Division 06 Section "Interior Architectural Woodwork" to match kitchen cabinets **OR** Wood-panel insert(s) specified in Division 12 Section "Residential Casework" to match kitchen cabinets **OR** Reversible panel(s) with choice of colors, **as directed**.
 - 1) Panel Color: White **OR** Black, **as directed**.
- i. Appliance Color/Finish: White **OR** Black **OR** Stainless steel, **as directed**.

G. Freezers

1. Freezer One **OR** Two freezer compartment(s) with door(s) **OR** configured as pull-out drawer(s), **as directed** and complying with AHAM HRF-1.
 - a. Type: Freestanding **OR** Built in **OR** Undercounter.
 - b. Dimensions:
 - 1) Width: 27 inches (686 mm) **OR** 30 inches (762 mm) **OR** 36 inches (914 mm), **as directed**.
 - 2) Depth: 24 inches (610 mm) **OR** 27 inches (686 mm), **as directed**.
 - 3) Height: 34-1/2 inches (876 mm) **OR** 70 inches (1778 mm) **OR** 73 inches (1854 mm) **OR** 84 inches (2134 mm), **as directed**.
 - c. Storage Capacity:
 - 1) Volume: 5.13 cu. ft. (0.15 cu. m) **OR** 15.0 cu. ft. (0.42 cu. m), **as directed**.
 - 2) Shelf Area: Three adjustable wire **OR** glass shelves, **as directed**, 26 sq. ft. (2.42 sq. m).
 - d. Features:
 - 1) Door Configuration: Framed **OR** Overlay, **as directed**.
 - 2) Automatic **OR** Manual defrost, **as directed**.
 - 3) Interior light in compartment.
 - 4) Automatic icemaker and storage bin.
 - 5) Temperature touch-pad controls for each compartment.
 - 6) Defrost drain.
 - 7) Lock with key.
 - e. Energy Performance, ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
 - f. Front Panel(s): Manufacturer's standard **OR** Wood panel(s) to match kitchen cabinets **OR** Porcelain enamel **OR** Stainless steel **OR** Wood-panel insert(s) specified in Division 06 Section "Interior Architectural Woodwork" to match kitchen cabinets **OR** Wood-panel insert(s) specified in Division 12 Section "Residential Casework" to match kitchen cabinets, **as directed**.
 - 1) Panel Color: White **OR** Black, **as directed**.
 - g. Appliance Color/Finish: White **OR** Black **OR** Stainless steel, **as directed**.



H. Icemakers

1. Icemaker:
 - a. Type: Undercounter.
 - b. Dimensions:
 - 1) Width: 14-3/4 inches (375 mm) **OR** 15-1/4 inches (387 mm), **as directed**.
 - 2) Depth: 24 inches (610 mm) **OR** 25-1/4 inches (641 mm), **as directed**.
 - 3) Height: 33-5/8 inches (386 mm) **OR** 34-1/2 inches (876 mm), **as directed**.
 - c. Ice Capacity:
 - 1) Production: 30 lb (13.6 kg) **OR** 50 lb (22.7 kg) per day, **as directed**.
 - 2) Storage: 25 lb (11.3 kg) **OR** 35 lb (15.9 kg), **as directed**.
 - d. Features:
 - 1) Door Configuration: Framed **OR** Overlay, **as directed**.
 - 2) Automatic defrost.
 - 3) Automatic shutoff.
 - 4) Defrost drain with pump.
 - e. Front Panel: Manufacturer's standard **OR** Wood panel to match kitchen cabinets **OR** Porcelain enamel **OR** Stainless steel **OR** Wood-panel insert specified in Division 06 Section "Interior Architectural Woodwork" to match kitchen cabinets **OR** Wood-panel insert specified in Division 12 Section "Residential Casework" to match kitchen cabinets, **as directed**.
 - a) Panel Color: White **OR** Black, **as directed**.
 - f. Appliance Color/Finish: White **OR** Black **OR** Stainless steel, **as directed**.

I. Dishwashers

1. Dishwasher Complying with AHAM DW-1 and ASSE 1006.
 - a. Type: Built-in undercounter **OR** Built-in under sink **OR** Portable, **as directed**.
 - b. Dimensions:
 - 1) Width: 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**.
 - 2) Depth: 23 inches (584 mm) **OR** 25-3/4 inches (654 mm), **as directed**.
 - 3) Height: 34-1/2 inches (876 mm), **as directed**.
 - c. Capacity:
 - 1) International Place Settings of China: Eight **OR** 12 **OR** 14, **as directed**.
 - 2) Water Consumption for Full Load: 3.2 gal. (12 L) per cycle.
 - d. Sound Level: Maximum 42 **OR** 48 dB, **as directed**.
 - e. Tub and Door Liner: Manufacturer's standard **OR** Porcelain-enameled steel **OR** Stainless steel **OR** Porcelain-enameled steel tub and molded-plastic door liner, **as directed** with sealed detergent and automatic rinsing-aid dispensers.
 - f. Rack System: Nylon **OR** PVC-coated sliding dish racks, **as directed**, with removable cutlery basket **OR** top cutlery tray **as directed**.
 - g. Controls: Touch-pad **OR** Rotary-dial controls, **as directed**, with four wash cycles and hot-air and heat-off drying cycle options.
 - h. Features:
 - 1) Features in first three subparagraphs below are standard with most models.
 - 2) Waste food disposer.
 - 3) Self-cleaning food-filter system.
 - 4) Hot-water booster heater for 140 deg F (60 deg C) **OR** 160 deg F (71 deg C) wash water with incoming water at 100 deg F (38 deg C).
 - 5) Lock-out feature.
 - 6) Half-load option.
 - 7) Delay-wash option.
 - 8) Digital display panel.
 - 9) Water softener.
 - 10) Soil-sensing water use control system.



- i. Energy Performance, ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
 - j. Front Panel: Manufacturer's standard **OR** Wood panel to match kitchen cabinets **OR** Porcelain enamel **OR** Stainless steel **OR** Wood-panel insert specified in Division 06 Section "Interior Architectural Woodwork" to match kitchen cabinets **OR** Wood-panel insert specified in Division 12 Section "Residential Casework" to match kitchen cabinets **OR** Reversible panel with choice of colors, **as directed**.
 - 1) Panel Color: White **OR** Black, **as directed**.
 - k. Appliance Color/Finish: White **OR** Black **OR** Stainless steel, **as directed**.
- J. Clothes Washers And Dryers
- 1. Clothes Washer Complying with ASSE 1007:
 - a. Type: Freestanding **OR** Stacking **OR** Undercounter, top **OR** front-loading unit.
 - b. Dimensions:
 - 1) Width: 23-1/2 inches (597 mm) **OR** 27 inches (686 mm) **OR** 30 inches (762 mm), **as directed**.
 - 2) Depth: 24 inches (610 mm) **OR** 29 inches (737 mm) **OR** 31 inches (787 mm), **as directed**.
 - 3) Height: 34-1/2 inches (876 mm) **OR** 38 inches (965 mm) **OR** 45 inches (1143 mm), **as directed**.
 - c. Drum: Manufacturer's standard **OR** Perforated porcelain-enameled steel **OR** Perforated stainless steel, **as directed**.
 - 1) Capacity: 2.7 cu. ft. (0.08 cu. m) **OR** 3.2 cu. ft. (0.09 cu. m) **OR** 3.8 cu. ft. (0.11 cu. m).
 - d. Controls: Touch-pad **OR** Rotary-dial controls, **as directed**, for water-fill levels, wash/rinse water temperatures, and variable-speed and fabric selectors.
 - 1) Wash Cycles: Four **OR** Six **OR** 10 wash cycles, **as directed**, including regular, delicate, and permanent press.
 - 2) Wash Temperatures: Three settings.
 - 3) Speed Combinations: Two **OR** Four **OR** Five, **as directed**.
 - e. Electrical Power: 120 V, 60 Hz, 1 phase.
 - f. Motor: Manufacturer's standard with built-in overload protector.
 - g. Features:
 - 1) Agitator: Center spindle **OR** Impeller (without spindle), **as directed**.
 - 2) Self-cleaning lint filter.
 - 3) Unbalanced-load compensator.
 - 4) Inlet Hoses: Minimum length 60 inches (1525 mm).
 - 5) Drain Hoses: Minimum length 48 inches (1220 mm).
 - 6) Self-leveling legs.
 - 7) Automatic dispenser for bleach **OR** fabric softener **OR** and **OR** detergent, **as directed**.
 - 8) Spin-cycle safety switch.
 - 9) End-of-cycle signal.
 - 10) Extra-rinse option.
 - 11) Delay-wash option.
 - 12) Electronic temperature control.
 - 13) Water levels automatically set.
 - 14) Pedestal: 8-inch- (203-mm-) high **OR** 15-inch- (381-mm-) high **OR** Manufacturer's standard height laundry pedestal , **as directed**, with storage drawer, matching appliance finish.
 - h. Energy Performance, ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
 - i. Water-Efficient Clothes Washer: Provide clothes washer with modified energy factor greater than or equal to 2.0 and water factor less than 5.5.
 - j. Appliance Finish: Porcelain enamel on top and lid; baked enamel on front and sides **OR** Stainless steel, **as directed**.



- 1) Color: White **OR** Almond, **as directed**.
- k. Front-Panel Finish: Manufacturer's standard **OR** Wood panel to match kitchen cabinets **OR** Porcelain enamel **OR** Stainless steel **OR** Wood-panel insert specified in Division 06 Section "Interior Architectural Woodwork" to match kitchen cabinets **OR** Wood-panel insert specified in Division 12 Section "Residential Casework" to match kitchen cabinets, **as directed**.
 - 1) Panel Color: White **OR** Black, **as directed**.
2. Clothes Dryer Complying with AHAM HLD-1:
 - a. Type: Freestanding **OR** Stacking **OR** Undercounter, **as directed**, frontloading, gas **OR** electric **OR** electric, ventless unit, **as directed**.
 - b. Dimensions:
 - 1) Width: 23-1/2 inches (597 mm) **OR** 27 inches (686 mm), **as directed**.
 - 2) Depth: 24 inches (610 mm) **OR** 31 inches (787 mm), **as directed**.
 - 3) Height: 34-1/2 inches (876 mm) **OR** 36 inches (914 mm), **as directed**.
 - c. Drum: Manufacturer's standard **OR** Perforated porcelain-enameled steel **OR** Perforated stainless steel, **as directed**.
 - 1) Capacity: 5.7 cu. ft. (0.16 cu. m) **OR** 7.0 cu. ft. (0.20 cu. m), **as directed**.
 - d. Controls: Touch-pad **OR** Rotary-dial controls for drying cycle, **as directed**, temperatures, and fabric selectors.
 - e. Electric-Dryer Power: 240 V, 60 Hz, 1 phase, 30 A.
 - f. Gas-Dryer Power: 120 V, 60 Hz, 1 phase, 15 A electric; 22,000-Btu/h (6400-W) gas.
 - g. Features:
 - 1) Features in first five subparagraphs below are standard with most manufacturers.
 - 2) Removable lint filter.
 - 3) Electronic temperature and moisture level sensor control.
 - 4) End-of-cycle signal.
 - 5) Interior drum light.
 - 6) Self-leveling legs.
 - 7) Antibacterial cycle.
 - 8) Auxiliary drying rack.
 - 9) Built-in electrical power fuse.
 - 10) Stacking kit to stack dryer over washer.
 - 11) Pedestal: 8-inch- (203-mm-) high **OR** 15-inch- (381-mm-) high **OR** Manufacturer's standard height laundry pedestal, **as directed**, with storage drawer, matching appliance finish.
 - h. Appliance Finish: Porcelain enamel on top and lid; baked enamel on front and sides **OR** Stainless steel, **as directed**.
 - 1) Color: White **OR** Almond, **as directed**.
 - i. Front-Panel Finish: Manufacturer's standard **OR** Wood panel to match kitchen cabinets **OR** Porcelain enamel **OR** Stainless steel **OR** Wood-panel insert specified in Division 06 Section "Interior Architectural Woodwork" to match kitchen cabinets **OR** Wood-panel insert specified in Division 12 Section "Residential Casework" to match kitchen cabinets.
 - 1) Panel Color: White **OR** Black, **as directed**.
- K. Clothes Washer/Dryer Combinations
 1. Clothes Washer/Dryer Combination Complying with ASSE 1007.
 - a. Type: Freestanding washer/dryer unit with dual-drum design and electric dryer **OR** dual-drum design and gas dryer **OR** all-in-one, single-drum design, **as directed**; washer is top **OR** front loading, **as directed**.
 - b. Dimensions:
 - 1) Width: 23-1/2 inches (597 mm) **OR** 27 inches (686 mm), **as directed**.
 - 2) Depth: 25 inches (635 mm) **OR** 32 inches (813 mm), **as directed**.
 - 3) Height: 34-1/2 inches (876 mm) **OR** 71-1/2 inches (1816 mm), **as directed**.
 - c. Washer and Dryer Drums: Manufacturer's standard **OR** Perforated porcelain-enameled steel **OR** Perforated stainless steel, **as directed**.



- 1) Washer-Drum Capacity: 1.5 cu. ft. (0.04 cu. m) **OR** 2.0 cu. ft. (0.06 cu. m) **OR** 2.6 cu. ft. (0.07 cu. m), **as directed**.
- 2) Dryer-Drum Capacity: 2.0 cu. ft. (0.06 cu. m) **OR** 3.4 cu. ft. (0.10 cu. m) **OR** 5.9 cu. ft. (0.17 cu. m), **as directed**.
- d. Washer/Dryer Drum: Manufacturer's standard **OR** Perforated stainless steel, **as directed**.
 - 1) Drum Capacity: 2.3 cu. ft. (0.07 cu. m).
2. Washer Controls: Touch-pad **OR** Rotary-dial controls for water-fill levels, **as directed**, wash/rinse water temperatures and variable-speed and fabric selectors.
3. Dryer Controls: Touch-pad **OR** Rotary-dial controls for drying cycle, **as directed**, temperatures and fabric selectors.
 - a. Wash Cycles: Three wash cycles including regular, delicate, and permanent press.
 - b. Wash Temperatures: Three settings.
 - c. Speed Combinations: Two.
4. Electric Washer/Dryer Power: 240 V, 60 Hz, 1 phase, 30 A **OR** 120 V, 60 Hz, 1 phase, 15 A, **as directed**.
5. Gas Washer/Dryer Power: 120 V, 60 Hz, 1 phase, 15 A electric; 22,000-Btu/h (6400-W) gas.
6. Motor: Manufacturer's standard with built-in overload protector.
7. Washing Features:
 - a. Self-cleaning lint filter.
 - b. Unbalanced-load compensator.
 - c. Inlet Hoses: Minimum length 60 inches (1525 mm).
 - d. Drain Hoses: Minimum length 48 inches (1220 mm).
 - e. Self-leveling legs.
 - f. Automatic dispenser for bleach, fabric softener and **OR** detergent.
 - g. Spin-cycle safety switch.
8. Drying Features:
 - a. Removable lint filter.
 - b. Electronic temperature and moisture level sensor control.
 - c. End-of-cycle signal.
 - d. Interior drum light.
9. Energy Performance, ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
10. Water-Efficient Clothes Washer: Provide clothes washer with modified energy factor greater than or equal to 2.0 and water factor less than 5.5.
11. Appliance Finish: Porcelain enamel on top and lid; baked enamel on front and sides **OR** Stainless steel, **as directed**.
 - 1) Color: White **OR** Almond, **as directed**.

L. Trash Compactors

- a. Type: Built in **OR** Convertible, **as directed**.
- b. Width: 15 inches (381 mm) **OR** 18 inches (457 mm), **as directed**.
- c. Capacity: 1.4 cu. ft. (0.04 cu. m) **OR** 1.7 cu. ft. (0.05 cu. m), **as directed**.
- d. Features:
 - 1) Key-operated starting switch.
 - 2) Rear wheels.
 - 3) Removable bag carrier.
 - 4) Retainer for disposable bags.
 - 5) Odor-control mechanism.
 - 6) Foot-operated drawer operator.
- e. Front Panel: Manufacturer's standard **OR** Wood panel to match kitchen cabinets **OR** Enameled steel **OR** Stainless steel **OR** Wood-panel insert specified in Division 06 Section "Interior Architectural Woodwork" to match kitchen cabinets **OR** Wood-panel insert specified in Division 12 Section "Residential Casework" to match kitchen cabinets, **as directed**.
 - a) Panel Color: White **OR** Black, **as directed**.



M. General Finish Requirements

1. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
2. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

1.3 EXECUTION

A. Examine

1. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances, power connections, and other conditions affecting installation and performance of residential appliances.
2. Examine roughing-in for piping systems to verify actual locations of piping connections before appliance installation.
3. Examine walls, ceilings, and roofs for suitable conditions where overhead exhaust hoods **OR** downdraft exhaust and microwave ovens with vented exhaust fans will be installed.
4. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
5. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation, General

1. General: Comply with manufacturer's written instructions.
2. Built-in Equipment: Securely anchor units to supporting cabinets or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.
3. Freestanding Equipment: Place units in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
4. Range Anti-Tip Device: Install at each range according to manufacturer's written instructions
5. Utilities: Refer to Division 21 AND Division 26 for plumbing and electrical requirements.

C. Field Quality Control

1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Perform visual, mechanical, and electrical inspection and testing for each appliance according to manufacturers' written recommendations. Certify compliance with each manufacturer's appliance-performance parameters.
 - b. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - c. Operational Test: After installation, start units to confirm proper operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and components.
3. An appliance will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

END OF SECTION 11 44 19 00



Task	Specification	Specification Description
11 44 19 00	11 21 63 00	Food Service Equipment
11 46 13 00	11 21 63 00	Food Service Equipment
11 46 16 00	11 21 63 00	Food Service Equipment
11 46 19 00	11 21 63 00	Food Service Equipment
11 46 83 00	11 21 63 00	Food Service Equipment
11 48 13 00	11 21 63 00	Food Service Equipment
11 48 16 00	11 21 63 00	Food Service Equipment



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SECTION 11 52 13 13 - PROJECTION SCREENS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for projection screens. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Manually operated projection screens.
 - b. Electrically operated projection screens and controls.
 - c. Rigid rear-projection screens.

C. Definitions

1. Gain of Front-Projection Screens: Ratio of light reflected from screen material to that reflected perpendicularly from a magnesium carbonate surface as determined per SMPTE RP 94.
2. Gain of Rear-Projection Screens: Ratio of light refracted by screen material to that reflected perpendicularly from a magnesium carbonate surface as determined per SMPTE RP 94, except that for measuring luminance of test screen, projection lamp shall be placed behind screen same distance as it was placed in front of magnesium carbonate surface for measuring luminance of reference standard.
3. Half-Gain Angle: The angle, measured from the axis of the screen surface to the most central position on a perpendicular plane through the horizontal centerline of the screen where the gain is half of the peak gain.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For projection screens. Show layouts and types of projection screens. Include the following:
 - a. For manually operated projection screens:
 - 1) Drop lengths.
 - 2) Anchorage details.
 - 3) Accessories.
 - b. For electrically operated projection screens and controls:
 - 1) Location of screen centerline relative to ends of screen case.
 - 2) Location of wiring connections for electrically operated units.
 - 3) Location of seams in viewing surfaces.
 - 4) Drop lengths.
 - 5) Anchorage details, including connection to supporting structure for suspended units.
 - 6) Details of juncture of exposed surfaces with adjacent finishes.
 - 7) Accessories.
 - 8) Wiring diagrams.
 - c. For rigid rear-projection screens:
 - 1) Frame details.
 - 2) Anchorage details.
 - 3) Details of juncture of exposed surfaces with adjacent finishes.
 - 4) Accessories.
3. Maintenance Data: For projection screens to include in maintenance manuals.

E. Quality Assurance



1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Delivery, Storage, And Handling

1. Environmental Limitations: Do not deliver or install projection screens until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Store rear-projection screens in manufacturer's protective packaging and according to manufacturer's written instructions.

1.2 PRODUCTS

A. Manually Operated Projection Screens

1. General: Manufacturer's standard spring-roller-operated units, consisting of case, screen, mounting accessories, and other components necessary for a complete installation.
 - a. Screen Mounting: Top edge securely anchored to a 3-inch- (75-mm-) diameter, rigid steel roller; bottom edge formed into a pocket holding a tubular metal slat, with ends of slat protected by plastic caps, and with a saddle and pull attached to slat by screws.
 - b. Tab Tensioning: Provide units that have a durable low-stretch cord, such as braided polyester, on each side of screen connected to edge of screen by tabs to pull screen flat horizontally. In lieu of tab tensioning, screens may be constructed from vinyl-coated screen cloth that contains horizontal stiffening monofilaments to resist edge curling, **as directed**.
2. Bracket-Mounted or Ceiling-Suspended, Metal-Encased, Manually Operated Screens: Units designed and fabricated for suspending from wall brackets or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with vinyl covering or baked-enamel finish and matching end caps. Provide mounting brackets unless otherwise indicated.
3. Surface-Mounted, Metal-Encased, Manually Operated Screens: Units designed and fabricated for surface mounting on wall or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with flat back design and vinyl covering or baked-enamel finish. Provide units with matching end caps and concealed mounting.
4. Surface-Mounted, Wood-Finished, Manually Operated Screens: Units designed and fabricated for surface mounting on wall or ceiling; with flat back design, hardwood finish, and concealed mounting brackets.
 - a. Hardwood: Oak **OR** Walnut **OR** Mahogany **OR** Cherry **OR** As selected from manufacturer's full range of species, **as directed**.
 - b. Finish: As selected from manufacturer's full range.

B. Electrically Operated Projection Screens

1. General: Manufacturer's standard units consisting of case, screen, motor, controls, mounting accessories, and other components necessary for a complete installation. Provide units that are listed and labeled as an assembly by UL or another testing and inspecting agency acceptable to authorities having jurisdiction, **as directed**.
 - a. Controls: Remote, key-operated, **as directed**, three-position control switch installed in recessed device box with flush cover plate matching other electrical device cover plates in room where switch is installed.
 - 1) Provide two **OR** three, **as directed**, control switches for each screen.
 - 2) Provide number of control switches indicated for each screen.
 - 3) Provide power supply for low-voltage systems if required.
 - 4) Provide locking cover plates for switches.
 - 5) Provide key-operated, power-supply switch.



- 6) Provide infrared **OR** radio-frequency, **as directed**, remote control consisting of battery-powered transmitter and receiver.
 - 7) Provide video interface control for connecting to projector. Projector provides signal to raise or lower screen.
 - b. Motor in Roller: Instant-reversing motor of size and capacity recommended by screen manufacturer; with permanently lubricated ball bearings, automatic thermal-overload protection, preset limit switches to automatically stop screen in up and down positions, and positive-stop action to prevent coasting. Mount motor inside roller with vibration isolators to reduce noise transmission.
 - c. End-Mounted Motor: Instant-reversing, gear-drive motor of size and capacity recommended by screen manufacturer; with permanently lubricated ball bearings, automatic thermal-overload protection, preset limit switches to automatically stop screen in up and down positions, and positive-stop action to prevent coasting. Locate motor in its own compartment on right end of screen unless otherwise indicated **OR** on left end of screen unless otherwise indicated **OR** on end of screen indicated, **as directed**.
 - d. Screen Mounting: Top edge securely anchored to rigid metal roller and bottom edge formed into a pocket holding a 3/8-inch- (9.5-mm-) diameter metal rod with ends of rod protected by plastic caps.
 - 1) Roller for end-mounted motor supported by self-aligning bearings in brackets.
 - 2) Roller for motor in roller supported by vibration- and noise-absorbing supports.
 - e. Tab Tensioning: Provide units that have a durable low-stretch cord, such as braided polyester, on each side of screen connected to edge of screen by tabs to pull screen flat horizontally. In lieu of tab tensioning, screens may be constructed from vinyl-coated screen cloth that contains horizontal stiffening monofilaments to resist edge curling.
2. Surface-Mounted, Metal-Encased, Electrically Operated Screens: Motor-in-roller **OR** End-mounted motor, **as directed**, units designed and fabricated for surface mounting on wall or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with flat back design and vinyl covering or baked-enamel finish. Provide with matching end caps and concealed mounting.
 3. Surface-Mounted, Wood-Finished, Electrically Operated Screens: Motor in roller units designed and fabricated for surface mounting on wall or ceiling; with flat back design, hardwood finish, and concealed mounting brackets.
 - a. Hardwood: Oak **OR** Walnut **OR** Mahogany **OR** Cherry **OR** As selected from manufacturer's full range of species, **as directed**.
 - b. Finish: As selected from manufacturer's full range.
 4. Suspended, Electrically Operated Screens without Ceiling Closure: Motor-in-roller **OR** End-mounted motor, **as directed**, units designed and fabricated for suspended mounting, with bottom of case entirely or partially open under screen compartment.
 - a. Provide metal or metal-lined motor enclosure on units with end-mounted motor.
 - b. Provide metal or metal-lined wiring compartment on units with motor in roller.
 - c. Screen Case: Made from metal **OR** metal and fire-retardant materials **OR** metal, wood, wood products, and fire-retardant materials, **as directed**.
 - d. Provide screen case with trim flange to receive ceiling finish **OR** constructed to be installed with underside flush with ceiling **OR** constructed to be installed with ceiling finish applied to underside, **as directed**.
 - e. Finish on Exposed Surfaces: Prime painted **OR** Vinyl covering or baked enamel, **as directed**.
 5. Suspended, Electrically Operated Screens with Automatic Ceiling Closure: Motor-in-roller **OR** End-mounted motor, **as directed**, units designed and fabricated for suspended mounting; with bottom of case composed of two panels, fully enclosing screen, motor, and wiring; one panel hinged and designed to open and close automatically when screen is lowered and fully raised, the other removable or openable for access to interior of case.
 - a. Provide metal or metal-lined motor enclosure on units with end-mounted motor.
 - b. Provide metal or metal-lined wiring compartment on units with motor in roller.
 - c. Screen Case: Made from metal **OR** metal and fire-retardant materials **OR** metal, wood, wood products, and fire-retardant materials, **as directed**.



- d. Provide screen case with trim flange to receive ceiling finish **OR** constructed to be installed with underside flush with ceiling **OR** constructed to be installed with ceiling finish applied to underside, **as directed**.
- e. Finish on Exposed Surfaces: Prime painted **OR** Vinyl covering or baked enamel, **as directed**.

C. Front-Projection Screen Material

1. Matte-White Viewing Surface: Peak gain not less than 0.9, and gain not less than 0.8 at an angle of 50 degrees from the axis of the screen surface.
2. Matte-Gray Viewing Surface: Peak gain not less than 0.8, and half-gain angle of not less than 50 degrees from the axis of the screen surface.
3. Glass-Beaded Viewing Surface: Peak gain not less than 2.0, and half-gain angle of at least 15 degrees from the axis of the screen surface.
4. Matte Reflective Viewing Surface: Peak gain not less than 1.3, and half-gain angle of at least 40 degrees from the axis of the screen surface.
5. Wide-Angle Reflective Viewing Surface: Peak gain not less than 1.5, and half-gain angle of at least 35 degrees from the axis of the screen surface.
6. Multipurpose Reflective Viewing Surface: Peak gain not less than 1.8, and half-gain angle of at least 25 degrees from the axis of the screen surface.
7. High-Gain Reflective Viewing Surface: Peak gain not less than 2.5, and half-gain angle of at least 20 degrees from the axis of the screen surface.
8. Material: Vinyl-coated, glass-fiber fabric or vinyl sheet.
9. Mildew-Resistance Rating: 0 or 1 when tested according to ASTM G 21.
10. Flame Resistance: Passes NFPA 701.
11. Flame-Spread Index: Not greater than 75 when tested according to ASTM E 84.
12. Seams: Where length of screen indicated exceeds maximum length produced without seams in material specified, provide screen with horizontal seam placed as follows:
 - a. At top **OR** bottom, **as directed**, of screen at juncture between extra drop length and viewing surface.
 - b. In location indicated.
13. Seamless Construction: Provide screens, in sizes indicated, without seams.
14. Edge Treatment: Black **OR** Without black, **as directed**, masking borders.
15. Size of Viewing Surface: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
16. Provide extra drop length of dimensions and at locations indicated.
 - a. Color: Same as viewing surface **OR** Black, **as directed**.

D. Flexible Rear-Projection Screen Material

1. Wide-Angle Screens: Peak gain not less than 1.0, and half-gain angle of at least 35 degrees from the axis of the screen surface.
2. Moderate-Gain Screens: Peak gain not less than 1.3, and half-gain angle of at least 30 degrees from the axis of the screen surface.
3. High-Gain Screens: Peak gain not less than 1.8, and half-gain angle of at least 15 degrees from the axis of the screen surface.
4. Material: Coated vinyl sheet.
5. Mildew-Resistance Rating: 0 or 1 when tested according to ASTM G 21.
6. Flame Resistance: Passes NFPA 701.
7. Flame-Spread Index: Not greater than 75 when tested according to ASTM E 84.
8. Seamless Construction: Provide screens, in sizes indicated, without seams.
9. Size of Viewing Surface: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.



10. Provide extra drop length of dimensions and at locations indicated.
 - a. Color: Same as viewing surface **OR** Black, **as directed**.
- E. Optically Coated Rigid Rear-Projection Screens
 1. Screen Substrate: Optically clear substrate complying with the following requirements:
 - a. Clear float glass complying with ASTM C 1036 for Type I (transparent glass, flat), Class 1 (clear), and Quality q3 (glazing select), 6.0 mm thick **OR** 10.0 mm thick **OR** 12.0 mm thick **OR** thickness as indicated, **as directed**.
 - b. Colorless, transparent, cast-acrylic sheet with a luminous transmittance of 92 percent per ASTM D 1003 and complying with ASTM D 4802, Category A-1 (cell cast), Finish 1 (smooth or polished), 1/4 inch (6.4 mm) thick **OR** 3/8 inch (9.5 mm) thick **OR** 1/2 inch (12.7 mm) thick **OR** thickness as indicated, **as directed**.
 - c. Fresnel lens cast from colorless, transparent, acrylic with a luminous transmittance of 92 percent per ASTM D 1003 and complying with ASTM D 4802, Category A-1 (cell cast), Finish 1 (smooth or polished) on one side and Finish 2 (patterned) on other side, 1/4 inch (6.4 mm) thick **OR** 3/8 inch (9.5 mm) thick **OR** 1/2 inch (12.7 mm) thick **OR** thickness as indicated, **as directed**.
 2. Optical Coating: Durable, washable coating bonded to one side of substrate.
 3. Wide-Angle Screens: Peak gain not less than 1.0, and half-gain angle of at least 35 degrees from the axis of the screen surface.
 4. Moderate-Gain Screens: Peak gain not less than 1.3, and half-gain angle of at least 30 degrees from the axis of the screen surface.
 5. General-Purpose Screens: Peak gain of not less than 1.8, and half-gain angle of at least 28 degrees from the axis of the screen surface.
 6. High-Gain Screens: Peak gain not less than 2.0, and half-gain angle of at least 20 degrees from the axis of the screen surface.
 7. Optical Tint: High-contrast dark gray **OR** Medium neutral gray **OR** Neutral white **OR** Manufacturer's standard, **as directed**.
 8. Protective Coating: Provide formulation designed by screen manufacturer as a permanent topcoat over optical coatings to protect against normal abrasion before, during, and after installation.
 9. Writing-Surface Coating: Provide screen manufacturer's protective coating, designed as a writing surface for dry-erase markers, on front of screen.
 10. Size of Viewing Surface: 40 by 54 inches (1016 by 1371 mm) **OR** 43 by 57 inches (1092 by 1447 mm) **OR** 50 by 67 inches (1270 by 1701 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 60 by 80 inches (1524 by 2032 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
- F. High-Performance Rigid Rear-Projection Screens
 1. High-Performance Screens, General: Acrylic screen with Fresnel lens on rear surface and linear lenses on front surface.
 - a. Screen Substrate: Optically clear acrylic with a luminous transmittance of 92 percent per ASTM D 1003 and complying with ASTM D 4802, Category A-1 (cell cast), Finish 2 (patterned), 1/4 inch (6.4 mm) thick **OR** 3/8 inch (9.5 mm) thick **OR** 1/2 inch (12.7 mm) thick **OR** thickness as indicated, **as directed**.
 2. Performance:
 - a. Peak gain not less than 3.0 **OR** 4.0, **as directed**, and horizontal half-gain angle of at least 50 degrees from the axis of the screen surface.
 - b. Peak gain of 3.5 **OR** 4.0, **as directed**, and horizontal half-gain angle of at least 30 degrees from the axis of the screen surface.
 - c. Performance: Peak gain of 5.0, and horizontal half-gain angle of at least 25 degrees from the axis of the screen surface.
 - d. Performance: Peak gain not less than 1.5 **OR** 3.0, **as directed**, and horizontal half-gain angle of at least 20 degrees from the axis of the screen surface.
 3. Size of Viewing Surface: 40 by 54 inches (1016 by 1371 mm) **OR** 43 by 57 inches (1092 by 1447 mm) **OR** 50 by 67 inches (1270 by 1701 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 60 by 80 inches (1524 by 2032 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.



G. Rigid Rear-Projection Screen Accessories

1. Factory Frames: Screen manufacturer's standard frames of profile indicated, fabricated to sizes required to fit screens from aluminum extrusions complying with ASTM B 221 (ASTM B 221M) for 6063-T5 alloy and temper.
 - a. Class II, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
 - b. Class II, Color Anodic Finish: AA-M12C22A42/A44 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker) complying with AAMA 611.
 - 1) Color: Black **OR** Dark bronze **OR** Either black or dark bronze, as standard with manufacturer, **as directed**.
2. Glazing Accessories for Factory Frames: Provide gaskets and setting blocks with proven record of compatibility with screen and frame surfaces, of sizes and shapes to accommodate thickness of screen indicated and to fit glazing channel provided.
3. Glazing Accessories for Field-Framed Screens: Provide materials compatible with screen and frame surfaces while complying with applicable requirements in Division 08 Section "Glazing".

1.3 EXECUTION

A. Front-Projection Screen Installation

1. Install front-projection screens at locations indicated to comply with screen manufacturer's written instructions.
2. Install front-projection screens with screen cases in position and in relation to adjoining construction indicated. Securely anchor to supporting substrate in a manner that produces a smoothly operating screen with vertical edges plumb and viewing surface flat when screen is lowered.
 - a. Install low-voltage controls according to NFPA 70 and complying with manufacturer's written instructions.
 - 1) Wiring Method: Install wiring in raceway except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
 - b. Test electrically operated units to verify that screen controls, limit switches, closures, and other operating components are in optimum functioning condition.
 - c. Test manually operated units to verify that screen-operating components are in optimum functioning condition.

B. Rigid Rear-Projection Screen Installation

1. Install rear-projection screens at locations indicated to comply with screen manufacturer's written instructions. Handle screens carefully during installation using procedures and tools recommended by screen manufacturer; do not abrade screen surfaces.
2. Install optically coated rear-projection screens with optical coating toward projector **OR** audience, **as directed**.
3. Install high-performance, rear-projection screens with orientation as indicated in manufacturer's written instructions.
4. Install factory-framed, rear-projection screens in prepared wall openings. Securely anchor frames to surrounding construction so frames are plumb and level and screen surfaces are flat.
5. Install rear-projection screens with glass substrates, in frames specified in other Sections, to comply with applicable requirements in Division 08 Section "Glazing" and with screen manufacturer's written instructions. Set projection screen with surfaces flat and edges plumb and level.



6. Install rear-projection screens with plastic substrates, in frames specified in other Sections, to comply with screen manufacturer's written instructions. Clamp units only at top edge and allow for expansion and contraction of plastic glazing material by providing frame with adequate bite and edge clearances.
- C. Protecting And Cleaning Rigid Rear-Projection Screens
1. Provide temporary covering of rear-projection screens until time of Final Completion. Use type of covering approved by screen manufacturer that will effectively protect screen from abrasion, breakage, or other damage.
 2. Clean rear-projection screens on both faces immediately before date scheduled for inspection intended to establish date of Final Completion. Use methods and cleaning materials recommended by screen manufacturer, taking care not to scratch or damage optical coatings or screen substrates.
- D. Projection Screen Schedule
1. Manually Operated, Front-Projection Screen Type: Surface mounted, metal encased **OR** Surface mounted, wood finished, **as directed**.
 - a. Screen Surface: Matte white **OR** Matte gray **OR** Glass beaded **OR** Matte reflective **OR** Wide-angle reflective **OR** Multipurpose reflective **OR** High-gain reflective, **as directed**.
 - b. Viewing Surface Size: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
 - c. Extra Drop Length: As needed at top of screen for bottom of screen to be 36 inches (900 mm) above floor and 36 inches (900 mm) at bottom of screen, **as directed**.
 2. Electrically Operated, Front-Projection Screen Type: Surface mounted, metal encased **OR** Surface mounted, wood finished **OR** Suspended, without ceiling closure **OR** Suspended, with automatic ceiling closure, **as directed**.
 - a. Motor Configuration: Motor in roller **OR** End-mounted motor on right end of screen **OR** End-mounted motor on left end of screen **OR** End-mounted motor on end of screen indicated, **as directed**.
 - b. Screen Surface: Matte white **OR** Matte gray **OR** Glass beaded **OR** Matte reflective **OR** Wide-angle reflective **OR** Multipurpose reflective **OR** High-gain reflective, **as directed**.
 - c. Viewing Surface Size: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
 - d. Extra Drop Length: As needed at top of screen for bottom of screen to be 36 inches (900 mm) above floor and 36 inches (900 mm) at bottom of screen, **as directed**.
 3. Manually Operated, Rear-Projection Screen Type: Surface mounted, metal encased **OR** Surface mounted, wood finished, **as directed**.
 - a. Screen Type: Wide angle **OR** Moderate gain **OR** High gain, **as directed**.
 - b. Viewing Surface Size: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
 - c. Extra Drop Length: As needed at top of screen for bottom of screen to be 36 inches (900 mm) above floor and 36 inches (900 mm) at bottom of screen, **as directed**.
 4. Electrically Operated, Rear-Projection Screen Type: Surface mounted, metal encased **OR** Surface mounted, wood finished **OR** Suspended, without ceiling closure **OR** Suspended, with automatic ceiling closure, **as directed**.
 - a. Motor Configuration: Motor in roller **OR** End-mounted motor on right end of screen **OR** End-mounted motor on left end of screen **OR** End-mounted motor on end of screen indicated, **as directed**.
 - b. Screen Type: Wide angle **OR** Moderate gain **OR** High gain, **as directed**.



- c. Viewing Surface Size: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
- d. Extra Drop Length: As needed at top of screen for bottom of screen to be 36 inches (900 mm) above floor and 36 inches (900 mm) at bottom of screen, **as directed**.
- 5. Rigid Rear-Projection Screen Type: Optically coated screen.
 - a. Screen Substrate: Glass **OR** Acrylic, **as directed**.
 - b. Screen Type: Wide angle **OR** Moderate gain **OR** General purpose **OR** High gain, **as directed**.
 - c. Optical Tint: High-contrast dark gray **OR** Medium neutral gray **OR** Neutral white, **as directed**.
 - d. Size of Viewing Surface: 40 by 54 inches (1016 by 1371 mm) **OR** 43 by 57 inches (1092 by 1447 mm) **OR** 50 by 67 inches (1270 by 1701 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 60 by 80 inches (1524 by 2032 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
 - e. Additional Features: Protective coating **OR** Writing surface coating **OR** Factory frame, **as directed**.
- 6. Rigid Rear-Projection Screen Type: High-performance screen.
 - a. Gain: Not less than 1.5 **OR** 3 **OR** 3.5 **OR** 4 **OR** 5, **as directed**.
 - b. Horizontal Half-Gain Angle: At least 20 **OR** 25 **OR** 30 **OR** 50, **as directed**, degrees from screen axis.
 - c. Size of Viewing Surface: 40 by 54 inches (1016 by 1371 mm) **OR** 43 by 57 inches (1092 by 1447 mm) **OR** 50 by 67 inches (1270 by 1701 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 60 by 80 inches (1524 by 2032 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
 - d. Additional Features: Factory frame.

END OF SECTION 11 52 13 13



Task	Specification	Specification Description
11 52 13 13	01 22 16 00	No Specification Required
11 52 13 16	11 52 13 13	Projection Screens
11 52 16 26	01 22 16 00	No Specification Required
11 53 43 00	01 22 16 00	No Specification Required



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SECTION 11 82 19 00 - PACKAGED INCINERATORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of packaged incinerators. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definitions

1. Waste Type

- a. Type 0, Trash: A mixture of highly combustible waste such as paper, cardboard cartons, wood boxes, and floor sweepings from commercial and industrial activities. The mixture consists of up to 10 percent by weight plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags, and plastic or rubber scraps. This type of waste contains up to 10 percent moisture and not more than 5 percent non-combustible solids, and has a heating value of 8,500 BTU per pound (19,805 kJ/kg) as fired.
- b. Type 1, Rubbish: A mixture of combustible waste such as paper, cardboard cartons, wood scraps, foliage, and floor sweepings from domestic, commercial, and industrial activities. The mixture consists of up to 20 percent by weight restaurant waste, but contains little or no treated paper, plastic, or rubber wastes. This type of waste contains up to 25 percent moisture and not more than 10 percent incombustible solids, and has a heating value of 6,500 BTU per pound (15,145 kJ/kg) as fired.
- c. Type 2, Refuse: An approximately even mixture of rubbish and garbage by weight. This type of waste, common to apartment and residential occupancy, consists of up to 50 percent moisture and not more than 7 percent incombustible solids, and has a heating value of 4,300 BTU per pound (10,019 kJ/kg) as fired.
- d. Type 3, Garbage: Garbage such as animal and vegetable wastes from restaurants, hotels, hospitals, markets, and similar installations. This type of waste contains up to 70 percent moisture and up to not more than 5 percent incombustible solids, and has a heating value of 2,500 BTU per pound (5825 kJ/kg) as fired.
- e. Type 4, Pathological: Human and animal remains, such as organs, animal carcasses, and solid organic wastes from hospitals, laboratories, slaughterhouses, animal pounds, and similar sources. This type of waste contains up to 85 percent moisture and not more than 5 percent incombustible solids, and has a heating value as low as 1,000 BTU per pound (2330 kJ/kg) as fired.
- f. Type 5, Classified: A mixture of highly combustible waste such as paper, plastics, or other items that have been used for intelligence purposes, or deemed sensitive to completing a sensitive mission on behalf of our National security. This mixture consists of up to 10 percent by weight plastic bags, coated paper, laminated paper, and plastic products. This type waste has approximately zero percent moisture content and non-combustible solids, and has a heating value of 7,000 to 10,000 BTU per pound (16,310 to 23,300 kJ/kg) as fired.

C. Submittals:

1. Shop Drawings: Equipment installation.
2. Product Data:
 - a. Incinerator
 - b. Controls and instruments
3. Test Reports:
 - a. Instrument readings
 - b. Computations
 - c. Methods



- d. Performance
- 4. Certificates: Incinerator
- 5. Operation and Maintenance Data: Incinerator

D. Special Tools

- 1. Equipment specified under this section requiring special tools for assembly, adjustment, setting, or maintenance thereof shall be furnished as standard accessories.

1.2 PRODUCTS

- A. Incinerator (Manufactured Units): Provide packaged type controlled-air incinerator capable of burning Type as required to meet project requirements waste suitable for indoor installation, As required to meet project requirements, outdoor installation including totally enclosed electric motors, and corrosion and moisture protection, and equipped for manual **OR** mechanical, **as directed**, loading and operation.
- B. Capacity: Burn rate shall be as required to meet project requirements. Ash removal shall be an entire clean-out. Incinerator shall require no more than three ash clean-outs per week. Burnout and cool-down for ash removal shall be accomplished in not more than 72 hours after first ignition and in not more than 20 hours after final load addition during the weekly time period specified herein.
- C. Incineration of Classified Material: Incinerator shall reduce paper content to ash. Oxidize or melt other materials containing classified information, to prevent recovery of information for intelligence purposes. Screening ash, manual stoking, manual agitation, or opening of incinerator doors will not be allowed.
- D. Stack Emissions: The incinerator shall conform to all Federal, State and local Environmental Protection Agency (EPA) requirements and regulations.
- E. Noise Level: Noise level at one foot from each incinerator component shall not exceed 84 decibels, A scale.
- F. Electromagnetic Interference Control: Equipment shall conform to Class IIIC electromagnetic interference control and test limit requirements specified in MIL-STD-461.
- G. Primary and Secondary Chambers: Incinerator shall consist of a primary combustion chamber for partial burning and conversion of combustible material to gas and a secondary combustion chamber that shall consume combustible gases and entrained combustible particles. Preassemble and mount incinerator in accordance with the manufacturer's instructions. Packaged unit shall include a combustion air fan, primary and secondary burners, air distribution controls, and burner controls. Unit shall be ready for immediate mounting and ready for attachment of fuel, electrical, and vent and water supply connections. Provide lifting eyes.
 - 1. Primary Chamber: Construct primary chamber casing of steel supported by a steel frame and provided with insulation and refractory. Casing shall be not less than 3/16 inch (4.76 mm) sheet steel conforming to ASTM A 569/A 569M and reinforced to withstand internal pressures without deflection or damage to refractory or other components. Construct frame and reinforcing members of steel conforming to ASTM A 36/A 36M. Frame shall be free standing and support the weight of incinerator components, including doors, burners, breeching, stack connections, and appurtenant assemblies without binding or warping. Provide access doors and ports with seals to prevent emission of smoke or admission of significant amounts of air during incinerator operation. Primary chamber shall have no grates, ash clean-out doors, or other openings which would permit leakage of waste fluids.
 - a. Insulation:
 - 1) The values for minimum thickness of insulation are in the following table:

INSULATION THICKNESS VS. CAPACITY



Capacity (pounds/hour)	(grams/second)	Min. Insulation Thickness (inches)	(mm)
For Walls	For Walls		
Up to 500	Up to 63	2	50.80
500 to 2,000	63 to 252	2 1/2	63.50
For Hearths			
Indoors			
Up to 500	Up to 63	2 1/2	63.50
500 to 2,000	63 to 252	4	101.60
Outdoors		1 1/2	38.10

- 2) Class 5 block conforming to ASTM C 612, containing no asbestos material, and of such thickness to prevent damage to the foundation due to excessive heat. Insulating cement shall conform to ASTM C 195 or ASTM C 196.

b. Refractory:

- 1) Values for minimum thickness of refractory:



REFRACTORY THICKNESS VS. CAPACITY

<u>Capacity</u> <u>(pounds/hour)</u>	<u>(grams/second)</u>	<u>Min. Insulation Thickness</u>	
		<u>(inches)</u>	<u>(mm)</u>
For Walls	For Walls		
Up to 500	Up to 63	4 1/4	108
500 to 2,000	63 to 252	4 1/4	108
For Hearths			
Indoors			
Up to 500	Up to 63	4 1/2	114
500 to 2,000	63 to 252	4 1/2	114
Outdoors		2 1/2	63.50

- 2) Heat-resistant non-asbestos containing clay, plastic or castable type. Attach refractory walls to casing with alloy steel or refractory anchors to form a monolithic structure which will resist heat and support walls with a safety factor of 4.
- c. Doors: Provide doors for stoking, clean-out, and charging areas of the incinerator. Construct doors and door frames of cast iron conforming to ASTM A 319 or steel conforming to ASTM A 569/A 569M or ASTM A 36/A 36M. Line doors exposed to flame or direct heat of combustion gases with the same type and thickness of refractory and insulation used in the combustion chamber. Attach refractory to doors to prevent sagging. Refractory shall have tapered edges to clear door frames during movement of swinging doors. Weld alloy steel hooked bars to the door cover to anchor the refractory. Doors shall be safely operable by one person. Temperature of door handles shall permit operation of door without gloves or other protective devices. Interlock charging doors with burners and air supply so that burners and blowers disconnect when door opens. Door closure gasket shall be non-asbestos high-temperature resistant material capable of withstanding expected temperatures. Vertically operated doors shall be counterweighted to require a manual operating force of 30 pounds (134 N) maximum. Guillotine type doors shall lift completely off the seals prior to movement. Provide full swing type doors with an integral smaller feed door having a minimum rectangular clear opening of 24 by 24 inches (610 by 610 mm) or a minimum circular clear opening of 30 inches (762 mm) diameter. Provide doors with hasps or brackets to permit locking. Furnish a lock and two keys for each door on classified waste incinerators.
- 1) Manual Charging Doors: Provide full swing type doors for batch feeding; guillotine type doors for continuous feeding. Minimum door size of 24 by 24 inches (610 by 610 mm).
 - 2) Mechanical Charging Doors: Guillotine type or sweep type. Provide an inner and outer door. The inner or charging door shall open with operation of the charger. Interlock the inner and outer doors to prevent simultaneous opening during operation of incinerator. Insulate door to combustion chamber of incinerator. Line door with refractory material and anchor as specified herein for refractory. Construct outer door of same materials as exterior casing of incinerator. Provide doors with means for manual operation.
 - 3) Clean-out Doors: Clean-out doors shall provide access for total clean-out and visual inspection of the entire interior of the incinerator and shall not permit leakage of waste fluids.
- d. Observation Ports: Provide two observation ports in the primary combustion chamber. Furnish ports with a heat-resistant glass cover or angular steel frame and closure plate with handle for operation without gloves or other protective devices. Ports shall extend from casing exterior to not less than one-half the thickness of the refractory lining. Observation ports shall be gas tight.



- e. Test Holes: Fit test holes with standard weight, 2 inch (50 mm) **OR** 4 inch (100 mm), **as directed**, diameter, black steel pipe sleeve welded to casing. Extend sleeve from casing exterior to not less than one-half the thickness of the refractory lining. Form refractory opening from the pipe sleeve end to the interior wall surface to shield the sleeve end from reflected heat. Fit sleeve with a brass screw cap.
 - f. Solid Hearth: Construct of non-asbestos heat-resistant clay, plastic or castable type. Provide solid hearth for incinerators burning pathological wastes. Provide refractory of sufficient thickness and strength to prevent heat transfer to casing or foundation, not less than 4 1/2 inches (114 mm) in thickness and able to withstand temperatures of 3000 degrees F (1649 degrees C). Hearth shall support not less than twice the hourly burn rate load and shall not permit leakage of waste fluids.
 - g. Draft Equipment: Capability of providing the correct amount of air to permit controlled combustion through operating range. Equipment shall include forced draft fans, draft gages, dampers, damper actuators, and linkage.
 - 1) Air Ducts: Introduce air for combustion to the primary chamber below the waste material through perforated under-fire air pipes or ducts. Over-fire air shall be controlled with automatic modulating air intake ports for completing combustion of combustible materials in gases, or for reducing operating temperatures. Ducts shall be constructed of sheet steel conforming to ASTM A 569/A 569M. Seams shall be air tight.
 - 2) Fan: Forced draft, multi-blade, forward curved, centrifugal type conforming to CID A-A-59222. Fan shall comply with standards of AMCA 99, applicable to centrifugal furnace fans, and rated for flow rate, pressure, power, speed of rotation, and efficiency in accordance with ANSI/AMCA 210.
 - 3) Damper: Controller-actuated to regulate air to the fan. Construct of wrought sheet steel conforming to ASTM A 569/A 569M, and no less than 1/16 inch (1.59 mm) thick. Damper shall operate without noise or flutter. Actuators shall be electric motor operated, 115 volts ac.
 - 2. Secondary Chamber: Provide with an exterior casing not less than 3/16 inch (4.76 mm steel) conforming to ASTM A 569/A 569M. Refractory lining shall be same type and thickness required for primary chamber walls. Insulation shall be of the same class and thickness used in the primary chamber. Minimum retention time of one second shall be allowed for conditions within normal operating limits.
- H. Burners
- 1. Insert appropriate fuel oil or gas specification section(s) associated with this project. Only allow direct electric spark ignition for burners up to 2,500,000 BTU/hour (732,500 watt). Values of minimum burner input capacity:



SIZE OF BURNERS, (x1000) Watts
Primary Burners

Capacity of Incinerator, (grams/sec)	2490 Min. kJ/kg Refuse	1905 Min. kJ/kg Refuse	1260 Min. kJ/kg Refuse	733 Min. kJ/kg Refuse	293 Min. kJ/kg Refuse	Secondary Burners All Refuse
6.30	350	350	582	815	990	466
12.60	466	466	1282	1631	1980	699
18.90	582	559	1514	2330	3262	932
31.50	699	699	1748	2680	3728	1514
63.00	1282	1282	2563	3845	5126	2330
94.50	1748	1748	3495	5242	6990	3029
126.00	2097	2047	3961	5592	7223	3961
189.00	2563	2563	5126	7689	10252	4893
252.00	3728	3728	7689	11650	15378	6291

SIZE OF BURNERS, (x1000) BTU/Hr
Primary Burners

Capacity of Incinerator, (lb/hr)	8500 Min. BTU/lb Refuse	6500 Min. BTU/lb Refuse	4300 Min. BTU/lb Refuse	2500 Min. BTU/lb Refuse	1000 Min. BTU/lb Refuse	Secondary Burners All Refuse
50	150	150	250	350	425	200
100	200	200	550	700	850	300
150	250	240	650	1,000	1,400	400
250	300	300	750	1,150	1,600	650
500	550	550	1,100	1,650	2,200	1,000
750	750	750	1,500	2,250	3,000	1,300
1,000	900	900	1,700	2,400	3,100	1,700
1,500	1,100	1,100	2,200	3,300	4,400	2,100
2,000	1,600	1,600	3,300	5,000	6,600	2,700

- Provide gas **OR** oil **OR** combination gas and oil, **as directed**, burners for the primary and secondary combustion chambers. Design burners for natural type gas or No. 2 fuel oil conforming to ASTM D 396. Fuel oil **OR** Gas, **as directed**, piping is covered in Division 23 Section(s) "Facility Fuel-oil Piping" OR "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Each burner shall be a complete burner assembly including fuel, control systems, and accessories. Secondary burner shall be capable of maintaining a minimum continuous temperature in the secondary chamber of 1,600 degrees F (871 degrees). Minimum continuous temperature of 1,400 degrees F (760 degrees C) shall be maintained at the roof near the exit of the primary chamber. Burners shall be interrupted type with gas-electric or electrically spark-ignited and regulated by a variable set point indicator-controller adjustable from zero to 3000 degrees F (1649 degrees C) to operate within temperature limits recommended by the manufacturer. Controllers shall be actuated by a thermocouple. Mounting, flame shape, and characteristics of each burner shall be suitable for the incinerator chamber in which the burner is installed. Flame impingement on the incinerator wall will not be permitted. Each burner shall be Factory Mutual listed in FM P7825 and furnished with flame failure protection. Flame safeguard sensor shall be sighted to detect only the burner flame for which it is designed. Furnish burners with manufacturer recommended appurtenances, for a complete installation. Burners shall be removable for inspection, cleaning, adjustment, and maintenance. Locate thermocouples in the



primary and secondary chambers capable of operating at a maximum temperature of 3000 degrees F (1649 degrees C).

- I. Controls And Instruments: Control equipment and instruments shall include burners and fan controls, time clocks, relays, operating switches, indicating lights, gages, motor starters, fuses, alarms, circuit elements of control system, and other instruments required for operation. Mount controls and instruments on a single control panel. Control system shall provide on-off control or proportioning control of the primary air supply and fuel supply to the secondary burner. Temperature indicator shall provide a visual indication for safe loading of the incinerator and excessive high temperature conditions which may require control by the operator. Interlock control circuit systems to prevent hazardous conditions, air pollution, and made fail safe.
 1. Control Panel: Sheet steel, weather tight, conforming to UL 50. Flush mount controls, instruments, and other equipment at the factory and test the assembly prior to shipment. Furnish a lock and two keys. Identify controls and instruments with nameplates conforming to MIL-DTL-15024. Provide a heater to prevent condensation.
 2. Draft Gages: ANSI/ASME B40.1, diaphragm or bellows actuating system and circular scale. The gages shall have a zero adjustment screw. Provide shut-off cocks.
 3. Pressure Gages: ANSI/ASME B40.1, single Bourdon tube style, suitable for measuring air pressure.
 4. Thermocouples: Provide to measure gas passage temperatures and control burner operation. Provide thermocouples which operation up to 3000 degrees F (1649 degrees C), and accurate within one-half percent of the operating and indicating temperature range.
 5. Emissions Monitoring Instrumentation: Provide incinerator and stack monitoring instrumentation for acceptance tests, emissions tests, and monitoring.
- J. Stack: Stack shall meet local building and fire protection codes, including local, state, and federal regulations conforming to NFPA 211. Attach a corrosion-resistant steel spark arrestor not less than No. 18 gage, and with 1/2 inch (15 mm) mesh wire screen extending to top of stack and a corrosion-resistant steel weather cap. Provide tests ports for acceptance testing and/or emissions testing and monitoring.
- K. Connectors: Provide to connect the incinerator to the stack in accordance with NFPA 211. Locate the connector at a minimum clear vertical distance of eight feet (2.45 mm) above the floor **OR** ground, **as directed**.
- L. Charging Method:
 1. Manual: Incinerators having a capacity of less than 300 pounds per hour (38 grams per second) should be manually charged. Manual charger shall include a front loading door with minimum dimensions of 24 by 24 inches (610 by 610 mm). Combustion chamber shall operate at negative air pressure when the loading door is open to prevent injury to the operator and the escape of smoke and gases. Provide an interlock to prevent operation of the charger when a predetermined safe operating temperature is exceeded. Locate the charger on the end **OR** side **OR** top, **as directed**, of the incinerator.
 2. Mechanical: Incinerators having a capacity of 300 pounds per hour (38 grams per second) or more should be mechanically charged. Provide an automatic mechanical loading device compatible with the incinerator. Flange loader to incinerator. Construct loading device of plate steel conforming to ASTM A 36/A 36M. The loader shall include a single **OR** dual, **as directed**, hydraulic power pack driven by an electric motor conforming to NEMA MG 1. Loader shall include a guillotine type fire door lined with the same thickness refractory as the combustion chamber. The charging chamber shall have a capacity of not less than one cubic yard (0.76 cubic meter). Locate charging chamber access door on top of the loader and hinged. Provide a temperature actuated automatic sprinkler device located inside the loader. Integrate operation of the automatic loader with the control system. An indicating light shall indicate when the incinerator can be charged. Mount light on control box, visible to the operator. When charging chamber door is closed and light on; indicating the incinerator can be charged, the following sequence shall take place when the loader is actuated in the charge mode: (1) fire door opens,



(2) ram pushes material into the incinerator, (3) ram retracts, (4) fire door closes, (5) indicator light signals the loader is ready to be charged. When loader is in the automatic mode of operation, fire door and charging chamber door shall not be allowed to open at the same time. Provide a manual override system so that ram, fire door, or charging chamber door can be operated independently.

3. Firing Tools: Provide firing tools, including shovel, hoe, rake, slice bar, used for firing the incinerator, and firing tool rack. Locate as indicated. Rack shall be steel and include hooks or other means for storing tools.

1.3 EXECUTION

- A. Equipment Installation: NFPA 82, as applicable. Combustion air supply and ventilation shall be in accordance with NFPA 54 **OR** NFPA 31, **as directed**.
- B. Utility Services Connections: Connect to utility services as directed.
- C. Foundation: Foundation shall be of size and strength to support incinerator and extend not less than 3 feet (one meter) beyond incinerator sides, and not less than 8 feet (2.45 meters) on front or side where ashes are removed.
- D. Fuel Supply: Install gas appliances and piping in accordance with NFPA 54, as applicable. Install oil burning equipment to conform to the applicable requirements of NFPA 31.
- E. Stack Support: Stack support shall be in accordance with paragraph entitled "Stack" of this section, NFPA 82 and NFPA 211, as applicable. Adequate vertical and lateral supports for exterior chimneys shall withstand wind forces of 106 miles per hour (171 km per hour), **unless directed otherwise**.
- F. Lubrication: Provide lubrication means for parts of equipment normally requiring lubrication. Where use of high pressure will damage grease seals or other parts, provide pressure release fittings.
- G. Treatment And Painting: Provide manufacturer's standard factory applied finish suitable for exterior service.
- H. Identification: Fasten an aluminum, brass, or corrosion-resistant steel nameplate to the equipment in a visible location by means of rivets or sheet metal screws. The nameplate shall contain data such as the manufacturer's name, model, or series number; electrical requirements; and serial number. The information shall be indented or embossed in the metal. The nameplate shall not be painted over.
- I. Field Quality Control
 1. General: Upon delivery to the job site, equipment and materials shall receive a preliminary inspection by the the Owner. Inspection will be continued during installation, after installation, and during tests. Inspections shall be made to assure equipment and installation comply with local, state, federal, and utility requirements for equipment, air pollution, and safety. Furnish labor, equipment, apparatus, and materials for testing, except waste materials used for testing. the Owner will supply waste material, fuel oil, gas, water, and electricity. Rectify defects disclosed by tests, and repeat tests. Two instruction manuals shall be available during tests. Perform tests under direct supervision of the start-up engineer employed by the Contractor. The the Owner shall be present for tests. Reports certifying instrument readings indicated are actual, computations required for testing are accurate, acceptable methods were used, and units satisfactory performed in accordance with requirements shall be furnished.
 2. Tests
 - a. Fuel Systems: Remove gages and apparatus that may be damaged by test pressure from the system prior to testing. Maintain required test pressure for not less than two hours to provide sufficient time for inspection of joints and connections. Correct defects which



- develop during testing and retest piping system until system shows no defects or weakness.
- 1) Oil: Test oil piping systems with a hydrostatic pressure of one and one-half times the maximum working pressure.
 - 2) Gas: Pneumatically test gas piping systems tested at operating pressure. Use the soap bubble method to verify the tightness of the system.
- b. Performance: Preheat incinerator for four hours to reach the firing temperature of 1800 degrees F (982 degrees C). Weight the waste charges and provide a record of the total charge weight. Charge incinerator with the Owner provided waste at rated capacity in lb/hr (kg/sec) for a period of four hours. Operate incinerator in accordance with manufacturer's written instructions. Waste shall be reduced to a fine ash residual. Follow normal burnout procedure. Weigh residue after incinerator has cooled. Weight of residue shall not exceed 5.0 percent charge weight.
- 1) Clean-out: Residue from burning classified material shall be hand sorted or screened into three categories; totally oxidized white or off-white ash, unburned materials, and blackened or partially burned paper fragments. Clean-out and sorting shall be witnessed by the the Owner. Inspect materials to verify that the requirements in paragraph entitled "Incineration" of Classified Materials, are met. After clean-out, inspect incinerator for deterioration such as slagged or spalling refractory, warping of parts, and discolored exterior paint. Unit will be rejected until these conditions are repaired and do not recur in retesting. Such procedures that may create respirable dust shall require use of a OSHA certified dust respirator.
- c. Control: Test incinerator under actual firing conditions. Test shall verify controls function within maximum and minimum limits for temperature or timing. Simulate actual unsafe conditions such as high temperatures and flame failure by reducing settings for the activation of limit and safety controls.
- d. Shell Temperature: Operate incinerator under normal load conditions for not less than four hours. Record temperature readings of the outer shell at not less than five random locations of the secondary chamber. Shield incinerators installed outdoors from direct rays of the sun.

END OF SECTION 11 82 19 00



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SECTION 11 82 26 00 - WASTE COMPACTORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for waste compactors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes waste compactors and diverters.

C. Definitions

1. WASTEC Rating: The volume of waste material in the charging chamber moved by the ram within the compactor in a single stroke.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties and accessories, and finishes.
2. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Dimensions locating chutes that interface with waste compactors.
 - c. Location and installation details of automatic sprinkler in hopper of each chute-fed compactor.
 - d. Equipment access points and required space for equipment service and operation.
 - e. Setting drawings, templates, and instructions for installing anchor bolts and other anchorages.
 - f. Wiring Diagrams: For power, signal, and control wiring.
3. Qualification Data: For qualified Installer.
4. Product Certificates: For each type of waste compactor, from manufacturer.
5. Field quality-control reports.
6. Operation and Maintenance Data: For waste compactors to include in operation and maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
2. Waste Compactor Standards: Comply with ANSI Z245.2 and with NFPA 82.
3. Waste Bin and Hopper Standard: Comply with ANSI Z245.30.

F. Maintenance Service

1. Initial Maintenance Service: Beginning at Final Completion, provide 12 months' full maintenance by skilled employees of waste compactor Installer. Include monthly preventive maintenance, repair, or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper waste-compactor operation at rated speed and capacity. Provide parts and supplies the same as those used in the manufacture and installation of original equipment.
2. Continuing Maintenance Proposal: From Installer to the Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.



1.2 PRODUCTS

A. Waste Compactors

1. Waste Compactors: Manufacturer's standard vertical **OR** stationary horizontal **OR** self-contained horizontal **OR** combination-container **OR** vertical **OR** pivoting-ram type, **as directed**, packaged units with components, options, and accessories needed to comply with requirements and provide complete functional systems.
 - a. WASTEC Rating Size (Volume): Minimum: 0.14 cu. yd. (0.11 cu. m) **OR** 1.00 cu. yd. (0.77 cu. m) **OR** 1.50 cu. yd. (1.15 cu. m) **OR** 2.00 cu. yd. (1.53 cu. m) **OR** 3.50 cu. yd. (2.68 cu. m) **OR** 5.00 cu. yd. (3.82 cu. m) **OR** 7.50 cu. yd. (5.73 cu. m) **OR** 10.00 cu. yd. (7.65 cu. m), **as directed**.
 - b. Clear Top Opening (Length by Width) Minimum: 20 by 28 inches (508 by 711 mm) **OR** 24 by 36 inches (610 by 914 mm) **OR** 30 by 48 inches (762 by 1219 mm) **OR** 60 by 48 inches (1524 by 1219 mm) **OR** 108 by 72 inches (2743 by 1829 mm), **as directed**.
 - c. Cycle Time: Maximum 30 **OR** 40 **OR** 50 **OR** 60 **OR** 70 seconds, as directed.
 - d. Discharge Opening (Width by Height): Maximum: **As directed**.
 - e. Minimum Discharge Opening: **As directed**.
 - f. Ground Height: Minimum **As directed**.
 - g. Ram Face: **As directed**.
 - h. Ram Penetration: 6 inches (152 mm) **OR** 14 inches (355 mm) **OR** 30 inches (762 mm), **as directed**.
 - i. Normal/Maximum Result Ram Forces: 20,000/22,000 lbf (89/98 kN) **OR** 36,000/40,000 lbf (160/178 kN) **OR** 70,000/80,000 lbf (311/356 kN) **OR** 125,000/150,000 lbf (556/667 kN), **as directed**.
 - j. Normal/Maximum System Pressures: 1600/1800 psi (11.0/12.4 MPa) **OR** 2000/2400 psi (13.8/16.5 MPa) **OR** 2500/2800 psi (17.2/19.3 MPa), **as directed**.
 - k. Scale Weight. Maximum: 2500 lb (1134 kg) **OR** 6000 lb (2722 kg) **OR** 12,000 lb (5443 kg) **OR** 20,000 lb (9072 kg), **as directed**.
 - l. Motor Size: 3 hp **OR** 10 hp **OR** 15 hp **OR** 20 hp **OR** 30 hp **OR** 50 hp, **as directed**.
 - m. Electrical Power Supply: 120 **OR** 208 **OR** 240 **OR** 480 V, 1 **OR** 3 phase, **as directed**, 60 Hz.
 - n. Controls: **As Directed**.
 - o. Finish: Manufacturer's standard **OR** as selected by the Owner.
 - p. Deodorizing Device: Manufacturer's standard **OR** as selected by the Owner.
2. Diverter: Compactor Manufacturer's standard **OR** as selected by the Owner coordinated with chute dimensions and designed to divert waste from one chute into two compactors, with chute-relay controls and finished to match compactor or as directed by the Owner.
3. Number of Extra Storage Containers: One **OR** Two, **as directed**.

B. Fabrication

1. Fabricate waste compactors with smooth, eased, exposed edges to prevent injury to persons in vicinity of the equipment.
2. Fabricate containers, hoppers, compaction chambers, unit bodies, and similar components of steel with welded joints. Reinforce with steel members sized and spaced to withstand impacts and pressures of normal operations and to prevent deformation.
3. Fabricate equipment with replaceable parts at points of normal wear.
4. Fabricate liquidtight compactor baffles to stop liquid from leaking out.
5. Fabricate diverter to fit chute and properly align with compactor hoppers.

1.3 EXECUTION

A. Examination



1. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, clearances, service rough-ins, and other conditions affecting performance of waste-compactor work.
 2. Examine walls, floors, and chutes for suitable conditions where each waste compactor will be installed.
 3. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
 4. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Installation
1. Install each waste compactor according to manufacturer's written instructions, ANSI Z245.2, and ANSI Z245.21 including annexes.
 2. Install automatic sprinkler in hopper of each chute-fed compactor according to NFPA 82.
 3. Set waste compactors level, plumb, properly aligned, and securely in place. Anchor as required for secure operation.
 4. Install diverter to chute and properly align with compactor hoppers.
- C. Field Quality Control
1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. Perform installation and startup checks according to ANSI Z245.21, Annex D, "Tests for Evaluation of Equipment and Performance," and manufacturer's written instructions.
 - b. Test and adjust controls, alarms, and safeties. Replace damaged and malfunctioning controls and equipment.
 - c. Verify unrestricted access to each firefighting access door or fire port required by ANSI Z245.21 and NFPA 82 for compactor container(s).
 - d. Verify correct locations, color-coding, and legibility of caution, warning, and danger markings.
 - e. Certify compliance with test parameters.
 3. A waste compactor will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.

END OF SECTION 11 82 26 00



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Task	Specification	Specification Description
11 82 26 00	11 21 63 00	Food Service Equipment



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SECTION 11 98 12 00 - DETENTION DOOR HARDWARE

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for detention door hardware. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Detention door hardware for the following:
 - 1) Swinging detention doors.
 - 2) Sliding detention doors.
 - b. Detention cylinders for doors specified in other Sections.

C. Performance Requirements

1. Swinging Detention Door Assemblies: Provide detention door hardware as part of a detention door assembly that complies with security grade indicated, when tested according to ASTM F 1450, based on testing manufacturer's standard units in assemblies similar to those indicated for this Project.
 - a. Bullet Resistance: Comply with Level 3 rating when tested according to UL 752; where indicated.
 - 1) Listed and labeled as bullet resisting by a testing agency acceptable to authorities having jurisdiction.
 - b. Tool-Attack Resistance: Comply with small-tool-attack-resistance rating when tested according to UL 1034 and UL 437.
2. Detention Door Hardware Functional Performance: Provide detention door hardware with features, functions, and internal equipment required to perform control and monitoring functions indicated in Division 28 Section "Plc Electronic Detention Monitoring And Control Systems".

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For each type of detention door hardware.
 - a. Wiring Diagrams: For power, signal, and control wiring; differentiate between manufacturer-installed and field-installed wiring for electrified and pneumatic, **as directed**, detention door hardware.
 - b. Compressed-Air System Diagrams: For compressed-air piping for door control systems; differentiate between manufacturer-installed and field-installed piping for pneumatic detention door hardware.
 - c. Detail interface between electrified detention door hardware and perimeter security, detention monitoring and control, fire-alarm, and building control, **as directed**, system.
 - d. Detail interface between pneumatic detention door hardware and perimeter security, detention monitoring and control, fire-alarm, and building control, **as directed**, system.
3. Other Action Submittals:
 - a. Door Hardware Schedule: Prepared by or under the supervision of supplier, detailing fabrication and assembly of door hardware, as well as procedures and diagrams. Coordinate the final Door Hardware Schedule with detention doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.
 - 1) Integrate detention door hardware indicated in "Detention Door Hardware Sets" Article into the Door Hardware Schedule, and indicate complete designations of every item required for each door and opening.



- b. Keying Schedule: Comply with requirements specified in Division 08 Section "Door Hardware". Coordinate detention keying with other door hardware in the final Keying Schedule.
 - 1) Indicate each lock and type of key using the following prefixes: "P" for paracentric, "M" for mogul, "HS" for high security, and "C" for commercial.
- c. Operation and Maintenance Data: For electrified and pneumatic, **as applicable**, detention door hardware to include in emergency, operation, and maintenance manuals.
- 4. Warranties: Sample of special warranties.

E. Quality Assurance

- 1. Installer Qualifications: An employer of workers trained and approved by manufacturer and an authorized representative of detention door hardware manufacturer for installation and maintenance of units required for this Project.
- 2. Supplier Qualifications: Detention door hardware supplier with warehousing facilities in Project's vicinity and who is or employs a qualified Architectural Hardware Consultant, available during the course of the Work to consult with Contractor, Architect, and the Owner about detention door hardware and keying.
 - a. Detention Door Hardware Supplier Qualifications: An experienced detention door hardware supplier who has completed projects with electrified and pneumatic, **as directed**, detention door hardware similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance, and who is acceptable to manufacturer of primary materials.
 - 1) Engineering Responsibility: Prepare data for electrified and pneumatic, **as directed**, detention door hardware, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
 - b. Scheduling Responsibility: Preparation of door hardware and keying schedules.
- 3. Architectural Hardware Consultant Qualifications: A person who is currently certified by DHI as an Architectural Hardware Consultant and who is experienced in providing consulting services for detention door hardware installations that are comparable in material, design, and extent to that indicated for this Project.
 - a. Detention Door Hardware Consultant Qualifications: Experienced in providing consulting services for electrified and pneumatic, **as directed**, detention door hardware installations.
- 4. Source Limitations for Detention Door Hardware: Obtain each type of detention door hardware from single source from single manufacturer.
 - a. Provide electrified and pneumatic, **as directed**, detention door hardware from same manufacturer as mechanical detention door hardware unless otherwise indicated.
- 5. Regulatory Requirements: Comply with provisions of the following:
 - a. Where indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1, **as directed**, as follows:
 - 1) Handles, Pulls, Latches, Locks, and other Operating Devices: Shape that is easy to grasp with one hand and does not require tight grasping, tight pinching, or twisting of the wrist.
 - 2) Security Door Closers: Comply with the following maximum opening-force requirements indicated:
 - a) Interior Hinged Doors: 5 lbf (22 N) applied perpendicular to door.
 - b) Sliding Doors: 5 lbf (22 N) applied parallel to door at latch.
 - c) Fire Doors: Minimum opening force allowable by authorities having jurisdiction.
 - b. NFPA 101: Comply with the following for means-of-egress doors:
 - 1) Latches and Locks: Not more than 15 lbf (67 N) to release the latch.
 - 2) Security Door Closers: Not more than 30 lbf (133 N) to set door in motion and not more than 15 lbf (67 N) to open door to minimum required width.



- 3) Sliding Detention Door Devices: Not more than 50 lbf (222 N) to slide door to its fully open position with a perpendicular force of 50 lbf (222 N) against door.
 - c. Electrified and Pneumatic, **as directed**, Door Hardware: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 6. Fire-Rated Detention Door Assemblies: Provide detention door hardware for assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure **OR** as close to neutral pressure as possible, **as directed**, according to NFPA 252 **OR** UBC Standard 7-2 **OR** UL 10B **OR** UL 10C, **as directed**.
 7. Keying Conference: Conduct conference at Project site Incorporate keying conference decisions into the final Keying Schedule after reviewing detention door hardware keying system including, but not limited to, the following:
 - a. Function of building, flow of traffic, purpose of each area, degree of security required, and plans for future expansion.
 - b. Preliminary key system schematic diagram.
 - c. Requirements for key-control system including key exclusivity and duplication control.
 - d. Address for delivery of keys.
 8. Preinstallation Conference: Conduct conference at Project site.
- F. Delivery, Storage, And Handling
1. Inventory detention door hardware on receipt and provide secure lockup for detention door hardware delivered to Project site.
 2. Tag each item or package separately with identification related to the final Door Hardware Schedule, and include basic installation instructions with each item or package.
 3. Deliver keys to the Owner by registered mail or overnight package service.
- G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of detention door hardware that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Structural failures including excessive deflection, cracking, or breakage.
 - 2) Faulty operation of operators and detention door hardware.
 - 3) Deterioration of metals, metal finishes, and other materials beyond normal weathering or detention use.
 2. Warranty Period: Three years from date of Final Completion.
 3. Warranty Period for Continuous-Pin Detention Hinges: 10 years from date of Final Completion.
 4. Warranty Period for Security Door Closers: 10 years from date of Final Completion.
- H. Maintenance Service
1. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for the Owner's continued adjustment, maintenance, and removal and replacement of detention door hardware.
 2. Initial Maintenance Service: Beginning at Final Completion, provide three **OR** six **OR** nine **OR** 12, **as directed**, months' full maintenance by skilled employees of detention door hardware Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper detention door hardware operation. Provide parts and supplies the same as those used in the manufacture and installation of original equipment.

1.2 PRODUCTS

A. Security Fasteners



1. General: Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive-system type, head style, material, and protective coating as required for assembly, installation, and strength, and as follows:
 - a. Drive-System Types: Pinned Torx-Plus **OR** Pinned Torx, **as directed**.
 - b. Fastener Strength: 120,000 psi (827 MPa).
 - c. Socket Button Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - d. Socket Flat Countersunk Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - e. Socket Head Cap Fasteners:
 - 1) Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
 - 2) Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
 - f. Protective Coatings for Heat-Treated Alloy Steel:
 - 1) Zinc and clear trivalent chromium where indicated.
 - 2) Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

B. Detention Hinges, General

1. Standard for Electric Detention Hinges: UL 634.
2. Quantity: Provide the following unless otherwise indicated:
 - a. Two Detention Hinges: For detention doors with heights up to 60 inches (1524 mm).
 - b. Three Detention Hinges: For detention doors with heights 61 to 90 inches (1549 to 2286 mm).
 - c. Four Detention Hinges: For detention doors with heights 91 to 120 inches (2311 to 3048 mm).
 - d. For detention doors with heights more than 120 inches (3048 mm), provide four detention hinges, plus one detention hinge for every 30 inches (762 mm) of detention door height greater than 120 inches (3048 mm).
3. Size: Provide the following, unless otherwise indicated, with detention hinge widths sized for 2-inch (51-mm) detention door thickness and clearances required:
 - a. Doors up to 42 Inches (1067 mm) Wide: Minimum 4-1/2 inches (114 mm) wide by 0.180 inches (4.6 mm) thick or 5 inches (127 mm) wide by 0.190 inches (4.8 mm) thick.
 - b. Doors Greater Than 42 Inches (1067 mm) Wide: Minimum 6 inches (152 mm) wide by 0.203 inches (5.2 mm) thick.
4. Detention Doors with Security Closers: Unless otherwise indicated, provide antifriction-bearing detention hinges.
5. Detention Hinge Base Metal: Unless otherwise indicated, provide the following:
 - a. Exterior Detention Hinges: Stainless steel, with stainless-steel pin.
 - b. Interior Detention Hinges: Steel, with steel pin **OR** Stainless steel, with stainless-steel pin, **as directed**.
 - c. Detention Hinges for Fire-Rated Assemblies: Steel, with steel pin **OR** Stainless steel, with stainless-steel pin, **as directed**.
6. Electrified Functions for Detention Hinges: Comply with the following:
 - a. Electrical Contact: Exposed electrical contacts for transfer of power.
 - b. Power Transfer: Concealed PTFE-jacketed wires, secured at each leaf and continuous through detention hinge knuckle.
 - c. Monitoring: Concealed electrical monitoring switch.
7. Fastening: Comply with the following:
 - a. Welding: Where indicated, weld hinges to detention doors and frames with continuous fillet weld around three sides of hinge perimeter.
 - b. Security Fasteners: Provide socket flat countersunk head machine screws; finish screw heads to match surface of detention hinges. Install into drilled and tapped holes.



C. Detention Hinges

1. Utility-Door Detention Hinges DH-1: Heavy weight, plain bearing; fabricated from cast iron or steel; 3/8-inch- (9.5-mm-) diameter, case-hardened, fully welded, **as directed**, steel hinge pin; full surface.
 - a. Leaves: Drilled for countersunk security fasteners **OR Solid, as directed**.
 - b. Size: Minimum 3 by 4 inches by 0.200 inch (75 by 100 by 5 mm).
 - c. Security Grade: 1 **OR 2 OR 3 OR 4, as directed**, according to ASTM F 1758.
 - d. Finish: BHMA 600.
2. Food-Pass Detention Hinges DH-2: Heavy weight, plain bearing; fabricated from cast iron or steel; 3/8-inch- (9.5-mm-) diameter, case-hardened, fully welded, **as directed**, steel hinge pin; with applied stop preventing door from opening more than 90 degrees and supporting door in horizontal position as a shelf; full surface.
 - a. Leaves: Drilled for countersunk security fasteners **OR Solid, as directed**.
 - b. Size: Minimum 3 by 4 inches by 0.200 inch (75 by 100 by 5 mm).
 - c. Security Grade: 1 **OR 2 OR 3 OR 4, as directed**, according to ASTM F 1758.
 - d. Finish: BHMA 600.
3. Full-Surface Detention Hinges DH-3: Extra heavy weight; two heavy-duty thrust bearings with hardened-steel ball bearings; fabricated from steel plate; 3/4-inch- (19-mm-) diameter, case-hardened, fully welded, steel hinge pin.
 - a. Leaves: Drilled for countersunk security fasteners **OR Solid, as directed**.
 - b. Size: Minimum 5 by 5-1/4 inches by 1/2 inch (127 by 133 by 13 mm).
 - c. Security Grade: 1 **OR 2 OR 3 OR 4, as directed**, according to ASTM F 1758.
 - d. Finish: BHMA 600.
4. Half-Surface Detention Hinges DH-4: Extra heavy weight; two heavy-duty thrust bearings with hardened-steel ball bearings; fabricated from steel plate; 3/4-inch- (19-mm-) diameter, case-hardened, fully welded, steel hinge pin.
 - a. Leaves: Drilled for countersunk security fasteners **OR Solid, as directed**.
 - b. Size: Minimum 5 by 5-1/4 inches by 1/2 inch (127 by 133 by 13 mm).
 - c. Security Grade: 1 **OR 2 OR 3 OR 4, as directed**, according to ASTM F 1758.
 - d. Finish: BHMA 600.
5. Gap-Mounted Detention Hinges DH-5: Extra heavy weight; two heavy-duty thrust bearings with hardened-steel ball bearings; fabricated from steel plate; 3/4-inch- (19-mm-) diameter, case-hardened, fully welded, steel hinge pin.
 - a. Leaves: Drilled for countersunk security fasteners **OR Solid, as directed**.
 - b. Size: Minimum 5 by 6 inches by 1/2 inch (127 by 152 by 13 mm).
 - c. Security Grade: 1 **OR 2 OR 3 OR 4, as directed**, according to ASTM F 1758.
 - d. Finish: BHMA 600.
6. Continuous-Pin Detention Hinges DH-6: Minimum 0.109-inch- (2.78-mm-) thick, stainless-steel hinge leaves with minimum overall width of 4 inches (100 mm); with 1/4-inch- (6-mm-) diameter continuous pin; fabricated to full height of detention door and frame. Finish components after milling and drilling are complete. Fabricate continuous-pin detention hinges to template screw locations.
 - a. Security Grade: 1 **OR 2 OR 3 OR 4, as directed**, according to ASTM F 1758.

D. Detention Locks And Latches, General

1. Swinging Detention Door Lock and Latch Performance: Provide detention door locks and latches that comply with security grade indicated, when tested according to ASTM F 1577, based on testing manufacturer's standard units in assemblies similar to those indicated for this Project.
2. Detention Lock Functions: Provide function numbers and descriptions indicated in detention door hardware sets complying with ASTM F 1577.
3. Detention Lock Construction: Fabricate detention lock case and cover plate from steel plate. Fabricate bolts from solid sections; laminated construction unacceptable.
4. Detention Lock Throw: Comply with testing requirements for length of bolts to comply with labeled fire door requirements, and as follows:
 - a. Latchbolts for Detention Food Pass **OR Security Access Doors, as directed**: Minimum 5/8-inch (16-mm) latchbolt throw.



- b. Latchbolts: Minimum 3/4-inch (19-mm) latchbolt throw.
- c. Deadbolts: Minimum 1-inch (25-mm) bolt throw.
- 5. Detention Lock Trim:
 - a. Levers: Solid stainless steel.
 - b. Knobs: Stainless steel **OR** Brass, **as directed**.
 - c. Escutcheons for Paracentric Locks: 0.125-inch- (3.18-mm-) thick, 3-inch- (75-mm-) diameter stainless steel with BHMA 626 **OR** brass with BHMA 606, **as directed**, finish. Attach with security fasteners.
 - 1) Style: Single wing **OR** Double wing **OR** Single or double wing as required by lock function **OR** As indicated, **as directed**.
 - 2) Provide escutcheons unless otherwise **OR** where, **as directed**, indicated.
 - d. Cylinder Shields for Paracentric Locks: 0.125-inch- (3.18-mm-) thick, 3-inch- (75-mm-) diameter stainless steel with BHMA 626 **OR** brass with BHMA 606, **as directed**, finish and swinging cover to protect keyhole. Attach with security fasteners.
 - 1) Style: Single wing **OR** Double wing **OR** Single or double wing as required by lock function **OR** As indicated, **as directed**.
 - 2) Provide cylinder shields unless otherwise **OR** where, **as directed**, indicated.
- 6. Pneumatic Detention Locks and Latches: Operate when supplied with air between 40 psig (275 kPa) minimum and 100 psig (690 kPa) maximum. Factory install quick-connect air fitting and factory-wired plug connector with 6-inch (150-mm) wire pigtail.
 - a. Provide security ring for installation of pneumatic detention lock in hollow-metal detention frame, welded to frame or access cover unless otherwise **OR** where, **as directed**, indicated.

E. Mechanical Detention Locks And Latches

- 1. General: Provide mechanical detention lock mountings as follows:
 - a. Hollow-Metal Detention Doors: Mount detention lock to back of 0.179-inch (4.56-mm) nominal-thickness steel **OR** 0.183-inch (4.65-mm) nominal-thickness galvanized-steel, **as directed**, cover plate for installation in lock pocket fabricated into detention door. Attach cover plate to hollow-metal detention door with security fasteners.
 - b. Bar-Grille Detention Doors: Mount detention lock to back of galvanized, **as directed**, steel enclosure welded to flat horizontal bars of bar-grille detention door; cover with 0.179-inch (4.56-mm) nominal-thickness steel **OR** 0.183-inch (4.65-mm) nominal-thickness galvanized-steel, **as directed**, plate. Attach plate with security fasteners.
 - c. Steel-Plate Detention Doors: Mount detention lock to inside surface of 0.179-inch (4.56-mm) nominal-thickness steel **OR** 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.183-inch (4.65-mm) nominal-thickness galvanized-steel **OR** 0.138-inch (3.50-mm) nominal-thickness galvanized-steel, **as directed**, enclosure with integrally formed mounting flanges. Attach enclosure to steel-plate detention door with security fasteners **OR** rivets, **as directed**.
- 2. Utility-Door Mechanical Deadlocks, Paracentric ML-1: For use on small swinging doors, such as access panels, plumbing space doors, electric panel doors, and hatches that are infrequently used.
 - a. Function: Lockbolt retracted and extended by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**.
 - b. Lockbolt: 1-1/2 inches high by 3/4 inch (38 mm high by 19 mm) thick; 5/8-inch (16-mm) throw.
 - c. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
- 3. Utility-Door Mechanical Deadlocks, Mogul ML-2: For use on small swinging doors, such as access panels, plumbing space doors, electric panel doors, and hatches that are infrequently used.
 - a. Function: Lockbolt retracted and extended by mogul cylinder; keyed one side **OR** two sides, **as directed**.
 - b. Lockbolt: 1-1/2 inches high by 3/4 inch (38 mm high by 19 mm) thick; 5/8-inch (16-mm) throw.



- c. Security Grade: **1 OR 2 OR 3 OR 4, as directed.**
4. Mechanical Snaplatches, Paracentric ML-3: For use on small swinging doors, such as food-pass doors, observation panels, gun locker doors, and other small doors where snaplocking is needed and deadlocking is not required.
 - a. Function: Automatic snaplatch when door is closed; latchbolt retracted by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed.**
 - b. Latchbolt: 1 inch high by 7/16 inch (25 mm high by 11 mm) thick; 5/16-inch (8-mm) throw.
 - c. Security Grade: **1 OR 2 OR 3 OR 4, as directed.**
5. Mechanical Snaplatches, Mogul ML-4: For use on small swinging doors, such as food-pass doors, observation panels, gun locker doors, and other small doors where snaplocking is needed and deadlocking is not required
 - a. Function: Automatic snaplatch when door is closed; latchbolt retracted by mogul cylinder; keyed one side **OR** two sides, **as directed.**
 - b. Latchbolt: 1 inch high by 7/16 inch (25 mm high by 11 mm) thick; 5/16-inch (8-mm) throw.
 - c. Security Grade: **1 OR 2 OR 3 OR 4, as directed.**
6. Mechanical Concealed Snaplatches ML-5: For use on small swinging doors, such as observation panels, wickets, covers, and other small doors.
 - a. Function: Automatic snaplatch when door is closed; latchbolt retracted by five-tumbler paracentric cylinder; keyed one side. When closed, latch is concealed within lock case.
 - b. Latchbolt: 1 inch high by 7/16 inch (25 mm high by 11 mm) thick; 7/16-inch (11-mm) throw.
 - c. Provide angled strike.
 - d. Security Grade: **1 OR 2 OR 3 OR 4, as directed.**
7. Sliding Door Mechanical Deadlatches ML-6: For use on sliding doors, such as entrance, safety vestibule, and corridor doors.
 - a. Function: Hookbolt snaplatches and automatically deadlocks through action of plunger pin when door is closed (slam locking); hookbolt raised by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed.**
 - b. Hookbolt: 1/2-inch- (13-mm-) thick, case-hardened steel; 5/8-inch (16-mm) lift.
 - c. Provide case-hardened-steel deadlock plunger pin.
 - d. Security Grade: **1 OR 2 OR 3 OR 4, as directed.**
8. Sliding Door Mechanical Deadlocks ML-7: For use on sliding doors, such as entrance, safety vestibule, corridor, and inmate cell doors.
 - a. Function: Hookbolt raised and lowered by five **OR** six, **as directed**,-tumbler paracentric cylinder (no slam locking); keyed one side **OR** two sides, **as directed.**
 - b. Hookbolt: 1/2-inch- (13-mm-) thick, case-hardened steel; 5/8-inch (16-mm) lift.
 - c. Security Grade: **1 OR 2 OR 3 OR 4, as directed.**
9. Mechanical Snaplatches ML-8: For use on swinging doors, such as corridor, dining room, and recreational area doors.
 - a. Function: Automatic snaplatch when door is closed (slam locking); latchbolt retracted by half turn and extended by full turn in opposite direction of five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed.**
 - 1) Knob operation retracts latchbolt unless deadlocked. Locate knobs on one side **OR** two sides, **as directed.**
 - b. Latchbolt: 2-inch-high by 3/4-inch- (50-mm-high by 19-mm-) thick steel, with two case-hardened-steel insert pins; 3/4-inch (19-mm) throw; 1/2-inch (13-mm) **OR** 1-1/4-inch (32-mm), **as directed**, bolt projection when retracted.
 - c. Listed and labeled for use on fire doors.
 - d. Security Grade: **1 OR 2 OR 3 OR 4, as directed.**
10. Mechanical Deadlatches/Deadlocks ML-9: For use on swinging doors, such as day room, dining room, and recreational area doors.
 - a. Function: Automatic snaplatch and automatic deadlock through action of actuator when door is closed (slam locking); latchbolt retracted by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed.**
 - b. Latchbolt: 2-inch-high by 3/4-inch- (50-mm-high by 19-mm-) thick steel, with two case-hardened-steel insert pins; 3/4-inch (19-mm) throw; 1/2-inch (13-mm) **OR** 1-1/4-inch (32-mm), **as directed**, bolt projection when retracted.



- c. Deadlock Actuator: 3/4-inch-high by 3/4-inch- (19-mm-high by 19-mm-) thick steel; 1/2-inch (13-mm) throw.
 - d. Listed and labeled for use on fire doors.
 - e. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
11. Mechanical Deadlocks ML-10: For use on swinging doors where slam locking is not required, such as holding cell, segregation cell, control room, armory, key cabinet, storage, utility, and hollow-metal access doors.
- a. Function: Deadlocked in both locked and unlocked position; latchbolt retracted and extended by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**.
 - b. Latchbolt: 2-inch-high by 3/4-inch- (50-mm-high by 19-mm-) thick steel, with two case-hardened-steel insert pins; 3/4-inch (19-mm) throw; 1/2-inch (13-mm) **OR** 1-1/4-inch (32-mm), **as directed**, bolt projection when retracted.
 - c. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
12. Cremona Bolt Mechanical Snaplatches ML-11: For use on swinging doors or active leaf of pairs of swinging doors where slam locking is needed.
- a. Function: Automatic snaplatch and deadlocking when door is closed (slam locking); latchbolt retracted and extended by five-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**. Lever operation one side **OR** two sides, **as directed**, retracts head and foot rods, unless deadlocked, for three-point locking.
 - b. Latchbolt: 2-inch-high by 3/4-inch- (50-mm-high by 19-mm-) thick steel, with two case-hardened-steel insert pins; 3/4-inch (19-mm) throw.
 - c. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
13. Cremona Bolt Mechanical Deadlocks, Paracentric ML-12: For use on swinging doors or active leaf of pairs of swinging doors where doors may be subject to mass attack. Delete inactive leaf for single door.
- a. Function: Active leaf deadlocks when door is closed (no slam locking); active-leaf deadbolt retracted and extended by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**. Active-leaf lever operation one side **OR** two sides, **as directed**, retracts active-leaf head and foot bolts unless deadlocked.
 - 1) Inactive Leaf: Head and foot bolts deadlocked by five **OR** six, **as directed**,-tumbler, inactive-leaf paracentric cylinder. Inactive-leaf lever operation one side **OR** two sides, **as directed**, retracts inactive-leaf head and foot bolts unless deadlocked.
 - b. Deadbolt: 2-inch-high by 3/4-inch- (50-mm-high by 19-mm-) thick steel, with two case-hardened-steel insert pins; 3/4-inch (19-mm) throw.
 - c. Head and Foot Bolts: 7/8-inch (22-mm) diameter; 3/4-inch (19-mm) throw.
 - d. Provide foot bolt receptacle(s).
 - e. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
14. Mechanical Head and Foot Bolts ML-14: For use on the inactive leaf of pairs of swinging doors.
- a. Function: Bolt retracted and extended by spanner-type key **OR** five-tumbler paracentric cylinder, **as directed**; enclosed in iron or steel case with steel cover (not applicable for hollow-metal doors).
 - b. Latchbolt: 1-inch- (25-mm-) diameter steel; 3/4-inch (19-mm) throw.
 - c. Footbolt Receptacle: Spring-loaded mechanism; brass.
 - d. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.

F. Electromechanical Detention Locks And Latches

- 1. General: Provide electromechanical detention locks and latches with factory-wired plug connector with 6-inch (152-mm) wire pigtail.
 - a. Provide security ring for installation of electromechanical detention lock in hollow-metal detention frame, welded to frame or access cover, unless otherwise **OR** where, **as directed**, indicated.
 - b. Equip direct-current solenoid-operated detention locks and latches with diode transient voltage protection at each locking device.



2. Solenoid-Operated Deadlatches, Paracentric EL-1: For use on swinging doors, such as entrance, sally port, corridor, and inmate cell doors, that are to be unlocked from remote locations.
 - a. Function: Remote switch activates electric solenoid that retracts latchbolt; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**; if latchbolt is retracted by key, it remains retracted until relocked by key.
 - 1) Latchback: Latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is activated; latchbolt extends when power is discontinued, **as directed**.
 - 2) If power fails, latchbolt automatically deadlocks (fail secure).
 - b. Latchbolt: 2-inch-high by 3/4-inch- (50-mm-high by 19-mm-) thick hardened steel; 3/4-inch (19-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Provide roller-type deadlock actuator.
 - e. Voltage: 120-V ac.
 - f. Listed and labeled for use on fire doors.
 - g. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
3. Motor-Operated Deadlatches, Paracentric EL-2: For use on swinging doors, such as entrance, sally port, corridor, and inmate cell doors, that are to be unlocked from remote locations.
 - a. Function: Remote switch activates electric motor that retracts latchbolt; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**; if latchbolt is retracted by key, it remains retracted until relocked by key.
 - 1) Latchback: Latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is activated; latchbolt extends when power is discontinued, **as directed**.
 - 2) If power fails, latchbolt automatically deadlocks (fail-secure).
 - b. Latchbolt: 2-inch-high by 3/4-inch- (50-mm-high by 19-mm-) thick hardened steel; 3/4-inch (19-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Provide roller-type deadlock actuator.
 - e. Voltage: 120-V ac **OR** 24-V dc, **as directed**.
 - f. Listed and labeled for use on fire doors.
 - g. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
4. Sliding Door Motor-Operated Deadlatches EL-3: For use on sliding doors, such as entrance, sally port, corridor, and inmate cell doors, that are to be unlocked from remote locations.
 - a. Function: Remote switch activates electric motor that raises hookbolt; spring-loaded actuator pin pushes door open 1 to 3 inches (25 to 75 mm); automatic latching and deadlocking when door is closed (slam locking). Hookbolt can be mechanically raised by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**; if hookbolt is raised by key, it remains raised until relocked by key.
 - 1) Latchback: Hookbolt remains raised until door is opened 2 inches (50 mm), then lowers **OR** as long as control switch is in open position; hookbolt lowers when control switch is moved to locked position, **as directed**.
 - 2) If power fails, hookbolt automatically deadlocks (fail-secure).
 - b. Hookbolt: 1-3/4- by 1/2-inch- (44- by 13-mm-) thick, case-hardened steel; 3/4-inch (19-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Provide case-hardened-steel deadlock actuator.
 - e. Voltage: 120-V ac.
 - f. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
5. Solenoid-Operated Deadlatches, Mogul EL-4: For use on swinging doors, such as entrance, sally port, corridor, and inmate cell doors, that are to be unlocked from remote locations.



- a. Function: Remote switch activates electric solenoid that retracts latchbolt; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by mogul cylinder; keyed one side **OR** two sides, **as directed**.
 - 1) Latchback: Latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is activated; latchbolt extends when power is discontinued, **as directed**.
 - 2) Local Electric Key (LEK): Inmate key operates lock electrically when enabled; staff key always operates lock manually and electrically; where indicated.
 - 3) Key Holdback: If latchbolt is retracted by key, it remains retracted until relocked by key (listing for use on fire doors is not available).
 - 4) Knob operation retracts latchbolt; always active.
 - 5) If power fails, latchbolt automatically deadlocks (fail-secure).
 - b. Latchbolt: 1-1/2-inch-high by 3/4-inch- (38-mm-high by 19-mm-) thick hardened steel; 1-inch (25-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Provide roller-type deadlock actuator.
 - e. Voltage: 120-V ac.
 - f. Listed and labeled for use on fire doors.
 - g. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
6. Motor-Operated Deadlatches, Mogul EL-5: for use on swinging doors, such as entrance, sally port, corridor, and inmate cell doors, that are to be unlocked from remote locations.
- a. Function: Remote switch activates electric motor that retracts latchbolt; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by mogul cylinder; keyed one side **OR** two sides, **as directed**.
 - 1) Latchback: Latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is in open position; latchbolt extends when control switch is moved to locked position, **as directed**.
 - 2) Local Electric Key (LEK): Inmate key operates lock electrically when enabled; staff key always operates lock manually and electrically; where indicated.
 - 3) Key Holdback: If latchbolt is retracted by key, it remains retracted until relocked by key (listing for use on fire doors is not available).
 - 4) Knob operation retracts latchbolt; always active.
 - 5) If power fails, latchbolt automatically deadlocks (fail-secure).
 - b. Latchbolt: 1-1/2-inch-high by 3/4-inch- (38-mm-high by 19-mm-) thick hardened steel; 1-inch (25-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Provide roller-type deadlock actuator.
 - e. Voltage: 120-V ac **OR** 24-V dc, **as directed**.
 - f. Listed and labeled for use on fire doors.
 - g. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
7. Solenoid-Operated Deadlatches, Commercial EL-6: For use on swinging doors, hung in standard 2-inch (50-mm) hollow-metal frames, that are to be unlocked from remote locations.
- a. Function: Remote switch activates electric solenoid that retracts latchbolt; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by high-security, **as directed**, commercial cylinder; keyed one side **OR** two sides, **as directed**.
 - 1) Latchback: Latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is activated; latchbolt extends when power is discontinued, **as directed**.
 - 2) Local Electric Key (LEK): Inmate key operates lock electrically when enabled; staff key always operates lock manually and electrically; where indicated.
 - 3) If power fails, latchbolt automatically deadlocks (fail-secure).
 - b. Latchbolt: 1-1/2-inch-high by 5/8-inch- (38-mm-high by 16-mm-) thick hardened steel; 3/4-inch (19-mm) throw.
 - c. Provide internal deadlock indicator switch.



- d. Deadlock Actuator: Stainless steel.
 - e. Strike: Stainless steel.
 - f. Voltage: 24-V dc.
 - g. Listed and labeled for use on fire doors.
 - h. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
8. Motor-Operated Deadlatches, Commercial EL-7: For use on swinging doors, hung in standard 2-inch (50-mm) hollow-metal frames, that are to be unlocked from remote locations.
- a. Function: Remote switch activates electric motor that retracts latchbolt; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by high-security, **as directed**, commercial cylinder; keyed one side **OR** two sides, **as directed**.
 - 1) Latchback: Latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is in open position; latchbolt extends when control switch is moved to locked position, **as directed**.
 - 2) Local Electric Key (LEK): Inmate key operates lock electrically when enabled; staff key always operates lock manually and electrically; where indicated.
 - 3) If power fails, latchbolt automatically deadlocks (fail-secure).
 - b. Latchbolt: 1-1/2-inch-high by 5/8-inch- (38-mm-high by 16-mm-) thick hardened steel; 3/4-inch (19-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Deadlock Actuator: Stainless steel.
 - e. Strike: Stainless steel.
 - f. Voltage: 24-V dc.
 - g. Listed and labeled for use on fire doors.
 - h. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
9. Solenoid-Operated Gate Locks, Paracentric EL-8: For use on swinging and sliding gates that are to be unlocked from remote locations.
- a. Function: Remote switch activates electric solenoid that raises an internal bolt; automatic deadlocking when gate is closed. Bolt can be mechanically retracted by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**.
 - 1) Latchback: Bolt remains raised until gate is closed.
 - 2) If power fails, latchbolt automatically deadlocks (fail-secure).
 - b. Bolt: 5/8-inch- (16-mm-) diameter stainless steel; 1-inch (25-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Voltage: 120-V ac.
 - e. Finish: Galvanized.
 - f. Mounting: Mount lock to gate post; mount locking tongue to gate frame.
 - g. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
- G. Pneumatic Detention Locks And Latches
- 1. General: Provide pneumatic detention locks and latches that operate when supplied with air between 40 psig (275 kPa) minimum and 100 psig (690 kPa) maximum.
 - 2. Factory install quick-connect air fitting and factory-wired plug connector with 6-inch (150-mm) wire pigtail.
 - a. Provide security ring for installation of pneumatic detention lock in hollow-metal detention frame, welded to frame or access cover, unless otherwise **OR** where, **as directed**, indicated.
 - 3. Pneumatic Deadlatches, Paracentric PL-1: For use on swinging doors, such as entrance, sally port, corridor, and inmate cell doors, that are to be unlocked from remote locations.
 - a. Function: Remote switch activates pneumatic cylinder that retracts latchbolt; latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is activated, **as directed**; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by five **OR** six, **as directed**,-tumbler paracentric cylinder; keyed one side **OR** two sides, **as directed**.
 - 1) If power fails or compressed-air system fails, latchbolt automatically deadlocks (fail-secure).



- b. Latchbolt: 2-inch-high by 3/4-inch- (50-mm-high by 19-mm-) thick hardened steel; 3/4-inch (19-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Provide roller-type deadlock actuator.
 - e. Voltage: 24-V dc.
 - f. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
4. Pneumatic Deadlatches, Mogul PL-2: For use on swinging doors, such as entrance, sally port, corridor, and inmate cell doors, that are to be unlocked from remote locations.
- a. Function: Remote switch activates pneumatic cylinder that retracts latchbolt; latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is activated, **as directed**; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by mogul cylinder; keyed one side **OR** two sides, **as directed**.
 - 1) Local Electric Key (LEK): Inmate key operates lock electrically when enabled; staff key always operates lock manually and electrically; where indicated.
 - 2) Knob on opposite side of cylinder retracts latchbolt.
 - 3) If power fails or compressed-air system fails, latchbolt automatically deadlocks (fail-secure).
 - b. Latchbolt: 1-1/2-inch-high by 3/4-inch- (38-mm-high by 19-mm-) thick hardened steel; 1-inch (25-mm) throw.
 - c. Provide internal deadlock indicator switch.
 - d. Provide roller-type deadlock actuator.
 - e. Voltage: 24-V dc.
 - f. Listed and labeled for use on fire doors.
 - g. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
5. Pneumatic Deadlatches, Commercial PL-3: For use on swinging doors, hung in standard 2-inch (50-mm) hollow-metal frames, that are to be unlocked from remote locations.
- a. Function: Remote switch activates pneumatic cylinder that retracts latchbolt; latchbolt remains retracted until door is opened 2 inches (50 mm), then releases **OR** as long as control switch is activated, **as directed**; automatic latching and deadlocking when door is closed (slam locking). Latchbolt can be mechanically retracted by high-security, **as directed**, commercial cylinder; keyed one side **OR** two sides, **as directed**.
 - 1) Local Electric Key (LEK): Inmate key operates lock electrically when enabled; staff key always operates lock manually and electrically; where indicated.
 - 2) If power fails or compressed-air system fails, latchbolt automatically deadlocks (fail-secure).
 - b. Latchbolt: 1-1/2-inch-high by 5/8-inch- (38-mm-high by 16-mm-) thick hardened steel; 3/4-inch (19-mm) throw.
 - c. Faceplate: Stainless steel.
 - d. Provide internal deadlock indicator switch.
 - e. Provide roller-type deadlock actuator.
 - f. Voltage: 24-V dc.
 - g. Listed and labeled for use on fire doors.
 - h. Security Grade: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.

H. Cylinders And Keying

- 1. General: Subject to compliance with requirements, provide cylinders and keying for paracentric and mogul cylinders by the same manufacturer as for detention locks and latches.
- 2. Commercial (Builders' Hardware) Cylinders: As specified in Division 08 Section "Door Hardware".
- 3. Paracentric Cylinders: Manufacturer's standard lever-tumbler type, constructed from one-piece spring-tempered brass; with tumblers activated by phosphor bronze springs; five tumblers per lock unless otherwise indicated.



4. Mogul Cylinders: Manufacturer's standard pin-tumbler type, minimum 2-inch (50-mm) diameter; body constructed from brass or bronze, stainless steel, or nickel silver; with stainless-steel tumblers and engaging cylinder balls; complying with the following:
 - a. Number of Pins: Five **OR** Six **OR** Seven, **as directed**.
 - b. Mortise Type: Threaded cylinders with rings and straight- or clover-type cam.
 - 1) High-Security Grade: Listed and labeled as complying with pick- and drill-resistant testing requirements in UL 437 (Suffix A); where indicated.
 - c. Finish: BHMA 606 **OR** BHMA 626, **as directed**.
 5. Keying System: Unless otherwise indicated, provide a factory-registered keying system complying with the following requirements:
 - a. Paracentric cylinders operated by change keys only.
 - b. No Master Key System: Mogul cylinders operated by change keys only.
OR
Master Key System: Mogul cylinders operated by a change key and a master key.
OR
Grand Master Key System: Mogul cylinders operated by a change key, a master key, and a grand master key.
OR
Great-Grand Master Key System: Mogul cylinders operated by a change key, a master key, a grand master key, and a great-grand master key.
 - c. Existing System: Master key or grand master key mogul-cylinder locks to the Owner's existing system.
 - d. Existing System: Re-key the Owner's existing master key system for mogul-cylinder locks into new keying system.
 6. Keys: Provide cast silicon-bronze copper alloy keys complying with the following:
 - a. Stamping: Permanently inscribe each key with a visual key-control number and include the following notation:
 - 1) Notation: "DO NOT DUPLICATE" **OR** Information to be furnished by the Owner, **as directed**.
 - b. Quantity: In addition to one extra blank key for each lock, provide the following:
 - 1) Cylinder Change Keys: Three.
OR
Master Key(s): One.
OR
Grand Master Key(s): One.
OR
Great-Grand Master Key(s): One.
- I. Switches
1. General: Provide switches configured with type of contacts required for functions indicated, including multiple circuiting where required by functional performance of Division 28 Section "Plc Electronic Detention Monitoring And Control Systems".
 2. Concealed, Magnetic Door Position Switches: Consisting of actuating magnet mortised into detention door and switch mortised into frame; with stainless-steel faceplates; 24-V dc, factory wired with plug connector. Wire in series with lock monitors. Attach with security fasteners.
 3. Concealed, Mechanical Door Position Switches: Consisting of metal track mortised into head of detention door connected by steel actuator arm to steel actuator mortised into frame; switch fully concealed when door is in closed position; with stainless-steel faceplate; 120-V ac; factory wired with plug connector. Action of door mechanically activates switch. Wire in series with lock monitors. Attach with security fasteners.
 4. Surface-Mounted Door Position Switches: Switch enclosed in 0.134-inch (3.42-mm) nominal-thickness steel enclosure, factory primed for painting; 120-V ac; factory wired with plug connector. Wire in series with lock monitors. Attach with security fasteners.
 - a. Galvanize enclosure for exterior locations and where indicated.



5. Strike Indicator Switches: Designed to be mortised behind strike and to indicate whether door is locked or unlocked; enclosed in metal strike box. Wire in series with door position switches. Attach with security fasteners.
 - a. Voltage: 120-V dc **OR** 240-V ac **OR** As indicated, **as directed**.
 - b. Locations: At doors with mechanical detention lock **OR** Where indicated, **as directed**.
 - c. Manufacturer: Same as detention lock.
 6. Inmate Door Control Switches, as directed: Momentary **OR** Maintained-contact, **as directed**, push-button switch with metal faceplate. Attach with security fasteners.
 - a. Material and Finish: Brass with BHMA 606 **OR** Brass with BHMA 626 **OR** Stainless steel with BHMA 630, **as directed**, finish.
 - b. Operation: When activated from remote location, switch allows inmate operation of electric cell door lock.
 7. Push-Button, Inmate Door Control Switches, as directed: Momentary **OR** Maintained-contact, **as directed**, push-button switch for installation without faceplate. Attach with security fasteners.
 - a. Material and Finish: Brass with BHMA 606 **OR** Brass with BHMA 626 **OR** Stainless steel with BHMA 630, **as directed**, finish.
 - b. Operation: When activated from remote location, switch allows inmate operation of electric cell door lock.
- J. Detention Operating Trim
1. Standard: BHMA A156.6, Grade 1.
 2. Surface-Mounted Door Pulls (not typically used inside cells): 8-3/4-inch (222-mm) overall length and 2-1/4-inch (57-mm) projection; attach to door with two security fasteners.
 - a. Material: Cast bronze with BHMA 606 **OR** BHMA 626, **as directed**, finish.
 - b. Material: Cast stainless steel with BHMA 630 finish.
 3. Round, Surface-Mounted Door Pulls (not typically used inside cells): 7-inch (178-mm) overall length by 1-inch- (25-mm-) diameter solid bar, with 2-1/4-inch (57-mm) projection; attach to door with two security through fasteners.
 - a. Material: Cast or extruded bronze with BHMA 606 **OR** BHMA 626, **as directed**, finish.
 - b. Material: Cast stainless steel with BHMA 630 finish.
 4. Flush Door Pulls: 5 inches high by 4 inches wide by 1 inch deep (127 mm high by 102 mm wide by 25 mm deep), with 1/8-inch- (3-mm-) thick faceplate; attach to door with four security fasteners.
 - a. Material: Formed, wrought, or cast brass/bronze with BHMA 606 **OR** BHMA 626, **as directed**, finish.
 - b. Material: Formed or cast stainless steel with BHMA 630 finish.
 5. Knob Pulls: 2-inch (50-mm) diameter; fabricated from solid brass with BHMA 606 **OR** BHMA 626, **as directed**, finish. Attach with security fasteners.
 6. Lever-Handle Guides: Guide track and escutcheon, **as directed**, that provides selective stopping of lever handle by use of an adjustable stop; fabricated from steel with BHMA 633 **OR** stainless steel with BHMA 630, **as directed**, finish. Attach with security fasteners.
- K. Security Door Closers
1. Standard: BHMA A156.4, Grade 1.
 - a. Certified Products: Provide security door closers listed in BHMA's "Directory of Certified Products."
 2. Surface-Mounted Security Door Closers:
 - a. Arms: Minimum 3/8-inch- (9.5-mm-) thick by 1-1/8-inch- (29-mm-) wide, rectangular steel main arm; 5/16-inch- (8-mm-) thick by 1-inch- (25-mm-) wide, rectangular steel secondary arm; full rack-and-pinion type; fabricated with orbital-riveted, pinned, or welded elbow and arm shoe/soffit plate joints designed to prevent disassembly with ordinary hand tools.
 - b. Cover: Heavy-duty metal, attached with four security fasteners.
 - c. Mounting: Attach security door closer with security fasteners.
 3. Concealed Security Door Closers:



- a. Construction: Forged-steel arm; security roller; with track concealed in head of detention door, designed to eject foreign objects during opening and closing; fabricated with joints designed to prevent disassembly with ordinary hand tools. Closer arm and track fully concealed when door is closed.
 - b. Cover Plates: Heavy-duty metal, attached with security fasteners.
 - c. Provide door position switch integral to closer.
4. Unit Size: Unless otherwise indicated, comply with manufacturer's written recommendations for size of security door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.
- L. Detention Door Stops
1. Detention Floor Stops: 1-1/2-inch-high by 2-inch- (38-mm-high by 50-mm-) diameter rubber bumper mounted on steel lag bolt; BHMA A156.16; install in floor with nonshrink grout; for detention doors unless wall or other type stops are indicated. Do not mount floor stops where they will impede traffic.
 2. Silencers for Detention Door Frames: BHMA A156.16, Grade 1; neoprene or rubber, minimum 1/2-inch (13-mm) diameter; fabricated for drilled-in application to detention door frame. Attach with security fasteners.
- M. Sliding Detention Door Device Assemblies
1. Performance Requirements: Provide sliding detention door device assemblies, including locking device, receiver, overhead door hanger, bottom door guide, lock column, and enclosure, as a complete assembly, complying with Grade 1 **OR** Grade 2, **as directed**, according to ASTM F 1643, as determined by testing manufacturers' standard units representing those indicated for Project.
 2. Assembly Construction: As follows:
 - a. Enclosure: Fabricated from 0.179-inch (4.56-mm) nominal-thickness steel plate, with 0.134-inch (3.42-mm) nominal-thickness steel removable **OR** hinged, **as directed**, cover. Baffle openings in enclosure. Provide closures for ends of housings.
 - 1) Provide sloping-top housings. Flat-top housings may be provided for operators mounted to ceiling, **as directed**.
 - b. Lock Column: Vertical tube enclosure fabricated from 0.134-inch (3.42-mm) nominal-thickness steel, providing mechanical locking control of detention sliding door at door location; operated by paracentric key. Doors shall be capable of being locked at top and bottom, at rear of door, in both open and closed positions, with no components projecting into door opening.
 - c. Receiver: Fabricated from 0.134-inch (3.42-mm) nominal-thickness steel plate.
 - d. Hanger Assembly: Extend steel carrier full width of door and door travel required for clear door opening. Provide antifriction ball-bearing steel rollers with hardened members and grease shield.
 - e. Finish: Factory prime painted.
 3. Mechanical-Locking, Manual-Door-Movement, Sliding Door Device Assemblies SDA-1: Doors are manually opened and closed and mechanically locked by means of jamb-mounted mechanical detention lock specified elsewhere in this Section.
 4. Electromechanical-Locking, Manual-Door-Movement, Sliding Door Device Assemblies SDA-2: Operated from remote-control panel that activates electric motors to unlock sliding doors. Doors spring open a small distance after unlocking and are manually opened and closed. Locks automatically deadlock when doors are moved to fully open or fully closed position. Provide factory-wired cable harness with plug connectors for each motor unit.
 - a. Single-Door Function: In an emergency or if power fails, individual doors can be unlocked using a manual-release tool and manually moved; doors relock in either fully open or fully closed position.
 - b. Multiple-Door Function: Each door can be individually unlocked locally or from a remote panel, or unlocked from a remote panel with other doors as a group. In an emergency or if power fails, door group can be manually operated from mechanical-release cabinet at end



- of cell line **OR** pilaster release adjacent to receiving jamb of each door operated by paracentric key, **as directed**; doors shall not relock in any position.
- c. Electric Key Switch: Operated by paracentric **OR** mogul, **as directed**, key and providing electric control of detention sliding door operation at door location; where indicated.
5. Electromechanical-Locking, Electromechanical-Door-Movement, Sliding Door Device Assemblies SDA-3: Operated from remote-control panel that activates electric motors to unlock sliding doors and motorized rack-and-pinion drive mechanisms to open and close doors. Doors lock in open position and deadlock when closed. Provide factory-wired cable harness with plug connectors for each motor unit.

NOTE: Paragraph above describes Southern Folger's "Southern Steel Model 3150LX" and "Southern Steel Model 3165LX." Only the 3150LX system offers multiple door functions, such as for cell doors; the 3165LX system is for individual doors, such as for vestibules, day rooms, and corridors.

 - 1) Single-Door Function: In an emergency or if power fails, individual doors can be unlocked using a manual-release tool and manually moved; doors relock in either fully open or fully closed position.
 - 2) Multiple-Door Function: Each door can be individually unlocked locally or from a remote panel, or unlocked from a remote panel with other doors as a group. In an emergency or if power fails, door group can be manually operated from mechanical-release cabinet at end of cell line **OR** pilaster release adjacent to receiving jamb of each door operated by paracentric key, **as directed**; doors shall not relock in any position.
 - b. Electric Key Switch: Operated by paracentric **OR** mogul, **as directed**, key and providing electric control of detention sliding door operation at door location; where indicated.
6. Electromechanical-Locking, Pneumatic-Door-Movement, Sliding Door Device Assemblies SDA-4 (for individual doors, such as for vestibules, day rooms, and corridors): Operated from remote-control panel that activates electric motors to unlock sliding doors and pneumatic system to open and close doors. Doors lock in open position and deadlock when closed. Factory install quick-connect air fitting and factory-wired cable harness with plug connectors for each motor unit; 24-V dc.
 - a. Single-Door Function: In an emergency or if pneumatic systems or electric power fails, individual doors can be unlocked using a manual-release tool and manually moved; doors relock in either fully open or fully closed position.
 - 1) Lock Control at Door: Mechanical key release adjacent to receiving jamb of each door, contained in pilaster and operated by paracentric key; where indicated.
 7. Pneumatic-Locking, Manual-Door-Movement, Sliding Door Device Assemblies SDA-5: Operated from remote-control panel that activates pneumatic cylinders to unlock doors. Doors spring open a small distance after unlocking and are manually opened and closed. Locks automatically deadlock when doors are moved to fully open or fully closed position. Factory install quick-connect air fitting and factory-wired cable harness with plug connectors for each motor unit.
 - a. Single-Door Function: In an emergency or if pneumatic systems or electric power fails, individual doors can be unlocked using a manual-release tool and manually moved; doors relock in either fully open or fully closed position.
 - 1) Lock Control at Door: Mechanical key release adjacent to receiving jamb of each door, contained in pilaster and operated by paracentric key; where indicated.
 - b. Multiple-Door Function: Each door can be individually unlocked locally or from a remote panel, or unlocked from a remote panel with other doors as a group. In an emergency or if pneumatic systems or electric power fails, door group can be operated from remotely located auxiliary pneumatic-release system **OR** pilaster release adjacent to receiving jamb of each door operated by paracentric key, **as directed**; doors shall not relock in any position.
 - c. Electric Key Switch: Operated by paracentric **OR** mogul, **as directed**, key and providing electric control of detention sliding door operation at door location; where indicated.
 8. Pneumatic-Locking, Pneumatic-Door-Movement, Sliding Door Device Assemblies SDA-6 (Paragraph below describes Southern Folger's "Southern Steel Model 8050L" and "Southern



Steel Model 8065L." Only the 8050L system offers multiple door functions, such as for cell doors; the 8065L system is for individual doors, such as for vestibules, day rooms, and corridors.); Operated from remote-control panel that activates pneumatic cylinder to unlock sliding doors and open and close doors. Doors lock in open position and deadlock when closed. Factory install quick-connect air fitting and factory-wired cable harness with plug connectors for each motor unit; 24-V dc.

- a. Single-Door Function: In an emergency or if pneumatic systems or electric power fails, individual doors can be unlocked using a manual-release tool and manually moved; doors relock in either fully open or fully closed position.
- b. Multiple-Door Function: Each door can be individually unlocked locally or from a remote panel, or unlocked from a remote panel with other doors as a group. In an emergency or if pneumatic systems or electric power fails, door group can be operated from remotely located auxiliary pneumatic-release system **OR** pilaster release adjacent to receiving jamb of each door operated by paracentric key, **as directed**; doors shall not relock in any position.
- c. Electric Key Switch: Operated by paracentric **OR** mogul, **as directed**, key and providing electric control of detention sliding door operation at door location; where indicated.
- d. Provide security ring for installation of pneumatic detention lock in hollow-metal detention frame, welded to frame or access cover, unless otherwise **OR** where, **as directed**, indicated.

N. Fabrication

1. Manufacturer's Nameplate: Do not provide products that have manufacturer's name or trade name displayed in a visible location (omit removable nameplates) except in conjunction with required fire-rated labels and as otherwise approved.
2. Base Metals: Produce detention door hardware units of base metal, fabricated by forming method indicated, using manufacturer's standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified detention door hardware units and BHMA A156.18 finishes. Do not furnish manufacturer's standard materials or forming methods if different from specified standard.
3. Fasteners: Provide flat-head security fasteners with finished heads to match surface of detention door hardware unless otherwise indicated.
 - a. Security Fasteners: Fabricate detention door hardware using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials. Provide stainless-steel security fasteners in stainless-steel materials, **as directed**.
 - b. Concealed Fasteners: For detention door hardware units that are exposed when detention door is closed except for units already specified with concealed fasteners. Do not use through bolts for installation where bolt head or nut on opposite face is exposed unless it is the only means of securely attaching detention door hardware. Where through bolts are used on hollow-metal detention door and frame construction, provide sleeves for each through bolt.
 - c. Steel Machine Screws (for fire-rated detention door assemblies. NFPA 80 requires locks, latches, and surface-mounted top and bottom bolts to be secured with machine screws or through bolts.): For the following fire-rated applications:
 - 1) Mortise detention hinges to detention doors.
 - 2) Strike plates to detention frames.
 - 3) Security door closers to detention doors and frames.
 - d. Steel Through Bolts (for fire-rated detention door assemblies. NFPA 80 requires locks, latches, and surface-mounted top and bottom bolts to be secured with machine screws or through bolts.): For the following fire-rated applications unless door blocking is provided:
 - 1) Surface detention hinges to detention doors.
 - 2) Security door closers to detention doors and frames.
 - e. Spacers or Sex Bolts: For through bolting of hollow-metal detention doors.
 - f. Fasteners for Wood Detention Doors: Comply with DHI WDHS.2.



O. Finishes

1. Standard: Comply with BHMA A156.18.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. BHMA Designations: Comply with base material and finish requirements indicated by the following:
 - a. BHMA 600: Primed for painting, over steel base metal.
 - b. BHMA 606: Satin brass, clear coated, over brass base metal.
 - c. BHMA 626: Satin chromium plated over nickel, over brass or bronze base metal.
 - d. BHMA 630: Stainless steel, satin, over stainless-steel base metal.
 - e. BHMA 652: Satin chromium plated over nickel, over steel base metal.

1.3 EXECUTION

A. Preparation

1. Steel Detention Doors and Frames: Comply with ANSI/DHI A115 Series.
 - a. Surface-Applied Detention Door Hardware: Drill and tap detention doors and frames according to ANSI/SDI A250.6.
2. Wood Detention Doors: Comply with DHI A115-W Series.

B. Installation

1. Mounting Heights: Mount detention door hardware units at heights indicated in the following applicable publications unless specifically indicated or required to comply with governing regulations:
 - a. Steel Detention Doors and Frames: DHI's "Recommended Locations for Builders' Hardware for Custom Steel Doors and Frames."
 - b. Wood Detention Doors: DHI WDHS.3.
2. Install each detention door hardware item to comply with Shop Drawings and manufacturer's written instructions. Where cutting and fitting are required to install detention door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 09. Do not install surface-mounted items until finishes have been completed on substrates involved.
 - a. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
 - b. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.
3. Install interconnecting wiring and connectors between detention door hardware devices. Terminate device wiring for detention door hardware installed in swinging doors at a plug-type connector located in lock pocket or door frame junction box and for sliding doors at a junction box in door frame.
4. Security Fasteners: Install detention door hardware using security fasteners with head style appropriate for installation requirements, strength, and finish of adjacent materials.

C. Field Quality Control

1. Inspect installed products to verify compliance with requirements. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents.
2. Perform the following field tests and inspections and prepare test reports:
 - a. After installing electrified and pneumatic, **as directed**, detention door hardware and after electrical circuitry has been energized and compressed-air system is functional, **as directed**, test detention door hardware for compliance with requirements.
 - 1) Test: Operate lock of each door and group of doors in normal remote, normal local, and emergency operating modes. Verify that remote controls operate correct door locks and in correct sequence.



- b. Verify that lock bolts engage strikes with required bolt projection.
- c. Verify that detention door hardware is installed, connected, and adjusted according to the Contract Documents.
- d. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements.
- 3. Remove and replace detention work if inspections indicate that work does not comply with specified requirements. Remove malfunctioning units, replace with new units, and retest as specified above.
- 4. Perform additional inspections to determine compliance of replaced or additional work. Prepare inspection reports.
- 5. Prepare field quality-control certification endorsed by Detention Specialist, **as directed**, that states installed products and their installation comply with requirements in the Contract Documents.

D. Adjusting

- 1. Adjust and check each operating item of detention door hardware and each detention door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust detention door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
 - a. Strikes: Adjust horizontal and vertical alignment of keeper to properly engage lock bolt.
 - b. Security Door Closers: Adjust sweep period so that, from an open position of 90 degrees, detention door will take at least five seconds to move to a position of 12 degrees.

E. Cleaning And Protection

- 1. Clean adjacent surfaces soiled by detention door hardware installation.
- 2. Clean operating items as necessary to restore proper function and finish.
- 3. Provide final protection and maintain conditions that ensure that detention door hardware is without damage or deterioration at time of Final Completion.

1.4 Detention Door Hardware Sets

- Note 1: Hanging devices below include detention hinges and sliding detention door device assemblies. Indicate whether detention hinges are attached to detention doors and frames by security fasteners or by welding.
- Note 2: Securing devices (inactive leaf) below include door position switches and strike indicator switches.
- Note 3: Securing devices (active leaf) below include detention locksets and latchsets, cylinders, door position switches, strike indicator switches, and inmate door control switches.\
- Note 4: Operating trim below includes detention door pulls, flush pulls, knob pulls, and lever-handle guides.
- Note 5: Closing devices below include security door closers.
- Note 6: Stops below include detention floor stops and door silencers if not specified with steel detention doors and frames.
- Note 7: Miscellaneous items that could be inserted at end of detention door hardware sets include key-control cabinets, software if not included in Division 08 Section "Door Hardware", and detention door hardware not otherwise listed.

- A. General: Provide detention door hardware for each detention door to comply with requirements in this Section and detention door hardware sets indicated in a door and frame schedule **OR** and detention door hardware sets indicated below, **as directed**.

Detention Door Hardware Set No. [#]

Single Door No. [#]; each to have the following:

*	Hanging Devices	<Insert description.>	<Insert manufacturer.>	<Insert finish.>
[#]	Securing Devices	<Insert description.>	<Insert manufacturer.>	<Insert finish.>



	(inactive leaf)			
<#>	Securing Devices	<Insert description.>	<Insert manufacturer.>	<Insert finish.>
	(active leaf)			
[#]	Operating Trim	<Insert description.>	<Insert manufacturer.>	<Insert finish.>
[#]	Closing Devices	<Insert description.>	<Insert manufacturer.>	<Insert finish.>
[#]	Stops	<Insert description.>	<Insert manufacturer.>	<Insert finish.>

* Number of Hinges,
as specified.

Note 8: Insert additional requirements and sequence of operation in schedule above for electrified and pneumatic detention door hardware if required.

END OF SECTION 11 98 12 00

**SECTION 11 98 12 00a - DETENTION ENCLOSURES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for detention enclosures. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Bar-grille assemblies.
 - b. Woven-rod-mesh assemblies.
 - c. Security grilles and vents.

C. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit MR 4.1 and Credit MR 4.2: Indicating percentages by weight of postconsumer and preconsumer recycled content for products having recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
3. Shop Drawings: For detention enclosures. Include plans, elevations, sections, details, and attachments to other work.
 - a. Indicate requirements for cast-in anchors to be installed as work of other Sections.
4. Samples: For units with factory-applied color finishes.
5. Samples for Verification:
 - a. Include 12-by-12-inch (305-by-305-mm) cut-away corner section of bar-grille assembly, constructed of specified round and flat bars, showing fabrication techniques and workmanship.
 - b. Include 12-by-12-inch (305-by-305-mm) cut-away corner section of woven-rod-mesh assembly, constructed of specified framing and woven-rod panel, showing fabrication techniques and workmanship.
 - c. Include one full-size security grille and vent unit.
6. Welding certificates.
7. Material Certificates.
8. Material Test Reports: For tool-resisting steel.
9. Mill Certificates: For tool-resisting steel rods.
10. Maintenance Data.
11. Other Informational Submittals:
 - a. Examination reports documenting inspections of substrates, areas, and conditions.
 - b. Anchor inspection reports documenting inspections of built-in and cast-in anchors.
 - c. Field quality-control reports documenting inspections of installed products.
 - d. Field quality-control certification signed by Contractor and Detention Specialist.

D. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation and maintenance of units required for this Project.
2. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing tool-resisting steel.
3. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - c. AWS D1.6, "Structural Welding Code - Stainless Steel."
4. Preinstallation Conference: Conduct conference at Project site.



1.2 PRODUCTS

A. Materials

1. Recycled Content of Steel Products: Provide products with average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 **OR** 60, **as directed**, percent.
2. Mild Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
3. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, CS (Commercial Steel), Type B, suitable for exposed applications.
4. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, CS (Commercial Steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.
5. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, CS (Commercial Steel), Type B; with G60 (Z180) zinc (galvanized) or A60 (ZF180) zinc-iron-alloy (galvannealed) coating designation.
6. Steel Tubing: ASTM A 501 or ASTM A 513, Type B unless otherwise indicated.
7. Tool-Resisting Steel Round and Flat Bars: ASTM A 627.
8. Tool-Resisting Steel Round Rods: Fabricated from material with same chemical and physical properties as tool-resisting steel round bars.
9. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666 or ASTM A 240/A 240M, austenitic stainless steel, Type 304.
10. Security Fasteners: Operable only by tools produced by fastener manufacturer or other licensed fabricator for use on specific type of fastener. Drive-system type, head style, material, and protective coating as required for assembly, installation, and strength, and as follows:
 - a. Drive-System Type: Pinned Torx-Plus **OR** Pinned Torx, **as directed**.
 - b. Fastener Strength: 120,000 psi (827 MPa).
 - c. Socket Button Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - d. Socket Flat Countersunk Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - e. Socket Head Cap Fasteners:
 - 1) Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
 - 2) Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
 - f. Protective Coatings for Heat-Treated Alloy Steel:
 - 1) Zinc and clear trivalent chromium where indicated.
 - 2) Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.
11. Concealed Bolts: ASTM A 307, Grade A unless otherwise indicated.
12. Cast-in-Place Anchors in Concrete: Fabricated from corrosion-resistant materials capable of sustaining, without failure, a load equal to four times the load imposed, as determined by testing per ASTM E 488, conducted by a qualified testing agency; of type indicated below.
 - a. Threaded or wedge type; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed; hot-dip galvanized per ASTM A 153/A 153M or ASTM F 2329.
13. Embedded Plate Anchors: Fabricated from mild steel shapes and plates, minimum 3/16 inch (4.8 mm) thick; with minimum 1/2-inch- (12.7-mm-) diameter, headed studs welded to back of plate.
14. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Bar-Grille Assemblies

1. Tool-Resisting Steel Bar Grilles: ASTM A 627, Grade 1 **OR** Grade 2, **as directed**.
 - a. Vertical Bars: 1-inch- (25.4-mm-) diameter, double-ribbed, round **OR** hexagonal, **as directed**, composite tool-resisting steel bars at 4 inches (102 mm) **OR** 5 inches (127 mm) **OR** 6 inches (152 mm), **as directed**, o.c.



- b. Horizontal Flat Bars: 3/8-by-2-1/2-inch (9.6-by-63.5-mm) composite tool-resisting steel flat bars at 12 inches (305 mm) **OR** 18 inches (457 mm), **as directed**, o.c.
 - c. Perimeter Framing: 3/8-by-2-1/2-inch (9.6-by-63.5-mm) composite tool-resisting steel flat bars.
 2. Tool-Resisting Steel Bar Grilles: ASTM A 627, Grade 3.
 - a. Vertical Bars: 1-inch- (25.4-mm-) diameter, double-ribbed, round **OR** hexagonal, **as directed**, homogeneous tool-resisting steel bars at 4 inches (102 mm) **OR** 5 inches (127 mm) **OR** 6 inches (152 mm), **as directed**, o.c.
 - b. Horizontal Flat Bars: 5/16-by-2-1/4-inch (7.9-by-57.2-mm) homogeneous tool-resisting steel flat bars at 12 inches (305 mm) **OR** 18 inches (457 mm), **as directed**, o.c.
 - c. Perimeter Framing: 5/16-by-2-1/4-inch (7.9-by-57.2-mm) homogeneous tool-resisting steel flat bars.
 3. Tool-Resisting Steel Bar Grilles: ASTM A 627, Grade 4.
 - a. Vertical Bars: 7/8-inch- (22.2-mm-) diameter, double-ribbed, round **OR** hexagonal, **as directed**, homogeneous tool-resisting steel bars at 4 inches (102 mm) **OR** 5 inches (127 mm) **OR** 6 inches (152 mm), **as directed**, o.c.
 - b. Horizontal Flat Bars: 1/4-by-2-inch (6.4-by-50.8-mm) homogeneous tool-resisting steel flat bars at 12 inches (305 mm) **OR** 18 inches (457 mm), **as directed**, o.c.
 - c. Perimeter Framing: 1/4-by-2-inch (6.4-by-50.8-mm) homogeneous tool-resisting steel flat bars.
 4. Mild Steel Bar Grilles:
 - a. Vertical Bars: 7/8-inch- (22.2-mm-) diameter, double-ribbed, round **OR** hexagonal, **as directed**, mild steel bars at 4 inches (102 mm) **OR** 5 inches (127 mm) **OR** 6 inches (152 mm), **as directed**, o.c.
 - b. Horizontal Flat Bars: 3/8-by-2-1/4-inch (9.5-by-57-mm) mild steel flat bars at 12 inches (305 mm) **OR** 18 inches (457 mm), **as directed**, o.c.
 - c. Perimeter Framing: 3/8-by-2-1/4-inch (9.5-by-57-mm) mild steel flat bars.
 5. Finish: Factory primed for field painting.
- C. Woven-Rod-Mesh Assemblies
 1. Main Framing: Formed from 1-1/2-by-2-1/2-inch (38-by-63.5-mm) built-up tubular steel consisting of an open channel with fixed concealment plates.
 - a. Open Channel: Formed from 0.134-inch (3.42-mm) **OR** 0.105-inch (2.66-mm), **as directed**, nominal-thickness steel sheet or channel with individual slots along inner edges to support woven-rod panels.
 - b. Concealment Plates: Steel sheet to match open channel.
 2. Supplementary Framing: Formed from 2-inch-square by 3/16-inch- (51-mm-square by 4.8-mm-) thick steel tubing.
 3. Braces: Formed from same material as main framing.
 4. Woven-Rod Panels: Formed from double crimped, 1/4-inch- (6-mm-) **OR** 3/8-inch- (9.5-mm-), **as directed**, diameter steel rod, woven horizontally and vertically into a rigid grille with rods at 2 inches (51 mm) o.c.
 - a. Steel Rod for Galvanized Assemblies: Mild **OR** Homogeneous tool-resisting, **as directed**, steel.
 - b. Steel Rod for Nongalvanized Assemblies: Mild **OR** Homogeneous tool-resisting, **as directed**, steel.
 5. Floor Anchor Clips: 2-by-2-by-3/16-inch (51-by-51-by-4.8-mm) mild steel angles for straight framing; 1-1/2-by-1-1/2-by-3/16-inch (38-by-38-by-4.8-mm) mild steel angles for corners.
 6. Floor Anchors: 2-inch-square by 3/16-inch- (51-mm-square by 4.8-mm-) thick, mild steel tubing sleeve welded to 6-inch-square by 3/16-inch- (152-mm-square by 4.8-mm-) thick, mild steel plate.
 7. Wall and Ceiling Anchorage and Trim: Continuous 2-by-2-by-3/16-inch (51-by-51-by-4.8-mm) mild steel angle with 2-by-3/16-inch (51-by-4.8-mm) mild steel flat bar.
 8. Finishes:
 - a. Exterior Locations: Hot-dip galvanized after fabrication. Factory primed for field painting.
 - b. Interior Locations: Factory primed for field painting. Hot-dip galvanized after fabrication where indicated.



D. Security Grilles And Vents

1. Security Grilles:
 - a. Face Frame: 3/16-inch- (4.8-mm-) thick, mild **OR** homogeneous tool-resisting, **as directed**, steel flat bar.
 - b. Wire Mesh: 0.135-inch- (3.5-mm-) diameter steel wire woven into a 3/8-inch (9.5-mm) mesh, attached to perimeter frame by bolts or studs **OR** welding, **as directed**.
 - c. Perimeter Frame: 3/16-inch- (4.8-mm-) thick, mild steel flat bar with anchor studs **OR** masonry anchors, **as directed**, welded to back.
 - d. Vertical Bars: 7/8-inch- (22-mm-) **OR** 1-inch- (25-mm-), **as directed**, diameter, double-ribbed, round **OR** hexagonal, **as directed**, homogeneous tool-resisting steel bars at 4 inches (102 mm) o.c., welded to vertical bar supports.
 - e. Vertical Bar Supports: 2-1/2-by-3/8-inch- (63.5-by-9.5-mm-) thick, mild steel bars welded to perimeter frame.
 - f. Finish: Factory primed for field painting.
2. Perforated-Plate Security Vents:
 - a. Faceplate: 3/16-inch- (4.8-mm-) thick, mild steel **OR** stainless-steel, **as directed**, plate; with 5/16-inch (7.9-mm) round holes staggered 7/16 inch (11 mm) o.c. in each direction.
 - b. Opening Sleeve: 3/16-inch- (4.8-mm-) thick steel plate welded to faceplate.
 - c. Perimeter Frame: 1-by-1-by-3/16-inch- (25-by-25-by-4.8-mm-) thick, mild steel angles.
 - d. Provide anchor studs welded to back of faceplate for installation into concrete.
 - e. Finish: Factory primed for field painting **OR** No. 4 **OR** No. 2B, **as directed**.
 - f. Damper: Front-operated **OR** Rear-operated, **as directed**, opposed-blade type.
3. Perforated-Plate Security Vents with Wire Mesh:
 - a. Faceplate: 0.075-inch (1.90-mm) nominal-thickness, mild steel **OR** 0.078-inch- (1.98-mm-) thick, stainless-steel, **as directed**, sheet; with 3/4-inch- (19-mm-) square perforations 1/4 inch (6 mm) apart in each direction.
 - b. Wire Mesh: 0.062-inch- (1.6-mm-) diameter steel wire woven into a 1/4-inch (6-mm) mesh, welded to opening sleeve behind faceplate.
 - c. Opening Sleeve: 0.075-inch (1.90-mm) nominal thickness, formed from steel sheet and welded to faceplate.
 - d. Finish: Factory primed for field painting **OR** No. 4 **OR** No. 2B, **as directed**.
 - e. Damper: Front-operated **OR** Rear-operated, **as directed**, opposed-blade type.
4. Perforated-Plate Security Vents with Backup Plate:
 - a. Faceplate: 3/16-inch- (4.8-mm-) thick, mild steel **OR** stainless-steel, **as directed**, plate; with 2-inch- (51-mm-) square perforations 1 inch (25 mm) apart in each direction.
 - b. Wire Mesh: 0.135-inch- (3.5-mm-) diameter steel wire woven into a 3/8-inch (9.5-mm) mesh, secured between faceplate and backup plate.
 - c. Backup Plate: 1/4-inch- (6-mm-) thick, mild steel plate with perforations matching faceplate.
 - d. Perimeter Frame: 1-by-1-by-3/16-inch- (25-by-25-by-4.8-mm-) thick, mild steel angles.
 - e. Opening Sleeve: 0.134-inch (3.42-mm) nominal thickness, formed from steel sheet and welded to faceplate.
 - f. Finish: Factory primed for field painting **OR** No. 4 **OR** No. 2B, **as directed**.
 - g. Damper: Front-operated **OR** Rear-operated, **as directed**, opposed-blade type.
5. Tool-Resisting Steel, Perforated-Plate Security Vents:
 - a. Faceplate: 1/4-inch- (6-mm-) thick, homogeneous tool-resisting steel plate; with 2-inch- (51-mm-) square perforations 1 inch (25 mm) apart in each direction.
 - b. Wire Mesh: 0.135-inch- (3.5-mm-) diameter steel wire woven into a 3/8-inch (9.5-mm) mesh, attached to faceplate by bolts or studs.
 - c. Backup Plate: 1/4-inch- (6-mm-) thick, homogeneous tool-resisting steel plate with perforations matching faceplate.
 - d. Perimeter Frame: 3/16-inch- (4.8-mm-) thick, mild steel flat bar with anchor studs **OR** masonry anchors, **as directed**, welded to back.
 - e. Finish: Factory primed for field painting.



6. Anchors: Unless otherwise indicated, provide minimum 1/2-inch- (12.7-mm-) diameter, headed stud anchors at 12 inches (305 mm) o.c.
- E. Fabrication, General
1. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
 2. Coordinate dimensions and attachment methods of detention enclosures with those of adjoining construction to produce integrated assemblies with closely fitting joints and with edges and surfaces aligned unless otherwise indicated.
 3. Shear and punch metals cleanly and accurately. Remove burrs.
 4. Form and grind edges and corners to be free of sharp edges or rough areas.
 5. Form metal in maximum lengths to minimize joints. Form sheet-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.
 6. Weld corners and seams continuously to comply with referenced AWS standard and the following:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. Finish exposed welds and surfaces smooth and blended at exposed connections so that no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
 - e. Weld before finishing components to greatest extent possible. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
 7. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure detention enclosures rigidly in place and to support indicated loads. Build in straps, plates, and brackets as needed to support and anchor fabricated items to adjoining construction. Reinforce formed-metal units as needed to attach and support other construction.
 8. Cut, reinforce, drill, and tap detention enclosures as indicated to receive hardware, security fasteners, and similar items.
 9. Form exposed work true to line and level with accurate angles, surfaces, and straight sharp edges.
 10. Form exposed connections with hairline joints flush and smooth using concealed fasteners where possible. Use exposed security fasteners of type indicated or, if not indicated, flat-head (countersunk) security screws. Locate joints where least conspicuous.
 11. Exterior Detention Enclosures: Allow for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- F. Fabrication Of Bar-Grille Assemblies
1. General: Fabricate bar-grille assemblies with materials and to sizes and configurations indicated, complete with mounting flanges and anchors.
 - a. Pass vertical round bars through, and positively interlock them with, horizontal flat bars at each intersection without reducing circumference of round bars at these intersections and without using pipe sleeves, swedging, calking, or interlocks that depend on friction. Weld vertical round bars at each intersection with flat bars.
 - b. Pass ends of round bars at least 1 inch (25 mm) through framing, and weld bars to framing from back side of framing.
 - c. Fabricate cutouts and openings in bar-grille assemblies for penetrations of sizes and at locations indicated. Frame openings with flat bars of same material and size as horizontal flat bars.



- d. Frame connections with plates; use flat bars of same material and size as horizontal flat bars.
 2. Partitions: Connect top horizontal flat bar to vertical flat bar framing members with 2-by-2-by-1/4-inch- (51-by-51-by-6-mm-) thick, steel plate angle knee welded into place. Connect intersections of horizontal flat bars with vertical flat bar framing members by 3/16-inch (4.8-mm) fillet welds. Weld vertical bars securely to top and bottom flat bar framing members.
 3. Doors: Fabricate swinging **OR** sliding, **as directed**, doors of same type bar-grille assembly as bar-grille partition in which they are installed. Weld lockbox at lock jamb of door, fabricated of steel plate to match horizontal flat bars. Comply with requirements in Division 08 Section "Detention Door Hardware" for detention hinges and detention locks and latches.
 - a. Food-Pass Openings: Frame top and sides of opening with flat bar of same quality and size as horizontal flat bars. Weld 1/4-inch- (6-mm-) thick steel plate shelf, of same quality as horizontal flat bars, at bottom of opening.
- G. Fabrication Of Woven-Rod-Mesh Assemblies
1. Main Framing: Before inserting woven-rod panels, weld and grind smooth corners of open channel elements. Fabricate partitions taller than 12 feet (3.6 m) from multiple panels stacked on top of one another.
 2. Woven-Rod Panels: Insert panels symmetrically in main framing. Extend end of each rod at least 1 inch (25 mm) into main framing and, from inside of channel, weld into each slot where it contacts main framing.
 3. Concealment Plates: Weld plates to main framing with minimum 1 inch (25 mm) welds at minimum 10 inches (254 mm) o.c., staggered side to side and ground smooth, to form a fully enclosed tubular steel frame.
 4. Anchor Clips: For each enclosure panel, weld one anchor clip to secure side of main framing in line with vertical framing.
 5. Swinging Doors: Fabricate doors with framing on four sides of door from same material as adjacent panels and with 2-by-1/4-inch (51-by-6-mm) flat steel bar astragal continuous on lock jamb. Align bottom of door with bottom of adjacent panels. Comply with requirements in Division 08 Section "Detention Door Hardware" for detention hinges and detention locks and latches.
 6. Sliding Doors: Fabricate doors with framing on four sides of door from same material as adjacent panels. Align bottom of door with bottom of adjacent panels. Comply with requirements in Division 08 Section "Detention Door Hardware" for sliding detention door device assemblies and detention locks and latches.
 7. Hardware Preparation: Mortise, reinforce, drill, and tap doors and main framings for templated hardware to comply with approved Door Hardware Schedule. Frame openings to receive detention door locks.
 8. Fabricate joints that will be exposed to weather in a manner to exclude water, and provide weep holes where water may accumulate.
- H. Fabrication Of Security Grilles And Vents
1. General: Fabricate security grilles and vents with materials and to sizes and configurations indicated, complete with mounting flanges and anchors.
 2. Security Grilles:
 - a. Orient axis of ribs of each tool-resisting steel bar to run parallel to airflow.
 - b. Pass vertical round bars through, and positively interlock them with, vertical bar supports without reducing circumference of round bars at these intersections and without using pipe sleeves, swedging, calking, or interlocks that depend on friction.
 - c. Pass round bars at least 1 inch (25 mm) through vertical bar supports, and weld bars to supports from back side of supports.
 3. Where bolts are used to secure wire mesh, batter threads to prevent nut removal.
- I. Steel Finishes
1. Steel and Galvanized-Steel Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.



2. Steel and Galvanized-Steel Factory Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.

J. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - c. Directional Satin Finish: No. 4.
3. Bright, Cold-Rolled, Unpolished Finish: No. 2B.

1.3 EXECUTION

A. Installation, General

1. Install detention enclosures plumb, rigid, properly aligned, and securely fastened in place, complying with manufacturer's written recommendations.
2. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing detention enclosures to in-place construction. Include threaded fasteners for inserts, security fasteners, and other connectors.
 - a. Proprietary Built-in Masonry Anchors: Install integral with unit masonry. Comply with requirements in Division 04 Section "Unit Masonry".
3. Cutting, Fitting, and Placement: Obtain manufacturer's written approval for cutting, drilling, and fitting required for installing detention enclosures. Set detention enclosures accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
4. Provide temporary bracing or anchors in formwork for items that are to be built into adjacent construction.
5. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
6. Field Welding: Comply with the following requirements:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. Finish exposed welds and surfaces smooth and blended at exposed connections so that no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

B. Installation Of Bar-Grille Assemblies

1. Wall and Ceiling Anchorage: Weld framing to continuous angles with continuous welds. Anchor angles to embedded anchors by bolting **OR** welding, **as directed**.
2. Partitions: Weld adjacent framing members to each other with continuous 1/4-inch- (6-mm-) deep welds on both sides; grind smooth.
3. Doors: Install 2 inches (51 mm) above finish floor. Adjust to operate easily without binding.

C. Installation Of Woven-Rod-Mesh Assemblies

1. Floor Anchorage: Fasten anchor clips to floor with 3/8-inch- (9.5-mm-) diameter bolts with double-expansion shields.



2. Wall and Ceiling Anchorage: Anchor continuous angle to walls and ceilings with 3/8-inch- (9.5-mm-) diameter, security-type, double-expansion anchor bolts with "break-off" heads **OR** toggle bolts; weld bolt heads to angle, **as directed**.
 - a. Weld main framing to wall and ceiling angles with 1-inch (25-mm) welds at 12 inches (305 mm) o.c.
 3. Weld adjacent main framing members to each other with 1/4-inch-deep by 3/4-inch- (6-mm- by 19-mm-) long welds at 12 inches (305 mm) o.c. on both sides of framing.
 4. Provide supplementary framing at three-way connections and multiple-panel-height partitions. Weld main framing to supplementary framing with 1/8-inch (3-mm) fillet welds 1 inch (25 mm) long at 12 inches (305 mm) o.c. on both sides of framing.
 5. Provide additional field bracing as shown or as necessary for rigid, secure installation.
 6. Adjust doors to operate easily without binding.
- D. Installation Of Security Grilles And Vents
1. Locations: Unless otherwise indicated, install security grilles and vents in penetrations and openings with dimensions exceeding 8 inches (203 mm) in either direction **OR** diameter, **as directed**.
 2. Support Frames: Set support frames in adjacent construction.
 3. Grilles: Weld vertical bar supports to support frame.
 4. Field weld perimeter frames to duct sleeves.
- E. Field Quality Control
1. Detention Specialist shall inspect **OR** Inspect, **as directed**, installed products to verify compliance with requirements. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents.
 2. Remove and replace detention work if inspections indicate that work does not comply with specified requirements. Remove malfunctioning units; replace with new units.
 3. Perform additional inspections to determine compliance of replaced or additional work. Prepare inspection reports.
 4. Prepare field quality-control certification endorsed by Detention Specialist, **as directed**, that states installed products and their installation comply with requirements in the Contract Documents.
- F. Cleaning And Protection
1. Touchup Painting: Immediately after erection, clean bolted connections and abraded areas of shop paint, and paint exposed areas with same material used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 2. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas; repair galvanizing to comply with ASTM A 780.

END OF SECTION 11 98 12 00a



SECTION 11 98 12 00b - DETENTION FURNITURE

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for detention furniture. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Gun lockers.
 - b. Security key cabinets.
 - c. Detention bunks.
 - d. Detention mattresses.
 - e. Detention desks.
 - f. Detention tables.
 - g. Detention seating.

C. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For security sealants, including printed statement of VOC content.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
4. Samples: For factory-applied color finishes.
5. Samples for Verification:
 - a. Furniture: Full-size units. Approved Samples may become part of the completed Work.
 - b. Detention Mattresses: Not less than 6 inches (152 mm) square by full depth, including core and cover fabric.
6. Welding certificates.
7. Product certificates.
8. Maintenance data.
9. Other Informational Submittals:
 - a. Field quality-control reports documenting inspections of installed products.
 - b. Field quality-control certification signed by Contractor and Detention Specialist, **as directed**.

D. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - c. AWS D1.6, "Structural Welding Code - Stainless Steel."
2. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage And Handling

1. Detention Mattresses: Deliver wrapped to provide protection during transit and Project-site storage. Protect from contact with moisture.

1.2 PRODUCTS

A. Materials



1. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, CS (Commercial Steel), Type B; suitable for exposed applications.
3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, CS (Commercial Steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.
4. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666 or ASTM A 240/A 240M, austenitic stainless steel, Type 304.
5. Steel Tubing: ASTM A 513, Type B unless otherwise indicated; thickness indicated or required by structural loads.
6. Steel Pipe: ASTM A 53/A 53M, Standard Weight (Schedule 40) unless another weight is indicated or required by structural loads.
7. Concealed Bolts: ASTM A 307, Grade A unless otherwise indicated.
8. Cast-in-Place Anchors in Concrete: Fabricated from corrosion-resistant materials capable of sustaining, without failure, a load equal to four times the load imposed, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency; of type indicated below.
 - a. Threaded or wedge type; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed; hot-dip galvanized per ASTM A 153/A 153M or ASTM F 2329.
9. Embedded Plate Anchors: Fabricated from steel shapes and plates, minimum 3/16 inch (4.8 mm) thick; with minimum 1/2-inch- (12.7-mm-) diameter headed studs welded to back of plate.
10. Proprietary Built-in Masonry Anchors: Fabricated from 0.134-inch (3.42-mm) nominal-thickness steel sheet **OR** 1/4-inch (6-mm) nominal-thickness steel plate **OR** 1/2-inch (12.7-mm) nominal-thickness steel plate, **as directed**, into 6-inch- (152-mm-) **OR** 8-inch- (203-mm-), **as directed**, deep blocks matching size of concrete masonry units; with weld nuts attached on inside to receive field-bolted attachments, **as directed**.
 - a. Finish: Factory primed for field painting for anchors with field-welded attachments **OR** Polyester powder coat for anchors with bolted attachments **OR** Epoxy paint for anchors with bolted attachments, **as directed**.
11. Welding Rods and Bare Electrodes: Select according to AWS specifications.

B. Security Sealants

1. Manufacturer's standard, high-modulus, nonsag, two-part, pick-proof, epoxy sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), recommended for sealing nonmoving interior joints in security applications.

C. Security Fasteners

1. Fasteners operable only by tools produced by fastener manufacturer or other licensed fabricator for use on specific type of fastener.
2. Provide drive-system type, head style, material, and protective coating as required for assembly, installation, and strength, and as follows:
 - a. Drive-System Type: Pinned Torx-Plus **OR** Pinned Torx, **as directed**.
 - b. Fastener Strength: 120,000 psi (827 MPa).
 - c. Socket Button Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - d. Socket Flat Countersunk Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - e. Socket Head Cap Fasteners:
 - 1) Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
 - 2) Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
 - f. Protective Coatings for Heat-Treated Alloy Steel:
 - 1) Zinc and clear trivalent chromium where indicated.
 - 2) Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

**D. Gun Lockers**

1. Pistol Lockers:
 - a. Cabinet: Minimum 20 inches (508 mm) wide by 15 inches (381 mm) high by 10 inches (254 mm) deep; formed from 0.134-inch (3.42-mm) **OR** 0.075-inch (1.90-mm), **as directed**, nominal-thickness steel sheet. Line each compartment with mothproofed felt or nonabsorbing, closed-cell padding.
 - 1) Compartments: Six.
 - b. Doors: Formed from same material as cabinet, supported by heavy-duty continuous bottom hinge.
 - c. Locks: Snap **OR** Cylinder, **as directed**, type, keyed differently and master keyed, **as directed**; provide one lock for each compartment.
 - d. Mounting: Surface **OR** Recessed, with mounting flange formed from same material as body, **as directed**.
 - e. Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
2. Tilt-Out, Pistol Locker:
 - a. Cabinet: Minimum 39 inches (991 mm) wide by 15 inches (381 mm) high by 6 inches (152 mm) deep; formed from 0.134-inch (3.42-mm) **OR** 0.075-inch (1.90-mm), **as directed**, nominal-thickness steel sheet. Line each compartment with mothproofed felt or nonabsorbing, closed-cell padding.
 - 1) Compartments: Six.
 - b. Doors: Formed from same material as cabinet, supported by heavy-duty continuous bottom hinge, with attached tilt-out compartment with formed metal sides.
 - c. Locks: Snap **OR** Cylinder, **as directed**, type, keyed differently and master keyed, **as directed**; provide one lock for each compartment.
 - d. Mounting: Surface **OR** Recessed, with mounting flange formed from same material as body, **as directed**.
 - e. Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.

E. Security Key Cabinets

1. Cabinet: Minimum 16 inches (406 mm) wide by 24 inches (610 mm) high by 6-1/2 inches (165 mm) deep; formed from 0.134-inch (3.42-mm) nominal-thickness steel sheet. Provide 0.060-inch (1.52-mm) nominal-thickness, steel sheet interior panels, supported on pivots, for mounting 150 **OR** 300, **as directed**, paracentric or mogul keys.
2. Doors: Formed from same material as cabinet, supported by heavy-duty continuous side hinge welded to cabinet and door; with tumbler deadlock.
3. Cross-Index System: Set up by key control manufacturer; include labels, two sets of key tags with self-locking key holders, key-gathering envelopes, temporary and permanent markers, and the following:
 - a. Card Index: Furnish four sets of index cards for recording key information. Include three receipt forms for each key-holding hook.
 - b. Computer Software: Furnish cross-index software for recording and reporting key-holder listings, tracking keys and lock and key history, and printing receipts for transactions. Include instruction manual.
4. Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.

F. Detention Bunks

1. Freestanding Single Bunks:
 - a. Bunk Pan: Formed from 0.134-inch (3.42-mm) **OR** 0.105-inch (2.66-mm), **as directed** nominal-thickness steel sheet, perforated with at least six holes, **as directed**.
 - 1) Size: Minimum 27 inches (689 mm) wide by 76 inches (1930 mm) long with bunk pan 14 inches (356 mm) above floor.
 - 2) Turn up edges of back and sides and turn down edge of front **OR** back, sides, and front, **as directed**, with minimum 2-inch (51-mm) flanges.
 - b. Drawer: Minimum 21 inches (533 mm) wide by 24 inches (610 mm) deep by 5 inches (127 mm) high, with full-width integral pull formed from steel sheet **OR** solid-steel bar pull, **as directed**; formed from 0.134-inch (3.42-mm) nominal-thickness steel sheet.



- c. Legs and Frames: Formed from 2-by-2-by-3/16-inch (51-by-51-by-4.8-mm) steel angle welded at connections to each other and to bunk pan; provide four legs for each bunk.
 - d. Mounting Plates: Formed from 1/4-inch- (6-mm-) thick steel plate punched with one hole for floor anchorage; provide one mounting plate for each leg.
 - e. Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
2. Freestanding Double Bunks:
- a. Bunk Pan: Formed from 0.134-inch (3.42-mm) **OR** 0.105-inch (2.66-mm), **as directed**, nominal-thickness steel sheet, each pan perforated with at least six holes, **as directed**.
 - 1) Size: Minimum 27 inches (689 mm) wide by 76 inches (1930 mm) long with lower bunk pan 14 inches (356 mm) above floor and upper bunk pan at least 49 inches (1245 mm) above floor.
 - 2) Upper and Lower Bunks: Turn up edges of back and sides and turn down edge of front **OR** back, sides, and front, **as directed**, with minimum 2-inch (51-mm) flanges.
 - 3) Upper Bunk: Turn up edges of back and sides and turn down edge of front **OR** back, sides, and front, **as directed**, with minimum 2-inch (51-mm) flanges.
 - 4) Lower Bunk: Turn up edges of back and sides and turn down edge of front, with minimum 2-inch (51-mm) flanges.
 - b. Drawers: Two; minimum 21 inches (533 mm) wide by 24 inches (610 mm) deep by 5 inches (127 mm) high, with full-width integral pull formed from steel sheet **OR** solid-steel bar pull, **as directed**; formed from 0.134-inch (3.42-mm) nominal-thickness steel sheet.
 - c. Legs and Frames: Formed from 2-by-2-by-3/16-inch (51-by-51-by-4.8-mm) steel angle welded at connections to each other and to bunk pan; provide four legs for each bunk.
 - d. Mounting Plates: Formed from 1/4-inch- (6-mm-) thick steel plate punched with one hole for floor anchorage; provide one mounting plate for each leg.
 - e. Assembly: Factory assembled **OR** Knocked down for field assembly, **as directed**.
 - f. Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
3. Wall-Mounted Bunks:
- a. Bunk Pan: Formed from 0.134-inch (3.42-mm) **OR** 0.105-inch (2.66-mm), **as directed**, nominal-thickness steel sheet, perforated with at least six holes, **as directed**.
 - 1) Size: Minimum 27 inches (689 mm) wide by 76 inches (1930 mm) long with bunk pan 2 inches (51 mm) from wall.
 - 2) Turn up edges of back and sides and turn down edge of front **OR** back, sides, and front, **as directed**, with minimum 2-inch (51-mm) flanges.
 - b. Drawer: Minimum 21 inches (533 mm) wide by 24 inches (610 mm) deep by 5 inches (127 mm) high, with full-width integral pull formed from steel sheet **OR** solid-steel bar pull, **as directed**; formed from 0.134-inch (3.42-mm) nominal-thickness steel sheet.
 - c. Combination End Panel/Mounting Plate: Formed from 3/16-inch- (0.048-mm-) thick steel sheet welded at connections to bunk pan, with 2-inch (51-mm) flange for wall mounting; provide two end panel/mounting plates for each bunk.
 - d. Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.

G. Detention Mattresses

- 1. General: Comply with 16 CFR 1632 and California Technical Bulletin 121 as determined by testing identical products by a testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.
- 2. Core: Fire-resistive solid foam **OR** Fire-resistive densified polyester **OR** Cotton, with 10 percent boric acid treatment, tufted to nylon netting to retain shape, **as directed**.
- 3. Cover Fabric: Vinyl bonded to nylon scrim; with a minimum total weight of 10 oz./sq. yd. (339 g/sq. m). Fabricate cover of four-corner box construction with seams facing inside of detention mattress except end closing seam located at foot of mattress; sew with nylon thread in a double-lock stitch.
- 4. Thickness: 4 inches (102 mm) **OR** 6 inches (152 mm), **as directed**.

H. Detention Desks



1. Single-Seat, Floor-Mounted Desks:
 - a. Desk Top: Formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.105-inch (2.66-mm) nominal-thickness steel **OR** 0.141-inch- (3.57-mm-) thick, stainless-steel **OR** 0.062-inch- (1.59-mm-) thick, stainless-steel, **as directed**, sheet, with minimum 1-1/2-inch (38-mm) flanged edges.
 - b. Pedestal: Provide two storage shelves with sides and shelves formed from 0.134-inch (3.42-mm) nominal-thickness steel.
 - c. Legs: Formed from 1-1/2-inch-square by 3/16-inch- (38-mm-square by 4.8-mm-) thick steel tubing welded to desk top and mounting plate for an overall desk height of not less than 30 inches (762 mm).
 - d. Seat: 12-inch (305-mm) diameter, formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.075-inch (1.90-mm) nominal-thickness steel **OR** 0.141-inch- (3.57-mm-) thick, stainless-steel **OR** 0.062-inch- (1.59-mm-) thick, stainless-steel, **as directed**, sheet; reinforced with 0.134-inch (3.42-mm) nominal-thickness steel sheet, with minimum 1-1/2-inch (38-mm) flanged edges.
 - e. Swivel Seat Support: Formed from 1-by-2-by-0.075-inch (25-by-51-by-1.90-mm) nominal-thickness steel tubing, 2-inch-OD-by-0.075-inch (51-mm-OD-by-1.90-mm) nominal-thickness steel tubing, or 3/8-inch- (9.5-mm-) thick, steel plate bar; with 1/2-inch (12.7-mm) pivot pin welded to legs.
 - f. Towel Bar: Formed from 1/4-by-1-1/2-inch (6-by-38-mm) steel **OR** stainless-steel, **as directed**, plate, mounted on one side of desk.
 - g. Mounting Plates: Formed from 1/4-inch- (6-mm-) thick steel plate punched with one hole for floor anchorage; provide one mounting plate for each leg.
 - h. Steel Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - i. Stainless-Steel Finish: No. 3.
 - 1) Size: Minimum 36 inches (914 mm) wide by 15-1/2 inches (381 mm) deep.
 2. Wall-Mounted Desk and Seat:
 - a. Desk: Formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.141-inch- (3.57-mm-) thick, stainless-steel, **as directed**, sheet, with minimum 1-1/2-inch (38-mm) flanged edges.
 - 1) Size: Minimum 12 inches (305 mm) wide by 18 inches (457 mm) deep **OR** 18 inches (457 mm) wide by 18 inches (457 mm) deep **OR** 24 inches (610 mm) wide by 18 inches (457 mm) deep **OR** 30 inches (762 mm) wide by 20 inches (508 mm) deep, **as directed**.
 - b. Seat: Minimum 12 inches (305 mm) wide by 16 inches (406 mm) **OR** 18 inches (457 mm), **as directed**, deep; formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.141-inch- (3.57-mm-) thick, stainless-steel, **as directed**, sheet, with minimum 1-1/2-inch (38-mm) flanged edges.
 - c. Steel Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - d. Stainless-Steel Finish: No. 3.
- I. Detention Tables
1. Pedestal-Style Table:
 - a. Tabletop: Formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.105-inch (2.66-mm) nominal-thickness steel **OR** 0.109-inch- (2.78-mm-) thick, stainless-steel **OR** 0.078-inch- (1.98-mm-) thick, stainless-steel **OR** 0.062-inch- (1.59-mm-) thick, stainless-steel, **as directed**, sheet; reinforced with steel shapes or steel plate, with minimum 1-1/2-inch (38-mm) flanged edges.
 - 1) Size: Minimum 30 inches (762 mm) **OR** 40 inches (1016 mm), **as directed**, wide by length required for capacity by 30 inches (762 mm) **OR** 35 inches (889 mm), **as directed**, high.
 - 2) Game Top: Engrave, or otherwise integrally incorporate, checkerboard into tabletop.



- b. Seats: 12-inch (305-mm) diameter, formed from 0.105-inch (2.66-mm) nominal-thickness steel **OR** 0.075-inch (1.90-mm) nominal-thickness steel **OR** 0.078-inch- (1.98-mm-) thick, stainless-steel **OR** 0.062-inch- (1.59-mm-) thick, stainless-steel, **as directed**, sheet; reinforced with 0.134-inch (3.42-mm) nominal-thickness steel plate, with minimum 1-1/2-inch (38-mm) flanged edges.
 - c. Pedestal Supports: Formed from 3-inch-square by 3/16-inch- (76-mm-square by 4.8-mm-) **OR** 4-inch-square by 0.134-inch- (102-mm-square by 3.42-mm-), **as directed**, thick steel tubing welded to top and base plate. Provide two pedestals for tables with capacity of more than four persons.
 - d. Seat Framing: Formed from 3-inch-square by 0.134-inch- (76-mm-square by 3.42-mm-) **OR** 3-by-2-by-3/16-inch- (76-by-51-by-4.8-mm-), **as directed**, thick steel tubing welded to pedestal supports.
 - e. Base Plate: Minimum 16-inch- (406-mm-) square, 1/4-inch- (6-mm-) thick steel plate punched with four holes for floor anchorage.
 - f. Capacity: Four persons **OR** Six persons **OR** Eight persons **OR** As indicated on Drawings, **as directed**.
 - g. Steel Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - h. Stainless-Steel Finish: No. 3.
2. Bench-Style Table:
- a. Tabletop: Formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.105-inch (2.66-mm) nominal-thickness steel **OR** 0.109-inch- (2.78-mm-) thick, stainless-steel, **as directed**, sheet; reinforced with steel channel frame or steel plate, with minimum 1-1/2-inch (38-mm) flanged edges.
 - 1) Size: Minimum 24 inches (610 mm) wide by length required for capacity by 30 inches (762 mm) **OR** 35 inches (889 mm), **as directed**, high.
 - b. Benches: 12 inches (305 mm) deep by length of tabletop, formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.105-inch (2.66-mm) nominal-thickness steel **OR** 0.109-inch- (2.78-mm-) thick, stainless-steel **OR** 0.062-inch- (1.59-mm-) thick, stainless-steel, **as directed**, sheet, with minimum 1-1/2-inch (38-mm) flanged edges.
 - c. Vertical Supports: Formed from 8-inch (203-mm) hot-rolled steel channels or 0.164-inch- (4.18-mm-) thick, formed-steel channels; braced and welded, with steel base plates punched for floor anchorage. Provide three supports for tables with capacity of more than four persons.
 - d. Bench Supports: Formed from 2-by-2-1/2-by-1/4-inch- (51-by-64-by-6-mm-) thick steel angle or 2-inch-square by 1/4-inch- (51-mm-square by 6-mm-) thick steel tubing; welded to vertical supports.
 - e. Floor Anchor: Formed from steel angle punched for floor anchorage.
 - f. Capacity: Four persons **OR** Six persons **OR** Eight persons **OR** As indicated on Drawings, **as directed**.
 - g. Steel Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - h. Stainless-Steel Finish: No. 3.
- J. Detention Seating
- 1. Floor-Mounted Stool:
 - a. Seats: Minimum 12-inch (305-mm) diameter, formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.075-inch (1.90-mm) nominal-thickness steel **OR** 0.125-inch- (3.18-mm-) thick, stainless-steel **OR** 0.062-inch- (1.59-mm-) thick, stainless-steel, **as directed**, sheet; reinforced with 0.134-inch- (3.42-mm-) thick steel sheet cut to interior dimension of seat, with minimum 1-1/2-inch (38-mm) flanged edges.
 - b. Seat Support: Formed from steel pipe or 2-inch-OD-by-0.075-inch- (51-mm-OD-by-1.90-mm-) thick steel tubing welded to seat reinforcement and base plate for an overall stool height of not less than 18 inches (457 mm).



- c. Base Plate: Minimum 6-by-1/4-inch- (152-by-6-mm-) thick, square **OR** round, **as directed**, steel punched with four holes for floor anchorage.
 - d. Steel Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - e. Stainless-Steel Finish: No. 3.
2. Wall-Mounted Stool:
- a. Seat: Minimum 12-inch (305-mm) diameter, formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.075-inch (1.90-mm) nominal-thickness steel **OR** 0.125-inch- (3.18-mm-) thick, stainless-steel **OR** 0.078-inch- (1.98-mm-) thick, stainless-steel, **as directed**, sheet; reinforced with 0.134-inch- (3.42-mm-) thick steel sheet cut to interior dimension of seat, with minimum 1-1/2-inch (38-mm) flanged edges.
 - b. Seat Support: Formed from 1-by-2-by-0.075-inch- (25-by-51-by-1.90-mm-) thick steel tubing, 2-inch-OD-by-0.075-inch- (51-mm-OD-by-1.90-mm-) thick steel tubing or 3/8-inch- (9.5-mm-) thick, steel plate bar; welded to seat reinforcement and wall bracket.
 - c. Swivel Wall Bracket: Minimum 1/2-inch (12.7-mm) pivot pin, with 3/8-inch- (9.5-mm-) thick steel plate for welding to embedded steel plate **OR** for welding to steel wall **OR** punched with four holes for wall anchorage, **as directed**.
 - d. Steel Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - e. Stainless-Steel Finish: No. 3.
3. Floor-Mounted Bench:
- a. Bench Top: Formed from 0.134-inch (3.42-mm) nominal-thickness steel **OR** 0.105-inch (2.66-mm) nominal-thickness steel **OR** 0.141-inch- (3.57-mm-) thick, stainless-steel **OR** 0.109-inch- (2.78-mm-) thick, stainless-steel, **as directed**, sheet, with minimum 1-1/2-inch (38-mm) flanged edges.
 - 1) Size: Minimum 12 inches (305 mm) deep by 48 inches (1219 mm) **OR** 60 inches (1524 mm) **OR** 72 inches (1829 mm) **OR** 96 inches (2438 mm), **as directed**, long.
 - b. Supports: Formed from 0.164-inch- (4.18-mm-) thick, formed-steel channels 2-1/2-inch-OD-by-0.0677-inch- (64-mm-OD-by-1.7-mm-) thick steel tubing; welded to bench and base plate for an overall bench height of not less than 18 inches (457 mm). Provide three supports for benches with length of more than 72 inches (1829 mm).
 - c. Base Plates: Minimum 8-inch-square by 1/4-inch- (203-mm-square by 6-mm-) thick steel plate punched with four holes for floor anchorage.
 - d. Capacity: Four persons **OR** Six persons **OR** Eight persons **OR** As indicated on Drawings, **as directed**.
 - e. Steel Finish: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
 - f. Stainless-Steel Finish: No. 3.

K. Fabrication

1. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
2. Coordinate dimensions and attachment methods of detention furniture with those of adjoining construction to produce integrated assemblies with closely fitting joints and with edges and surfaces aligned unless otherwise indicated.
3. Shear and punch metals cleanly and accurately. Remove burrs.
4. Form and grind edges and corners to be free of sharp edges or rough areas.
 - a. Fabricate detention furniture with no more than 1/32-inch (0.8-mm) gap between component materials. Weld edges that cannot be crimped to meet tolerance so as to provide a seamless joint with no place for concealment of contraband.
5. Form metal in maximum lengths to minimize joints. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.
6. Weld corners and seams continuously to comply with referenced AWS standard and the following:



- a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. Finish exposed welds and surfaces smooth and blended at exposed connections so that no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
 - e. Weld before finishing components to greatest extent possible. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
7. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure detention furniture rigidly in place and to support expected loads. Build in straps, plates, and brackets as needed to support and anchor fabricated items to adjoining construction. Reinforce formed-metal units as needed to attach and support other construction.
 8. Cut, reinforce, drill, and tap detention furniture as indicated to receive hardware, security fasteners, and similar items.
 9. Form exposed work true to line and level with accurate angles, surfaces, and straight sharp edges.
 10. Form exposed connections with hairline joints, flush and smooth using concealed fasteners where possible. Use exposed security fasteners of type indicated or, if not indicated, flat-head (countersunk) security fasteners. Locate joints where least conspicuous.
 11. Attach drawer slides **OR** shelves, **as directed**, to furniture by welding **OR** with security fasteners, **as directed**.

L. Steel Finishes

1. Surface Preparation: Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning" or SSPC-SP 8, "Pickling". After cleaning, apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Prime Finish: Apply manufacturer's standard, fast-curing, lead- and chromate-free, universal primer immediately after surface preparation and pretreatment.
3. Baked-Enamel or Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.

M. Stainless-Steel Finishes

1. General: Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
2. Intermediate Polish Finish: No. 3 unless otherwise indicated.
3. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

1.3 EXECUTION

A. Installation

1. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing detention furniture to in-place construction. Include threaded fasteners for concrete and masonry inserts, security fasteners, and other connectors.
2. Cutting, Fitting, and Placement: Obtain manufacturer's written approval for cutting, drilling, and fitting required for installing detention furniture. Set detention furniture accurately in location,



- alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
3. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry or similar construction.
 4. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.
 5. Field Welding: Comply with the following requirements:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. Finish exposed welds and surfaces smooth and blended at exposed connections so that no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
 - e. Fillet Welds: Minimum size of 1/8 inch by 1-1/2 inches (3 mm by 38 mm) long, spaced not greater than 12 inches (305 mm) o.c. Fill spaces between welds with security sealant **OR** auto body filler, **as directed**, where weld is exposed.
OR
Fillet Welds: Continuous.
 6. Adjust doors and latches of detention gun lockers and key cabinets to operate easily without binding. Verify that integral locking devices operate properly.
 7. Assemble detention furniture requiring field assembly with security fasteners with no exposed fasteners on exposed faces and frames.
 8. Anchor furniture with security fasteners **OR** by welding **OR** as indicated on Drawings, **as directed**, to floors and walls at intervals required by expected loads, but not more than 12 inches (305 mm) o.c.
 - a. Install anchors through backup reinforcing plates where necessary to avoid metal distortion.
 - b. Use security fasteners with head styles appropriate for installation requirements, strength, and finish of adjacent materials, except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in painted materials.
 - c. Weld nuts onto cast-in-place anchors after installation so as to be nonremovable.
 9. Apply security sealant **OR** auto body filler, **as directed**, at all exposed gaps between detention furniture and adjacent construction greater than 1/16 inch (1.6 mm).
 10. Install one detention mattress for each detention bunk.
- B. Field Quality Control
1. Detention Specialist shall inspect **OR** Inspect, **as directed**, installed products to verify compliance with requirements. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents.
 2. Prepare field quality-control certification endorsed by Detention Specialist, **as directed**, that states installed products and their installation comply with requirements in the Contract Documents.
- C. Cleaning And Protection
1. Touchup Painting: Immediately after erection, clean bolted connections and abraded areas of shop paint, and paint exposed areas with same material used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

END OF SECTION 11 98 12 00b



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Task	Specification	Specification Description
11 98 12 00	08 34 53 00	Detention Doors And Frames



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SECTION 13 34 19 00 - METAL BUILDING SYSTEMS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for metal building systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Structural-steel framing.
 - b. Metal roof panels.
 - c. Metal wall panels.
 - d. Foam-insulation-core metal wall panels.
 - e. Translucent panels.
 - f. Metal soffit panels.
 - g. Thermal insulation.
 - h. Doors and frames.
 - i. Windows.
 - j. Accessories.

C. Definitions

1. Terminology Standard: See MBMA's "Metal Building Systems Manual" for definitions of terms for metal building system construction not otherwise defined in this Section or in referenced standards.

D. Submittals

1. Product Data: For each type of metal building system component. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Structural-steel-framing system.
 - b. Metal roof panels.
 - c. Metal wall panels.
 - d. Metal liner panels.
 - e. Translucent panels.
 - f. Insulation and vapor retarder facings.
 - g. Flashing and trim.
 - h. Doors.
 - i. Windows.
 - j. Accessories.
2. LEED Submittals:
 - a. Product Test Reports for Credit SS 7.2: For roof panels, documentation indicating that panels comply with Solar Reflectance Index requirement.
 - b. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.
3. Shop Drawings: For the following metal building system components. Include plans, elevations, sections, details, and attachments to other work.
 - a. Anchor-Bolt Plans: Submit anchor-bolt plans and templates before foundation work begins. Include location, diameter, and projection of anchor bolts required to attach metal building to foundation. Indicate column reactions at each location.



- b. Structural-Framing Drawings: Show complete fabrication of primary and secondary framing; include provisions for openings. Indicate welds and bolted connections, distinguishing between shop and field applications. Include transverse cross-sections.
 - 1) Show provisions for attaching roof curbs, service walkways, platforms and pipe racks.
- c. Metal Roof and Wall Panel Layout Drawings: Show layouts of metal panels including methods of support. Include details of edge conditions, joints, panel profiles, corners, anchorages, trim, flashings, closures, and special details. Distinguish between factory- and field-assembled work; show locations of exposed fasteners.
 - 1) Show roof-mounted items including roof hatches, equipment supports, pipe supports and penetrations, lighting fixtures, and items mounted on roof curbs.
 - 2) Show wall-mounted items including doors, windows, louvers, and lighting fixtures.
 - 3) Show translucent panels.
4. Samples: For each type of exposed finish required, prepared on Samples of sizes indicated below:
 - a. Metal Panels: Nominal 12 inches (300 mm) long by actual panel width. Include fasteners, closures, and other exposed panel accessories.
 - b. Translucent Panels: Nominal 12 inches (300 mm) long by actual panel width.
 - c. Flashing and Trim: Nominal 12 inches (300 mm) long. Include fasteners and other exposed accessories.
 - d. Vapor-Retarder Facings: Nominal 6-inch- (150-mm-) square Samples.
 - e. Windows: Full-size, nominal 12-inch- (300-mm-) long frame Samples showing typical profile.
 - f. Accessories: Nominal 12-inch- (300-mm-) long Samples for each type of accessory.
5. Door Schedule: For doors and frames. Use same designations indicated on Drawings. Include details of reinforcement.
 - a. Door Hardware Schedule: Include details of fabrication and assembly of door hardware. Organize schedule into door hardware sets indicating complete designations of every item required for each door or opening.
 - b. Keying Schedule: Detail the Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations.
6. Delegated-Design Submittal: For metal building systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
7. Qualification Data: For qualified erector, manufacturer, professional engineer, land surveyor and testing agency.
8. Welding certificates.
9. Metal Building System Certificates: For each type of metal building system, from manufacturer.
 - a. Letter of Design Certification: Signed and sealed by a qualified professional engineer. Include the following:
 - 1) Name and location of Project.
 - 2) Order number.
 - 3) Name of manufacturer.
 - 4) Name of Contractor.
 - 5) Building dimensions including width, length, height, and roof slope.
 - 6) Indicate compliance with AISC standards for hot-rolled steel and AISI standards for cold-rolled steel, including edition dates of each standard.
 - 7) Governing building code and year of edition.
 - 8) Design Loads: Include dead load, roof live load, collateral loads, roof snow load, deflection, wind loads/speeds and exposure, seismic design category or effective peak velocity-related acceleration/peak acceleration, and auxiliary loads (cranes).
 - 9) Load Combinations: Indicate that loads were applied acting simultaneously with concentrated loads, according to governing building code.
 - 10) Building-Use Category: Indicate category of building use and its effect on load importance factors.



- 11) AISC Certification for Category MB: Include statement that metal building system and components were designed and produced in an AISC-Certified Facility by an AISC-Certified Manufacturer.
10. Erector Certificates: For each product, from manufacturer.
11. Manufacturer Certificates: For each product, from manufacturer.
12. Material Test Reports: For each of the following products:
 - a. Structural steel including chemical and physical properties.
 - b. Bolts, nuts, and washers including mechanical properties and chemical analysis.
 - c. Tension-control, high-strength, bolt-nut-washer assemblies.
 - d. Shop primers.
 - e. Nonshrink grout.
13. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for insulation and vapor-retarder facings. Include reports for thermal resistance, fire-test-response characteristics, water-vapor transmission, and water absorption.
14. Source quality-control reports.
15. Field quality-control reports.
16. Surveys: Show final elevations and locations of major members. Indicate discrepancies between actual installation and the Contract Documents. Have surveyor who performed surveys certify their accuracy.
17. Maintenance Data: For metal panel finishes and door hardware to include in maintenance manuals.
18. Warranties: Sample of special warranties.

E. Quality Assurance

1. Manufacturer Qualifications: A qualified manufacturer and member of MBMA.
 - a. AISC Certification for Category MB: An AISC-Certified Manufacturer that designs and produces metal building systems and components in an AISC-Certified Facility.
 - b. Engineering Responsibility: Preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.
2. Land Surveyor Qualifications: A professional land surveyor who practices in jurisdiction where Project is located and who is experienced in providing surveying services of the kind indicated.
3. Erector Qualifications: An experienced erector who specializes in erecting and installing work similar in material, design, and extent to that indicated for this Project and who is acceptable to manufacturer.
4. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
5. Source Limitations: Obtain metal building system components, including primary and secondary framing and metal panel assemblies, from single source from single manufacturer.
6. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.3, "Structural Welding Code - Sheet Steel."
7. Structural Steel: Comply with AISC 360, "Specification for Structural Steel Buildings," for design requirements and allowable stresses.
8. Cold-Formed Steel: Comply with AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members" for design requirements and allowable stresses.
9. Fire-Resistance Ratings: Where indicated, provide metal panel assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.
 - b. Combustion Characteristics: ASTM E 136.
10. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C.



- a. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
11. Preinstallation Conference: Conduct conference at Project site.
- F. Delivery, Storage, And Handling
1. Deliver components, sheets, panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.
 2. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.
 3. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.
 4. Protect foam-plastic insulation as follows:
 - a. Do not expose to sunlight, except to extent necessary for period of installation and concealment.
 - b. Protect against ignition at all times. Do not deliver foam-plastic insulation materials to Project site before installation time.
 - c. Complete installation and concealment of foam-plastic materials as rapidly as possible in each area of construction.
- G. Project Conditions
1. Weather Limitations: Proceed with installation only when weather conditions permit metal panels to be installed according to manufacturers' written instructions and warranty requirements.
 2. Field Measurements:
 - a. Established Dimensions for Foundations: Comply with established dimensions on approved anchor-bolt plans, establishing foundation dimensions and proceeding with fabricating structural framing without field measurements. Coordinate anchor-bolt installation to ensure that actual anchorage dimensions correspond to established dimensions.
 - b. Established Dimensions for Metal Panels: Where field measurements cannot be made without delaying the Work, either establish framing and opening dimensions and proceed with fabricating metal panels without field measurements, or allow for field trimming metal panels. Coordinate construction to ensure that actual building dimensions, locations of structural members, and openings correspond to established dimensions.
- H. Coordination
1. Coordinate sizes and locations of concrete foundations and casting of anchor-bolt inserts into foundation walls and footings. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
 2. Coordinate installation of roof curbs, equipment supports and roof penetrations, which are specified in Division 07 Section "Roof Accessories".
 3. Coordinate metal panel assemblies with rain drainage work, flashing, trim, and construction of supports and other adjoining work to provide a leakproof, secure, and noncorrosive installation.
- I. Warranty
1. Special Warranty on Metal Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - a. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
 - 1) Color fading more than 5 Hunter units when tested according to ASTM D 2244.
 - 2) Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
 - 3) Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - b. Finish Warranty Period: **20 OR 10, as directed**, years from date of Final Completion.



2. Special Weathertightness Warranty for Standing-Seam Metal Roof Panels: Manufacturer's standard form in which manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that leak or otherwise fail to remain weathertight within specified warranty period.
 - a. Warranty Period: 20 years from date of Final Completion.

1.2 PRODUCTS

A. Metal Building Systems

1. Description: Provide a complete, integrated set of metal building system manufacturer's standard mutually dependent components and assemblies that form a metal building system capable of withstanding structural and other loads, thermally induced movement, and exposure to weather without failure or infiltration of water into building interior.
 - a. Provide metal building system of size and with bay spacings, roof slopes, and spans indicated.
2. Primary-Frame Type:
 - a. Rigid Clear Span: Solid-member, structural-framing system without interior columns.
 - b. Rigid Modular: Solid-member, structural-framing system with interior columns.
 - c. Truss-Frame Clear Span: Truss-member, structural-framing system without interior columns.
 - d. Truss-Frame Modular: Truss-member, structural-framing system with interior columns.
 - e. Lean to: Solid- or truss-member, structural-framing system without interior columns, designed to be partially supported by another structure.
3. End-Wall Framing: Manufacturer's standard, for buildings not required to be expandable, consisting of primary frame, capable of supporting one-half of a bay design load, and end-wall columns **OR** load-bearing end-wall and corner columns and rafters, **as directed**.
OR
End-Wall Framing: Engineer end walls to be expandable. Provide primary frame, capable of supporting full-bay design loads, and end-wall columns.
4. Secondary-Frame Type: Manufacturer's standard purlins and joists and flush-framed **OR** partially inset-framed **OR** exterior-framed (bypass), **as directed**, girts.
5. Eave Height: 16 feet (4.9 m) **OR** 20 feet (6.1 m) **OR** 24 feet (7.3 m) **OR** 28 feet (8.5 m) **OR** Manufacturer's standard height, as indicated by nominal height on Drawings, **as directed**.
6. Bay Spacing: 20 feet (6.1 m) **OR** 25 feet (7.6 m) **OR** 30 feet (9.1 m) **OR** As determined by manufacturer, **as directed**.
7. Roof Slope: 1/4 inch per 12 inches (1:48) **OR** 1/2 inch per 12 inches (1:24) **OR** 1 inch per 12 inches (1:12) **OR** 4 inches per 12 inches (1:3) **OR** Manufacturer's standard for frame type required, **as directed**.
8. Roof System: Manufacturer's standard vertical-rib, standing-seam **OR** trapezoidal-rib, standing-seam **OR** lap-seam, **as directed**, metal roof panels with field-installed insulation, **as directed**.
9. Exterior Wall System: Manufacturer's standard tapered-rib, exposed-fastener **OR** reverse-rib, exposed-fastener **OR** concealed-fastener, **as directed**, metal wall panels with field-installed insulation, **as directed**.
OR
Exterior Wall System: Manufacturer's standard foam-insulation-core metal wall panels.

B. Metal Building System Performance

1. Delegated Design: Design metal building system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Metal building systems shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to procedures in MBMA's "Metal Building Systems Manual."
 - a. Design Loads: As indicated on Drawings.**OR**



- Design Loads: As required by MBMA's "Metal Building Systems Manual" **OR** ASCE/SEI 7, **as directed**.
- b. Deflection Limits: Design metal building system assemblies to withstand design loads with deflections no greater than the following:
 - 1) Purlins and Rafters: Vertical deflection of 1/180 **OR** 1/240, **as directed**, of the span.
 - 2) Girts: Horizontal deflection of 1/180 **OR** 1/240, **as directed**, of the span.
 - 3) Metal Roof Panels: Vertical deflection of 1/180 **OR** 1/240, **as directed**, of the span.
 - 4) Metal Wall Panels: Horizontal deflection of 1/180 **OR** 1/240, **as directed**, of the span.
 - 5) Design secondary-framing system to accommodate deflection of primary framing and construction tolerances, and to maintain clearances at openings.
 - c. Drift Limits: Engineer building structure to withstand design loads with drift limits no greater than the following:
 - 1) Lateral Drift: Maximum of 1/200 **OR** 1/400, **as directed**, of the building height.
 - d. Metal panel assemblies shall withstand the effects of gravity loads and loads and stresses within limits and under conditions indicated according to ASTM E 1592.
3. Seismic Performance: Metal building systems shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 4. Thermal Movements: Allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
 5. Air Infiltration for Metal Roof Panels: Air leakage through assembly of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) of roof area when tested according to ASTM E 1680 at negative test-pressure difference of 1.57 lbf/sq. ft. (75 Pa).
 6. Air Infiltration for Metal Wall Panels: Air leakage through assembly of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) of wall area when tested according to ASTM E 283 at static-air-pressure difference of 1.57 lbf/sq. ft. (75 Pa).
 7. Water Penetration for Metal Roof Panels: No water penetration when tested according to ASTM E 1646 at test-pressure difference of 2.86 lbf/sq. ft. (137 Pa).
 8. Water Penetration for Metal Wall Panels: No water penetration when tested according to ASTM E 331 at a wind-load design pressure of not less than 2.86 lbf/sq. ft. (137 Pa).
 9. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for Class 30 **OR** Class 60 **OR** Class 90, **as directed**.
 10. Thermal Performance: Provide insulated metal panel assemblies with the following maximum U-factors and minimum R-values for opaque elements when tested according to ASTM C 1363 or ASTM C 518:
 - a. Metal Roof Panel Assemblies:
 - 1) U-Factor: as directed by the Owner.
 - 2) R-Value: as directed by the Owner.
 - b. Metal Wall Panel Assemblies:
 - 1) U-Factor: as directed by the Owner.
 - 2) R-Value: as directed by the Owner.
 11. Energy Performance (for LEED-NC Credit SS 7.2): Provide roof panels with Solar Reflectance Index not less than 78 **OR** 29, **as directed**, when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.
 12. Energy Performance (for ENERGY STAR requirements): Provide roof panels that are listed on the DOE's ENERGY STAR Roof Products Qualified Product List for low **OR** steep, **as directed**, -slope roof products.
 13. Energy Performance (for roofs that must comply with CEC-Title 24): Provide roof panels with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC.



C. Structural-Steel Framing

1. Primary Framing: Manufacturer's standard primary-framing system, designed to withstand required loads and specified requirements. Primary framing includes transverse and lean-to frames; rafter, rake, and canopy beams; sidewall, intermediate, end-wall, and corner columns; and wind bracing.
 - a. General: Provide frames with attachment plates, bearing plates, and splice members. Factory drill for field-bolted assembly. Provide frame span and spacing indicated.
 - 1) Slight variations in span and spacing may be acceptable if necessary to comply with manufacturer's standard, as approved by the Owner.
 - b. Rigid Clear-Span Frames: I-shaped frame sections fabricated from shop-welded, built-up steel plates or structural-steel shapes. Interior columns are not permitted.
 - c. Rigid Modular Frames: I-shaped frame sections fabricated from shop-welded, built-up steel plates or structural-steel shapes. Provide interior columns fabricated from round steel pipes or tubes, or shop-welded, built-up steel plates.
 - d. Truss-Frame, Clear-Span Frames: Rafter frames fabricated from joist girders, and I-shaped column sections fabricated from shop-welded, built-up steel plates or structural-steel shapes.
 - e. Truss-Frame Modular Frames: Rafter frames fabricated from joist girders, and I-shaped column sections fabricated from shop-welded, built-up steel plates or structural-steel shapes. Provide interior columns fabricated from round steel pipes or tubes, or shop-welded, built-up steel plates.
 - f. Long-Bay Frames: I-shaped frame sections fabricated from shop-welded, built-up steel plates or structural-steel shapes. Provide interior columns fabricated from round steel pipes or tubes, or shop-welded, built-up steel plates.
 - g. Frame Configuration: Single gable **OR** One-directional sloped **OR** Lean to, with high side connected to and supported by another structure **OR** Multiple gable **OR** Load-bearing-wall type **OR** Multistory, **as directed**.
 - h. Exterior Column Type: Uniform depth **OR** Tapered, **as directed**.
 - i. Rafter Type: Uniform depth **OR** Tapered, **as directed**.
2. End-Wall Framing: Manufacturer's standard primary end-wall framing fabricated for field-bolted assembly to comply with the following:
 - a. End-Wall and Corner Columns: I-shaped sections fabricated from structural-steel shapes; shop-welded, built-up steel plates; or C-shaped, cold-formed, structural-steel sheet.
 - b. End-Wall Rafters: C-shaped, cold-formed, structural-steel sheet; or I-shaped sections fabricated from shop-welded, built-up steel plates or structural-steel shapes.
3. Secondary Framing: Manufacturer's standard secondary framing, including purlins, girts, eave struts, flange bracing, base members, gable angles, clips, headers, jambs, and other miscellaneous structural members. Unless otherwise indicated, fabricate framing from either cold-formed, structural-steel sheet or roll-formed, metallic-coated steel sheet, prepainted with coil coating, to comply with the following:
 - a. Purlins: C- or Z-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes; minimum 2-1/2-inch- (64-mm-) wide flanges.
 - 1) Depth: As indicated **OR** As needed to comply with system performance requirements, **as directed**.

OR

Purlins: Steel joists of depths indicated.
 - b. Girts: C- or Z-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes. Form ends of Z-sections with stiffening lips angled 40 to 50 degrees from flange, with minimum 2-1/2-inch- (64-mm-) wide flanges.
 - 1) Depth: As indicated **OR** As required to comply with system performance requirements, **as directed**.
 - c. Eave Struts: Unequal-flange, C-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes; to provide adequate backup for metal panels.
 - d. Flange Bracing: Minimum 2-by-2-by-1/8-inch (51-by-51-by-3-mm) structural-steel angles or 1-inch (- (25-mm-) diameter, cold-formed structural tubing to stiffen primary-frame flanges.



- e. Sag Bracing: Minimum 1-by-1-by-1/8-inch (25-by-25-by-3-mm) structural-steel angles.
 - f. Base or Sill Angles: Minimum 3-by-2-inch (76-by-51-mm) zinc-coated (galvanized) steel sheet.
 - g. Purlin and Girt Clips: Manufacturer's standard clips fabricated from steel sheet. Provide galvanized clips where clips are connected to galvanized framing members.
 - h. Secondary End-Wall Framing: Manufacturer's standard sections fabricated from zinc-coated (galvanized) steel sheet **OR** structural-steel sheet, **as directed**.
 - i. Framing for Openings: Channel shapes; fabricated from cold-formed, structural-steel sheet or structural-steel shapes. Frame head and jamb of door openings and head, jamb, and sill of other openings.
 - j. Miscellaneous Structural Members: Manufacturer's standard sections fabricated from cold-formed, structural-steel sheet; built-up steel plates; or zinc-coated (galvanized) steel sheet; designed to withstand required loads.
4. Canopy Framing: Manufacturer's standard structural-framing system, designed to withstand required loads; fabricated from shop-welded, built-up steel plates or structural-steel shapes. Provide frames with attachment plates and splice members, factory drilled for field-bolted assembly.
- a. Type: Straight-beam, eave type **OR** Purlin-extension type **OR** Tapered-beam, below-eave type **OR** As indicated, **as directed**.
5. Bracing: Provide adjustable wind bracing as follows:
- a. Rods: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50 (345); or ASTM A 529/A 529M, Grade 50 (345); minimum 1/2-inch- (13-mm-) diameter steel; threaded full length or threaded a minimum of 6 inches (152 mm) at each end.
 - b. Cable: ASTM A 475, 1/4-inch- (6-mm-) diameter, extra-high-strength grade, Class B, zinc-coated, seven-strand steel; with threaded end anchors.
 - c. Angles: Fabricated from structural-steel shapes to match primary framing, of size required to withstand design loads.
 - d. Rigid Portal Frames: Fabricated from shop-welded, built-up steel plates or structural-steel shapes to match primary framing; of size required to withstand design loads.
 - e. Fixed-Base Columns: Fabricated from shop-welded, built-up steel plates or structural-steel shapes to match primary framing; of size required to withstand design loads.
 - f. Diaphragm Action of Metal Panels: Design metal building to resist wind forces through diaphragm action of metal panels.
 - g. Bracing: Provide wind bracing using any method specified above, at manufacturer's option.
6. Bolts: Provide plain-finish bolts for structural-framing components that are primed or finish painted. Provide zinc-plated or hot-dip galvanized bolts for structural-framing components that are galvanized.
7. Materials:
- a. W-Shapes: ASTM A 992/A 992M; ASTM A 572/A 572M, Grade 50 or 55 (345 or 380); or ASTM A 529/A 529M, Grade 50 or 55 (345 or 380).
 - b. Channels, Angles, M-Shapes, and S-Shapes: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50 or 55 (345 or 380); or ASTM A 529/A 529M, Grade 50 or 55 (345 or 380).
 - c. Plate and Bar: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50 or 55 (345 or 380); or ASTM A 529/A 529M, Grade 50 or 55 (345 or 380).
 - d. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B.
 - e. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B or C, structural tubing.
 - f. Structural-Steel Sheet: Hot-rolled, ASTM A 1011/A 1011M, Structural Steel (SS), Grades 30 through 55 (205 through 380), or High-Strength Low-Alloy Steel (HSLAS), Grades 45 through 70 (310 through 480); or cold-rolled, ASTM A 1008/A 1008M, Structural Steel (SS), Grades 25 through 80 (170 through 550), or High-Strength Low-Alloy Steel (HSLAS), Grades 45 through 70 (310 through 480).
 - g. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grades 33 through 80 (230 through 550), or High-Strength Low-Alloy Steel (HSLAS), Grades 50 through 80 (340 through 550); with G60 (Z180) coating designation; mill phosphatized.



- h. Metallic-Coated Steel Sheet Prepainted with Coil Coating: Steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
- 1) Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grades 33 through 80 (230 through 550), or High-Strength Low-Alloy Steel (HSLAS), Grades 50 through 80 (340 through 550); with G90 (Z275) coating designation.
 - 2) Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Structural Steel (SS), Grade 50 or 80 (340 or 550); with Class AZ50 (AZM150) coating.
- i. Joist Girders: Manufactured according to "Standard Specifications for Joist Girders," in SJI's "Standard Specifications and Load Tables for Steel Joists and Joist Girders"; with steel-angle, top- and bottom-chord members, and end- and top-chord arrangements as indicated and required for primary framing.
- j. Steel Joists: Manufactured according to "Standard Specifications for Open Web Steel Joists, K-Series," in SJI's "Standard Specifications and Load Tables for Steel Joists and Joist Girders"; with steel-angle, top- and bottom-chord members, and end- and top-chord arrangements as indicated and required for secondary framing.
- k. Non-High-Strength Bolts, Nuts, and Washers: ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), carbon-steel, hex-head bolts; ASTM A 563 (ASTM A 563M) carbon-steel hex nuts; and ASTM F 844 plain (flat) steel washers.
- 1) Finish: Plain **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
- l. High-Strength Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1, heavy-hex steel structural bolts; ASTM A 563 (ASTM A 563M) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M) hardened carbon-steel washers.
- 1) Finish: Plain **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
- m. High-Strength Bolts, Nuts, and Washers: ASTM A 490 (ASTM A 490M), Type 1, heavy-hex steel structural bolts or tension-control, bolt-nut-washer assemblies with spline ends; ASTM A 563 (ASTM A 563M) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M) hardened carbon-steel washers, plain.
- n. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, heavy-hex-head steel structural bolts with spline ends.
- 1) Finish: Plain **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50 **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, baked-epoxy coated, **as directed**.
- o. Unheaded Anchor Rods: ASTM F 1554, Grade 36 **OR** ASTM A 572/A 572M, Grade 50 (345) **OR** ASTM A 36/A 36M **OR** ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), **as directed**.
- 1) Configuration: Straight.
 - 2) Nuts: ASTM A 563 (ASTM A 563M) hex **OR** heavy-hex, **as directed**, carbon steel.
 - 3) Plate Washers: ASTM A 36/A 36M carbon steel.
 - 4) Washers: ASTM F 436 (ASTM F 436M) hardened carbon steel.
 - 5) Finish: Plain **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
- p. Headed Anchor Rods: ASTM F 1554, Grade 36 **OR** ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), **as directed**.
- 1) Configuration: Straight.
 - 2) Nuts: ASTM A 563 (ASTM A 563M) hex **OR** heavy-hex, **as directed**, carbon steel.
 - 3) Plate Washers: ASTM A 36/A 36M carbon steel.
 - 4) Washers: ASTM F 436 (ASTM F 436M) hardened carbon steel.
 - 5) Finish: Plain **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
- q. Threaded Rods: ASTM A 193/A 193M **OR** ASTM A 572/A 572M, Grade 50 (345) **OR** ASTM A 36/A 36M **OR** ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), **as directed**.



- 1) Nuts: ASTM A 563 (ASTM A 563M) hex **OR** heavy-hex, **as directed**, carbon steel.
 - 2) Washers: ASTM F 436 (ASTM F 436M) hardened **OR** ASTM A 36/A 36M, **as directed**, carbon steel.
 - 3) Finish: Plain **OR** Hot-dip zinc coating, ASTM A 153/A 153M, Class C **OR** Mechanically deposited zinc coating, ASTM B 695, Class 50, **as directed**.
- r. Recycled Content of Steel Products: Provide steel products with an average recycled content so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
8. Finish: Factory primed. Apply specified primer immediately after cleaning and pretreating.
- a. Apply primer to primary and secondary framing to a minimum dry film thickness of 1 mil (0.025 mm).
 - 1) Prime secondary framing formed from uncoated steel sheet to a minimum dry film thickness of 0.5 mil (0.013 mm) on each side.
 - b. Prime galvanized members with specified primer after phosphoric acid pretreatment.
 - c. Primer: SSPC-Paint 15, Type I, red oxide.
- D. Metal Roof Panels
1. Vertical-Rib, Standing-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Clips: Manufacturer's standard, fixed type **OR** floating type to accommodate thermal movement, **as directed**; fabricated from zinc-coated (galvanized) steel **OR** aluminum-zinc alloy-coated steel **OR** stainless-steel, **as directed**, sheet.
 - c. Joint Type: Panels snapped together.
OR
Joint Type: Mechanically seamed, single folded **OR** double folded **OR** folded according to manufacturer's standard, **as directed**.
 - d. Panel Coverage: 16 inches (406 mm).
 - e. Panel Height: 2 inches (51 mm).
 - f. Uplift Rating: UL 30 **OR** UL 60 **OR** UL 90, **as directed**.
 2. Trapezoidal-Rib, Standing-Seam Metal Roof Panels: Formed with raised trapezoidal ribs at panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Clips: Manufacturer's standard, fixed type **OR** floating type to accommodate thermal movement, **as directed**; fabricated from zinc-coated (galvanized) steel **OR** aluminum-zinc alloy-coated steel **OR** stainless-steel, **as directed**, sheet.
 - c. Joint Type: Panels snapped together.
OR
Joint Type: Mechanically seamed, single folded **OR** double folded **OR** folded according to manufacturer's standard, **as directed**.
 - d. Panel Coverage: 24 inches (610 mm).



- e. Panel Height: 3 inches (76 mm).
- f. Uplift Rating: UL 30 **OR** UL 60 **OR** UL 90, **as directed**.
- 3. Tapered-Rib-Profile, Lap-Seam Metal Roof Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major ribs; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Major-Rib Spacing: 6 inches (152 mm) **OR** 12 inches (305 mm), **as directed**, o.c.
 - c. Panel Coverage: 36 inches (914 mm).
 - d. Panel Height: 0.75 inch (19 mm) **OR** 1.125 inches (29 mm) **OR** 1.188 inches (30 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.
- 4. Tapered-Rib-Profile, Metal Liner Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major ribs; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Major-Rib Spacing: 6 inches (152 mm) **OR** 12 inches (305 mm), **as directed**, o.c.
 - c. Panel Coverage: 36 inches (914 mm).
 - d. Panel Height: 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.
- 5. Materials:
 - a. Metallic-Coated Steel Sheet: Restricted-flatness steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - 1) Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - 2) Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - 3) Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
- 6. Finishes:
 - a. Exposed Coil-Coated Finish:
 - 1) Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - b. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).

E. Metal Wall Panels



1. Tapered-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major ribs; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Major-Rib Spacing: 6 inches (152 mm) **OR** 12 inches (305 mm), **as directed**, o.c.
 - c. Panel Coverage: 36 inches (914 mm).
 - d. Panel Height: 0.75 inch (19 mm) **OR** 1.125 inches (29 mm) **OR** 1.188 inches (30 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.
2. Reverse-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with recessed, trapezoidal major valleys and intermediate stiffening valleys symmetrically spaced **OR** flat pan, **as directed**, between major valleys; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Major-Rib Spacing: 12 inches (305 mm) o.c.
 - c. Panel Coverage: 36 inches (914 mm).
 - d. Panel Height: 1.125 inches (29 mm) **OR** 1.188 inches (30 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.
3. Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and a single wide recess, centered between panel edges **OR** flush surface, **as directed**; with flush joint between panels; with 1-inch- (25-mm-) wide flange for attaching interior finish; designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant, **as directed**, in side laps.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Panel Coverage: 16 inches (406 mm).
 - c. Panel Height: 3 inches (76 mm).
4. Tapered-Rib-Profile, Metal Liner Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major ribs; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Siliconized polyester **OR** Acrylic enamel, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Major-Rib Spacing: 6 inches (152 mm) **OR** 12 inches (305 mm), **as directed** o.c.
 - c. Panel Coverage: 36 inches (914 mm).
 - d. Panel Height: 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.



5. Flush-Profile, Metal Liner Panels: Solid **OR** Perforated, **as directed**, panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between panel edges; with flush joint between panels; designed for interior side of metal wall panel assemblies and installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant, **as directed**, in side laps.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Siliconized polyester **OR** Polyester **OR** Acrylic enamel, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Sound Absorption: NRC not less than 0.65 **OR** 0.85 **OR** 1.00, **as directed** when tested according to ASTM C 423.
 - c. Panel Coverage: 12 inches (305 mm).
 - d. Panel Height: 1.5 inches (38 mm).
 6. Materials:
 - a. Metallic-Coated Steel Sheet: Restricted-flatness steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - 1) Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - 2) Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - 3) Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 7. Finishes:
 - a. Exposed Coil-Coated Finish:
 - 1) Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - b. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
- F. Foam-Insulation-Core Metal Wall Panels
1. Description: Provide factory-formed and -assembled, metal wall panels fabricated from two metal facing sheets and an insulation core foamed in place during fabrication, with joints between panels designed to form weathertight seals. Include accessories required for weathertight installation.
 - a. Concealed-Fastener, Foam-Insulation-Core Metal Wall Panels: Formed with tongue-and-groove panel edges; designed for sequential installation by interlocking panel edges and mechanically attaching panels to supports using concealed clips or fasteners.
 - 1) Facings: Fabricate panel with exterior and interior facings of same material and thickness.
 - 2) Exterior Surface: Smooth, flat **OR** Striated **OR** Shallow ribs **OR** Shallow V grooves, **as directed**.
 - 3) Panel Coverage: 36 inches (914 mm) **OR** 42 inches (1067 mm), **as directed**, nominal.



- 4) Panel Thickness: 2 inches (51 mm) **OR** 2.5 inches (64 mm) **OR** 3 inches (76 mm) **OR** 4 inches (102 mm) **OR** 5 inches (127 mm) **OR** 6 inches (152 mm), **as directed**.
 - 5) Thermal-Resistance Value (R-Value): as directed by the Owner.
2. Panel Performance:
 - a. Flatwise Tensile Strength: 30 psi (200 kPa) when tested according to ASTM C 297/C 297M.
 - b. Humid Aging: Volume increase not greater than 6.0 percent and no delamination or metal corrosion when tested for seven days at 140 deg F (60 deg C) and 100 percent relative humidity according to ASTM D 2126.
 - c. Heat Aging: Volume increase not greater than 2.0 percent and no delamination, surface blistering, or permanent bowing when tested for seven days at 200 deg F (93 deg C) according to ASTM D 2126.
 - d. Cold Aging: Volume decrease not more than 1.0 percent and no delamination, surface blistering, or permanent bowing when tested for seven days at minus 20 deg F (29 deg C) according to ASTM D 2126.
 - e. Fatigue: No evidence of delamination, core cracking, or permanent bowing when tested to a 20-lbf/sq. ft. (958-kPa) positive and negative wind load and with deflection of L/180 for two million cycles.
 - f. Autoclave: No delamination when exposed to 2-psi (13.8-kPa) pressure at a temperature of 212 deg F (100 deg C) for 2-1/2 hours.
 - g. Fire-Test-Response Characteristics: Class A according to ASTM E 108.
 3. Polyisocyanurate Insulation-Core Performance:
 - a. Density: 2.0 to 2.6 lb/cu. ft. (32 to 42 kg/cu. m) when tested according to ASTM D 1622.
 - b. Compressive Strength: Minimum 20 psi (140 kPa) when tested according to ASTM D 1621.
 - c. Shear Strength: 26 psi (179 kPa) when tested according to ASTM C 273/C 273M.
 4. Materials:
 - a. Polyisocyanurate Insulation: Modified polyisocyanurate foam using a non-CFC blowing agent, foamed-in-place or board type as indicated, with maximum flame-spread and smoke-developed indexes of 25 and 450, respectively.
 - 1) Closed-Cell Content: 90 percent when tested according to ASTM D 6226.
 - b. Metallic-Coated Steel Sheet: Restricted-flatness steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - 1) Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - 2) Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - 3) Surface: Smooth, flat **OR** Embossed, **as directed**, finish.
 5. Finishes:
 - a. Exposed Coil-Coated Finish:
 - 1) Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2) Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 3) Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 - b. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).



- G. Translucent Panels
1. Uninsulated Translucent Panels: Glass-fiber-reinforced polyester, translucent plastic; complying with ASTM D 3841, Type CC2 (general purpose) **OR** Type CC1 (limited flammability), **as directed**, Grade 1 (weather resistant); smooth finish on both sides. Match profile of adjacent metal panels.
 - a. Roof Panel Weight: Not less than 8 oz./sq. ft. (2441 g/sq. m).
 - b. Wall Panel Weight: Not less than 6 oz./sq. ft. (1831 g/sq. m).
 - c. Light Transmittance: Not less than 55 percent according to ASTM D 1494.
 - d. Metal Edge: Fabricate full length of each side of panel with metal edge for seaming into standing-seam roof panel joint.
 - e. Color: White.
 2. Insulated Translucent Panels: Fabricate insulating units of two sheets of glass-fiber-reinforced polyester, translucent plastic separated by an air space; complying with ASTM D 3841, Type CC1 (limited flammability), Grade 1 (weather resistant); smooth finish on both sides. Match profile of adjacent metal panels.
 - a. Exterior Panel Weight: Not less than 8 oz./sq. ft. (2441 g/sq. m) **OR** 6 oz./sq. ft. (1831 g/sq. m), **as directed**.
 - b. Interior Panel Weight: Not less than 8 oz./sq. ft. (2441 g/sq. m) **OR** 6 oz./sq. ft. (1831 g/sq. m) **OR** 4 oz./sq. ft. (1221 g/sq. m), **as directed**.
 - c. Light Transmittance: Not less than 42 percent according to ASTM D 1494.
 - d. Metal Edge: Fabricate full length of each side of panel with metal edge for seaming into standing-seam roof panel joint.
 - e. Color: White.
 3. Mastic for Translucent Panels: Nonstaining, saturated vinyl polymer as recommended by translucent panel manufacturer for sealing laps.
 4. Performance:
 - a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1) Flame-Spread Index: 25 or less.
 - 2) Smoke-Developed Index: 450 or less.
- H. Metal Soffit Panels
1. General: Provide factory-formed metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant, **as directed**, in side laps. Include accessories required for weathertight installation.
 2. Metal Soffit Panels: Match profile and material of metal roof **OR** wall, **as directed**, panels.
 - a. Finish: Match finish and color of metal roof panels **OR** Match finish and color of metal wall panels **OR** As indicated on Drawings, **as directed**.
 3. Tapered-Rib-Profile, Exposed-Fastener Metal Soffit Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced **OR** flat pan, **as directed**, between major ribs; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.
 - a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.022-inch (0.56-mm) **OR** 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
 - b. Major-Rib Spacing: 6 inches (152 mm) **OR** 12 inches (305 mm), **as directed**, o.c.
 - c. Panel Coverage: 36 inches (914 mm).
 - d. Panel Height: 0.75 inch (19 mm) **OR** 1.125 inches (29 mm) **OR** 1.188 inches (30 mm) **OR** 1.25 inches (32 mm) **OR** 1.5 inches (38 mm), **as directed**.
 4. Concealed-Fastener Metal Soffit Panels: Formed with vertical panel edges and a single wide recess, centered between panel edges **OR** flush surface, **as directed**; with flush joint between



panels; with 1-inch- (25-mm-) wide flange for attaching interior finish; designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant, **as directed**, in side laps.

- a. Material: Zinc-coated (galvanized) **OR** Aluminum-zinc alloy-coated, **as directed**, steel sheet, 0.028-inch (0.71-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal thickness.
 - 1) Exterior Finish: Fluoropolymer **OR** Siliconized polyester, **as directed**.
 - 2) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
- b. Panel Coverage: 12 inches (305 mm) **OR** 16 inches (406 mm), **as directed**.
- c. Panel Height: 1 inch (25 mm) **OR** 1.5 inches (38 mm), **as directed**.

I. Thermal Insulation

1. Faced Metal Building Insulation: ASTM C 991, Type II, glass-fiber-blanket insulation; 0.5-lb/cu. ft. (8-kg/cu. m) density; 2-inch- (51-mm-) wide, continuous, vapor-tight edge tabs; with a flame-spread index of 25 or less.
2. Unfaced Metal Building Insulation: ASTM C 991, Type I, or NAIMA 202, glass-fiber-blanket insulation; 0.5-lb/cu. ft. (8-kg/cu. m) density; 2-inch- (51-mm-) wide, continuous, vapor-tight edge tabs; with a flame-spread index of 25 or less.
 - a. Vapor-Retarder Facing: ASTM C 1136, with permeance not greater than 0.02 perm (1.15 ng/Pa x s x sq. m) when tested according to ASTM E 96/E 96M, Desiccant Method.
 - 1) Composition: White metallized-polypropylene film facing, fiberglass scrim reinforcement, and kraft-paper backing.
OR
Composition: Aluminum foil facing, elastomeric barrier coating, fiberglass scrim reinforcement, and kraft-paper backing.
OR
Composition: White polypropylene **OR** vinyl, **as directed**, film facing, fiberglass scrim reinforcement, and metallized-polyester film backing.
OR
Composition: White polypropylene film facing and fiberglass-polyester-blend fabric backing.
3. Mineral-Fiber-Blanket Insulation: ASTM C 665, type indicated below; consisting of fibers manufactured from glass, slag wool, or rock wool.
 - a. Nonreflective Faced: Type II (blankets with nonreflective membrane covering), Category 1 (membrane is a vapor retarder), Class A (membrane-faced surface with a flame-spread index of 25 or less).
 - b. Reflective Faced: Type III (blankets with reflective membrane covering), Category 1 (membrane is a vapor retarder), Class A (membrane-faced surface with a flame-spread index of 25 or less).
 - c. Unfaced: Type I (blankets without membrane covering), passing ASTM E 136 for combustion characteristics.
 - d. Vapor-Retarder Facing: ASTM C 1136, with permeance not greater than 0.02 perm (1.15 ng/Pa x s x sq. m) when tested according to ASTM E 96/E 96M, Desiccant Method.
 - 1) Composition: White metallized-polypropylene film facing, fiberglass scrim reinforcement, and kraft-paper backing.
 - 2) Composition: Aluminum foil facing, elastomeric barrier coating, fiberglass scrim reinforcement, and kraft-paper backing.
 - 3) Composition: White polypropylene **OR** vinyl, **as directed**, film facing, fiberglass scrim reinforcement, and metallized-polyester film backing.
 - 4) Composition: White polypropylene film facing and fiberglass-polyester blend fabric backing.
4. Faced, Polyisocyanurate Board Insulation: ASTM C 1289, Type I (foil facing), Class 2, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, based on



- tests performed on unfaced core. Provide units tested for interior exposure without an approved thermal barrier.
5. Retainer Strips: 0.025-inch (0.64-mm) nominal-thickness, formed, metallic-coated steel or PVC retainer clips colored to match insulation facing.
 6. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
- J. Doors And Frames
1. Swinging Personnel Doors and Frames: As specified in Division 08 Section "Hollow Metal Doors And Frames".
OR
Swinging Personnel Doors and Frames: Metal building system manufacturer's standard doors and frames; prepared and reinforced at strike and at hinges to receive factory- and field-applied hardware according to BHMA A156 Series.
 - a. Steel Doors: 1-3/4 inches (44 mm) thick; fabricated from 0.040-inch (1.02-mm) nominal-thickness, metallic-coated steel face sheets; of seamed **OR** seamless, **as directed**, hollow-metal construction; with 0.064-inch (1.63-mm) nominal-thickness, inverted metallic-coated steel channels welded to face sheets at top and bottom of door.
 - 1) Design: Flush panel **OR** As indicated, **as directed**.
 - 2) Core: Kraft honeycomb with U-factor rating of at least 0.47 Btu/sq. ft. x h x deg F (2.67 W/sq. m x K).
OR
Core: Polystyrene foam with U-factor rating of at least 0.16 Btu/sq. ft. x h x deg F (0.91 W/sq. m x K).
OR
Core: Polyurethane foam with U-factor rating of at least 0.07 Btu/sq. ft. x h x deg F (0.40 W/sq. m x K).
 - 3) Glazing Frames: Steel frames to receive field-installed glass.
 - 4) Glazing: As specified in Division 08 Section "Glazing".
 - b. Steel Frames: Fabricate 2-inch- (51-mm-) wide face frames from 0.064-inch (1.63-mm) nominal-thickness, metallic-coated steel sheet.
 - 1) Type: Knocked down for field assembly **OR** Factory welded, **as directed**.
 - c. Fabricate concealed stiffeners, reinforcement, edge channels, and moldings from either cold- or hot-rolled steel sheet.
 - d. Hardware:
 - 1) Provide hardware for each door leaf, as follows:
 - a) Hinges: BHMA A156.1. Three plain **OR** antifriction, **as directed**, -bearing, standard-weight, full-mortise, stainless-steel or bronze, template-type hinges; 4-1/2 by 4-1/2 inches (114 by 114 mm), with nonremovable pin.
 - b) Lockset: BHMA A156.2. Key-in-lever cylindrical **OR** Mortise, with lever handle, **as directed**, type.
 - c) Exit Device: BHMA A156.3. Touch- or push-bar type.
 - d) Threshold: BHMA A156.21. Extruded aluminum.
 - e) Silencers: Pneumatic rubber; three silencers on strike jambs of single door frames and two silencers on heads of double door frames.
 - f) Closer: BHMA A156.4. Surface-applied, standard-duty hydraulic type.
 - g) Weather Stripping: Vinyl applied to head and jambs, with vinyl sweep at sill.
 - 2) Provide each pair of double doors with the following hardware in addition to that specified for each leaf:
 - a) Astragal: Removable type.
 - b) Surface Bolts: Top and bottom of inactive door.
 - e. Anchors and Accessories: Manufacturer's standard units, galvanized according to ASTM A 123/A 123M.
 - f. Fabrication: Fabricate doors and frames to be rigid; neat in appearance; and free from defects, warp, or buckle. Provide continuous welds on exposed joints; grind, dress, and make welds smooth, flush, and invisible.



2. Horizontal-Sliding Doors: Manufacturer's standard horizontal-sliding door assembly including structural frame, door panels, brackets, guides, tracks, hardware, and installation accessories.
 - a. Door Frames: Channels and zeeks; fabricated from minimum 0.064-inch (1.63-mm) nominal-thickness, metallic-coated steel sheet or structural-steel shapes.
 - b. Door Panels: Same material and finish as metal wall panels.
 - c. Hardware: Manufacturer's standard metallic-coated steel track, bottom guides, lock angles for side closure, and brackets. Support each door leaf by two four-wheel trolleys. Provide metallic-coated steel handle for each leaf, and slide bolt or padlock hasp. Flash top of track with metallic-coated steel sheet hood.
3. Materials:
 - a. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.
 - b. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.
 - c. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with G60 (Z180) zinc (galvanized) or A60 (ZF180) zinc-iron-alloy (galvannealed) coating designation.
4. Finishes for Personnel Doors and Frames:
 - a. Prime Finish: Factory-apply manufacturer's standard primer immediately after cleaning and pretreating.
 - 1) Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.
 - b. Factory-Applied Paint Finish: Manufacturer's standard, complying with SDI A250.3 for performance and acceptance criteria.
 - 1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

K. Windows

1. Aluminum Windows: As specified in Division 08 Section "Aluminum Windows".
OR
Aluminum Windows: Metal building system manufacturer's standard, with self-flashing mounting fins, and as follows:
 - a. Type, Performance Class, and Performance Grade: Comply with AAMA/WDMA/CSA 101/I.S.2/A440 and as follows:
 - 1) Horizontal-Sliding Units: HS-LC25 **OR** HS-C30, **as directed**.
 - 2) Single-Hung Units: H-LC25 **OR** H-C30, **as directed**.
 - 3) Fixed Units: F-LC25 **OR** F-C30, **as directed**.
 - b. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy and temper recommended by manufacturer for strength, corrosion resistance, and application of required finish, but not less than 0.064-inch (1.63-mm) thickness at any location for main frame and sash members.
 - 1) Thermally Improved Construction: Fabricate window units with an integral, concealed, low-conductance thermal barrier; located between exterior materials and window members exposed on interior side; in a manner that eliminates direct metal-to-metal contact.
 - c. Mullions: Between adjacent windows, fabricated of extruded aluminum matching finish of window units.
 - d. Fasteners, Anchors, and Clips: Nonmagnetic stainless steel, aluminum, or other noncorrosive material, compatible with aluminum window members, trim, hardware, anchors, and other components of window units. Fasteners shall not be exposed, except for attaching hardware.
 - 1) Reinforcement: Where fasteners screw-anchor into aluminum less than 0.128 inch (3.26 mm) thick, reinforce interior with aluminum or nonmagnetic stainless steel to



- receive screw threads, or provide standard, noncorrosive, pressed-in, spline grommet nuts.
- e. Hardware: Manufacturer's standard; of aluminum, stainless steel, die-cast steel, malleable iron, or bronze; including the following:
 - 1) Cam-action sweep sash lock and keeper at meeting rails.
 - 2) Spring-loaded, snap-type lock at jambs.
 - 3) Pole-operated, cam-action locking device on meeting rail where rail is more than 72 inches (1830 mm) above floor.
 - 4) Lift handles for single-hung units.
 - 5) Nylon sash rollers for horizontal-sliding units.
 - 6) Steel or bronze operating arms.
 - f. Sliding-Type Weather Stripping: Woven-pile weather stripping of wool, polypropylene, or nylon pile and resin-impregnated backing fabric; complying with AAMA 701/702.
 - g. Insect Screens: Provide removable insect screen on each operable exterior sash, with screen frame finished to match window unit, and as follows:
 - 1) Aluminum Wire Fabric: 18-by-18 (1.1-by-1.1-mm), 18-by-16 (1.1-by-1.3-mm), or 18-by-14 (1.1-by-1.5-mm) mesh of 0.013-inch- (0.3-mm-) diameter, coated aluminum wire; complying with FS RR-W-365, Type VII.
OR
Glass-Fiber Mesh Fabric: 18-by-16 (1.1-by-1.3-mm) or 18-by-14 (1.1-by-1.5-mm) mesh of PVC-coated, glass-fiber threads, woven and fused to form a fabric mesh; complying with ASTM D 3656.
OR
Fabric: Manufacturer's standard aluminum wire fabric or glass-fiber mesh fabric.
2. Glazing: Comply with requirements specified in Division 08 Section "Glazing".
- OR**
- Glazing:
- a. Float Glass: ASTM C 1036, Type I, Quality-Q3, Class I (clear), 3 mm thick.
 - b. Heat-Treated Float Glass: ASTM C 1048, Type I, Quality-Q3, Class I (clear), Condition A, 3 mm thick.
 - c. Tinted Float Glass: ASTM C 1036, Type I, Quality-Q3, Class 2, 3 mm thick.
 - 1) Tint Color: Blue **OR** Blue-green **OR** Bronze **OR** Green **OR** Gray **OR** Manufacturer's standard color, **as directed**.
 - d. Patterned Glass: ASTM C 1036, Type II, Quality-Q6, Class 1 (clear), Form 3, Pattern P3 (random), 3 mm thick.
 - e. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of 2.5-mm-thick clear float glass separated by a dehydrated interspace, qualified according to ASTM E 2190.
 - f. Safety Glass: Category II materials complying with testing requirements in 16 CFR 1201.
 - 1) Provide safety glazing labeling.
 - g. Glazing Stops: Screw-applied or snap-on glazing stops coordinated with Division 08 Section "Glazing" and with glazing system indicated. Match material and finish of window frames.
 - h. Factory-Glazed Fabrication: Glaze window units in the factory to greatest extent possible and practical for applications indicated. Comply with requirements in Division 08 Section "Glazing".
3. Finish:
- a. Mill finish.
 - b. Baked-Enamel Finish: Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 2603 except with a minimum dry film thickness of 0.7 mil (0.02 mm), medium gloss.
 - 1) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

L. Accessories



1. General: Provide accessories as standard with metal building system manufacturer and as specified. Fabricate and finish accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes. Comply with indicated profiles and with dimensional and structural requirements.
 - a. Form exposed sheet metal accessories that are without excessive oil-canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
2. Roof Panel Accessories: Provide components required for a complete metal roof panel assembly including copings, fasciae, corner units, ridge closures, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels unless otherwise indicated.
 - a. Closures: Provide closures at eaves and ridges, fabricated of same material as metal roof panels.
 - b. Clips: Manufacturer's standard, formed from steel **OR** stainless-steel, **as directed**, sheet, designed to withstand negative-load requirements.
 - c. Cleats: Manufacturer's standard, mechanically seamed cleats formed from steel **OR** stainless-steel sheet or nylon-coated aluminum, **as directed**, sheet.
 - d. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 - e. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal roof panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
 - f. Thermal Spacer Blocks: Where metal panels attach directly to purlins, provide thermal spacer blocks of thickness required to provide 1-inch (25-mm) standoff; fabricated from extruded polystyrene.
3. Wall Panel Accessories: Provide components required for a complete metal wall panel assembly including copings, fasciae, mullions, sills, corner units, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal wall panels unless otherwise indicated.
 - a. Closures: Provide closures at eaves and rakes, fabricated of same material as metal wall panels.
 - b. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 - c. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal wall panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
4. Flashing and Trim: Formed from 0.022-inch (0.56-mm) nominal-thickness, metallic-coated steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating; finished to match adjacent metal panels.
 - a. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers.
 - b. Opening Trim: Formed from 0.022-inch (0.56-mm) **OR** 0.034-inch (0.86-mm), **as directed**, nominal-thickness, metallic-coated steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Trim head and jamb of door openings, and head, jamb, and sill of other openings.
5. Gutters: Formed from 0.022-inch (0.56-mm) nominal-thickness, metallic-coated steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating; finished to match roof fascia and rake trim. Match profile of gable trim, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96-inch- (2438-mm-) long sections, sized according to SMACNA's "Architectural Sheet Metal Manual."
 - a. Gutter Supports: Fabricated from same material and finish as gutters.
 - b. Strainers: Bronze, copper, or aluminum wire ball type at outlets.



6. Downspouts: Formed from 0.022-inch (0.56-mm) nominal-thickness, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating; finished to match metal wall panels. Fabricate in minimum 10-foot- (3-m-) long sections, complete with formed elbows and offsets.
 - a. Mounting Straps: Fabricated from same material and finish as gutters.
7. Roof Ventilators: Gravity type, complete with hardware, flashing, closures, and fittings.
 - a. Circular-Revolving Type: Minimum 20-inch- (508-mm-) diameter throat opening; fabricated from 0.028-inch (0.71-mm) nominal-thickness, metallic-coated steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating; finished to match metal roof panels; with matching base and rain cap.
 - 1) Type: Directional **OR** Stationary, **as directed**, revolving.
 - 2) Bird Screening: Galvanized steel, 1/2-inch- (13-mm-) square mesh, 0.041-inch (1.04-mm) wire; or aluminum, 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.6-mm) wire.
 - 3) Dampers: Spring-loaded, butterfly type; pull-chain operation; with pull chain of length required to reach within 36 inches (914 mm) of floor.
 - 4) Reinforce and brace units, with joints properly formed and edges beaded to be watertight under normal positive-pressure conditions.
 - 5) Mount ventilators on square-to-round bases for ridge or on-slope mounting, designed to match roof pitch and roll formed to match metal roof panel profile.
 - b. Continuous or Sectional-Ridge Type: Factory-engineered and -fabricated, continuous unit; fabricated from 0.022-inch (0.56-mm) nominal-thickness, metallic-coated steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating; finished to match metal roof panels. Fabricated in minimum 10-foot- (3-m-) long sections. Provide throat size and total length indicated, complete with side baffles, ventilator assembly, end caps, splice plates, and reinforcing diaphragms.
 - 1) Bird Screening: Galvanized steel, 1/2-inch- (13-mm-) square mesh, 0.041-inch (1.04-mm) wire; or aluminum, 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.6-mm) wire.
 - 2) Dampers: Manually operated, spring-loaded, vertically rising type; chain and worm gear operator; with pull chain of length required to reach within 36 inches (914 mm) of floor.
 - 3) Throat Size: 9 inches (229 mm) **OR** 12 inches (305 mm), **as directed**.
8. Louvers: Size and design indicated; self-framing and self-flashing. Fabricate welded frames from minimum 0.052-inch (1.32-mm) nominal-thickness, metallic-coated steel sheet; finished to match metal wall panels. Form blades from 0.040-inch (1.02-mm) nominal-thickness, metallic-coated steel sheet; folded or beaded at edges, set at an angle that excludes driving rains, and secured to frames by riveting or welding. Fabricate louvers with equal blade spacing to produce uniform appearance.
 - a. Blades: Fixed.
OR
Blades: Adjustable type, with weather-stripped edges, and manually operated by hand crank or pull chain.
 - b. Free Area: Not less than 7.0 sq. ft. (0.65 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - c. Bird Screening: Galvanized steel, 1/2-inch- (13-mm-) square mesh, 0.041-inch (1.04-mm) wire; with rewirable frames, removable and secured with clips; fabricated of same kind and form of metal and with same finish as louvers.
 - 1) Mounting: Interior **OR** Exterior, **as directed**, face of louvers.
 - d. Vertical Mullions: Provide mullions at spacings recommended by manufacturer, or 72 inches (1830 mm) o.c., whichever is less.
9. Roof Curbs: Fabricated from minimum 0.052-inch (1.32-mm) nominal-thickness, metallic-coated steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating; finished to match metal roof panels; with welded top box and bottom skirt, and integral full-length cricket; capable of withstanding loads of size and height indicated.



- a. Curb Subframing: Fabricated from 0.064-inch (1.63-mm) nominal-thickness, angle-, C-, or Z-shaped metallic-coated steel sheet.
- b. Insulation: 1-inch- (25-mm-) thick, rigid type.
10. Service Walkways: Fabricated from 0.052-inch (1.32-mm) nominal-thickness, metallic-coated steel plank grating; with slip-resistant pattern; 18-inch (457-mm) **OR** 24-inch (610-mm) **OR** 36-inch (914-mm), **as directed**, overall width. Support walkways on framing system anchored to metal roof panels without penetrating panels; with predrilled holes and clamps or hooks for anchoring.
11. Pipe Flashing: Premolded, EPDM pipe collar with flexible aluminum ring bonded to base.
12. Materials:
 - a. Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide fasteners with heads matching color of materials being fastened by means of plastic caps or factory-applied coating.
 - 1) Fasteners for Metal Roof Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws, with a stainless-steel cap or zinc-aluminum-alloy head and EPDM sealing washer.
OR
Fasteners for Metal Roof Panels: Self-drilling, Type 410 stainless-steel or self-tapping, Type 304 stainless-steel or zinc-alloy-steel hex washer head, with EPDM washer under heads of fasteners bearing on weather side of metal panels.
 - 2) Fasteners for Metal Wall Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws, with EPDM sealing washers bearing on weather side of metal panels, **as directed**.
OR
Fasteners for Metal Wall Panels: Self-drilling, Type 410 stainless-steel or self-tapping, Type 304 stainless-steel or zinc-alloy-steel hex washer head, with EPDM sealing washers bearing on weather side of metal panels, **as directed**.
 - 3) Fasteners for Flashing and Trim: Blind fasteners or self-drilling screws with hex washer head.
 - 4) Blind Fasteners: High-strength aluminum or stainless-steel rivets.
 - b. Corrosion-Resistant Coating: Cold-applied asphalt mastic, compounded for 15-mil (0.4-mm) dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.
 - c. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.
 - d. Metal Panel Sealants:
 - 1) Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene-compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape of manufacturer's standard size.
 - 2) Joint Sealant: ASTM C 920; one-part elastomeric polyurethane or polysulfide; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended by metal building system manufacturer.

M. Source Quality Control

1. Testing Agency (if required): Engage a qualified testing agency to evaluate product.
2. Special Inspector (if required by local code): Engage a qualified special inspector to perform the following tests and inspections and to submit reports. Special inspector will verify that manufacturer maintains detailed fabrication and quality-control procedures and will review the completeness and adequacy of those procedures to perform the Work.
 - a. Special inspections will not be required if fabrication is performed by manufacturer registered and approved by authorities having jurisdiction to perform such Work without special inspection.



- 1) After fabrication, submit copy of certificate of compliance to authorities having jurisdiction, certifying that Work was performed according to Contract requirements.
3. Testing: Test and inspect shop connections for metal buildings according to the following:
 - a. Bolted Connections: Shop-bolted connections shall be tested and inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
 - b. Welded Connections: In addition to visual inspection, shop-welded connections shall be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at inspector's option:
 - 1) Liquid Penetrant Inspection: ASTM E 165.
 - 2) Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - 3) Ultrasonic Inspection: ASTM E 164.
 - 4) Radiographic Inspection: ASTM E 94.
4. Product will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

N. Fabrication

1. General: Design components and field connections required for erection to permit easy assembly.
 - a. Mark each piece and part of the assembly to correspond with previously prepared erection drawings, diagrams, and instruction manuals.
 - b. Fabricate structural framing to produce clean, smooth cuts and bends. Punch holes of proper size, shape, and location. Members shall be free of cracks, tears, and ruptures.
2. Tolerances: Comply with MBMA's "Metal Building Systems Manual" for fabrication and erection tolerances.
3. Primary Framing: Shop fabricate framing components to indicated size and section, with baseplates, bearing plates, stiffeners, and other items required for erection welded into place. Cut, form, punch, drill, and weld framing for bolted field assembly.
 - a. Make shop connections by welding or by using high-strength bolts.
 - b. Join flanges to webs of built-up members by a continuous, submerged arc-welding process.
 - c. Brace compression flange of primary framing with steel angles or cold-formed structural tubing between frame web and purlin web or girt web, so flange compressive strength is within allowable limits for any combination of loadings.
 - d. Weld clips to frames for attaching secondary framing.
 - e. Shop Priming: Prepare surfaces for shop priming according to SSPC-SP 2. Shop prime primary framing with specified primer after fabrication.
4. Secondary Framing: Shop fabricate framing components to indicated size and section by roll-forming or break-forming, with baseplates, bearing plates, stiffeners, and other plates required for erection welded into place. Cut, form, punch, drill, and weld secondary framing for bolted field connections to primary framing.
 - a. Make shop connections by welding or by using non-high-strength bolts.
 - b. Shop Priming: Prepare uncoated surfaces for shop priming according to SSPC-SP 2. Shop prime uncoated secondary framing with specified primer after fabrication.
5. Metal Panels: Fabricate and finish metal panels at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements. Comply with indicated profiles and with dimensional and structural requirements.
 - a. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of metal panel.

1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with erector present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.



2. Before erection proceeds, survey elevations and locations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments to receive structural framing, with erector present, for compliance with requirements and metal building system manufacturer's tolerances.
 - a. Engage land surveyor to perform surveying.
 3. Proceed with erection only after unsatisfactory conditions have been corrected.
- B. Preparation
1. Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition.
 2. Provide temporary shores, guys, braces, and other supports during erection to keep structural framing secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural framing, connections, and bracing are in place unless otherwise indicated.
- C. Erection Of Structural Framing
1. Erect metal building system according to manufacturer's written erection instructions and erection drawings.
 2. Do not field cut, drill, or alter structural members without written approval from metal building system manufacturer's professional engineer.
 3. Set structural framing accurately in locations and to elevations indicated, according to AISC specifications referenced in this Section. Maintain structural stability of frame during erection.
 4. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
 - a. Set plates for structural members on wedges, shims, or setting nuts as required.
 - b. Tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 - c. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
 5. Align and adjust structural framing before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with framing. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
 - a. Level and plumb individual members of structure.
 - b. Make allowances for difference between temperature at time of erection and mean temperature when structure will be completed and in service.
 6. Primary Framing and End Walls: Erect framing level, plumb, rigid, secure, and true to line. Level baseplates to a true even plane with full bearing to supporting structures, set with double-nutted anchor bolts. Use grout to obtain uniform bearing and to maintain a level base-line elevation. Moist-cure grout for not less than seven days after placement.
 - a. Make field connections using high-strength bolts installed according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for bolt type and joint type specified.
 - 1) Joint Type: Snug tightened or pretensioned.
 7. Secondary Framing: Erect framing level, plumb, rigid, secure, and true to line. Field bolt secondary framing to clips attached to primary framing.
 - a. Provide rake or gable purlins with tight-fitting closure channels and fasciae.
 - b. Locate and space wall girts to suit openings such as doors and windows.
 - c. Locate canopy framing as indicated.
 - d. Provide supplemental framing at entire perimeter of openings, including doors, windows, louvers, ventilators, and other penetrations of roof and walls.
 8. Steel Joists and Joist Girders: Install joists, girders, and accessories plumb, square, and true to line; securely fasten to supporting construction according to SJI's "Standard Specifications and



Load Tables for Steel Joists and Joist Girders," joist manufacturer's written instructions, and requirements in this Section.

- a. Before installation, splice joists delivered to Project site in more than one piece.
- b. Space, adjust, and align joists accurately in location before permanently fastening.
- c. Install temporary bracing and erection bridging, connections, and anchors to ensure that joists are stabilized during construction.
- d. Bolt joists to supporting steel framework using carbon-steel bolts unless otherwise indicated.

OR

Bolt joists to supporting steel framework using high-strength structural bolts unless otherwise indicated. Comply with RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for high-strength structural bolt installation and tightening requirements.

- e. Install and connect bridging concurrently with joist erection, before construction loads are applied. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams.
9. Bracing: Install bracing in roof and sidewalls where indicated on erection drawings.
 - a. Tighten rod and cable bracing to avoid sag.
 - b. Locate interior end-bay bracing only where indicated.
10. Framing for Openings: Provide shapes of proper design and size to reinforce openings and to carry loads and vibrations imposed, including equipment furnished under mechanical and electrical work. Securely attach to structural framing.
11. Erection Tolerances: Maintain erection tolerances of structural framing within AISC 303.

D. Metal Panel Installation, General

1. Examination: Examine primary and secondary framing to verify that structural-panel support members and anchorages have been installed within alignment tolerances required by manufacturer.
 - a. Examine roughing-in for components and systems penetrating metal panels, to verify actual locations of penetrations relative to seams before metal panel installation.
2. General: Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - a. Field cut metal panels as required for doors, windows, and other openings. Cut openings as small as possible, neatly to size required, and without damage to adjacent metal panel finishes.
 - 1) Field cutting of metal panels by torch is not permitted unless approved in writing by manufacturer.
 - b. Install metal panels perpendicular to structural supports unless otherwise indicated.
 - c. Flash and seal metal panels with weather closures at perimeter of openings and similar elements. Fasten with self-tapping screws.
 - d. Locate and space fastenings in uniform vertical and horizontal alignment.
 - e. Locate metal panel splices over, but not attached to, structural supports with end laps in alignment.
 - f. Lap metal flashing over metal panels to allow moisture to run over and off the material.
3. Lap-Seam Metal Panels: Install screw fasteners using power tools with controlled torque adjusted to compress EPDM washers tightly without damage to washers, screw threads, or metal panels. Install screws in predrilled holes.
 - a. Arrange and nest side-lap joints so prevailing winds blow over, not into, lapped joints. Lap ribbed or fluted sheets one full rib corrugation. Apply metal panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.
4. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.



5. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal panel assemblies. Provide types of gaskets, fillers, and sealants indicated; or, if not indicated, provide types recommended by metal panel manufacturer.
 - a. Seal metal panel end laps with double beads of tape or sealant the full width of panel. Seal side joints where recommended by metal panel manufacturer.
 - b. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants".

E. Metal Roof Panel Installation

1. General: Provide metal roof panels of full length from eave to ridge unless otherwise indicated or restricted by shipping limitations.
 - a. Install ridge and hip caps as metal roof panel work proceeds.
 - b. Flash and seal metal roof panels with weather closures at eaves and rakes. Fasten with self-tapping screws.
2. Standing-Seam Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each standing-seam joint, at location and spacing and with fasteners recommended by manufacturer.
 - a. Install clips to supports with self-drilling or self-tapping fasteners.
 - b. Install pressure plates at locations indicated in manufacturer's written installation instructions.
 - c. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.
OR
Seamed Joint: Crimp standing seams with manufacturer-approved motorized seamer tool so that clip, metal roof panel, and factory-applied sealant are completely engaged.
 - d. Rigidly fasten eave end of metal roof panels and allow ridge end free movement due to thermal expansion and contraction. Predrill panels for fasteners.
 - e. Provide metal closures at peaks, rake edges, rake walls and each side of ridge and hip caps.
3. Lap-Seam Metal Roof Panels: Fasten metal roof panels to supports with exposed fasteners at each lapped joint, at location and spacing recommended by manufacturer.
 - a. Provide metal-backed sealing washers under heads of exposed fasteners bearing on weather side of metal roof panels.
 - b. Provide sealant tape at lapped joints of metal roof panels and between panels and protruding equipment, vents, and accessories.
 - c. Apply a continuous ribbon of sealant tape to weather-side surface of fastenings on end laps and on side laps of nesting-type metal panels, on side laps of ribbed or fluted metal panels, and elsewhere as needed to make metal panels weatherproof to driving rains.
 - d. At metal panel splices, nest panels with minimum 6-inch (152-mm) end lap, sealed with butyl-rubber sealant and fastened together by interlocking clamping plates.
4. Metal Fascia Panels: Align bottom of metal panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws. Flash and seal metal panels with weather closures where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.
5. Metal Roof Panel Installation Tolerances: Shim and align metal roof panels within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

F. Metal Wall Panel Installation

1. General: Install metal wall panels in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to girts, extending full height of building, unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - a. Unless otherwise indicated, begin metal panel installation at corners with center of rib lined up with line of framing.
 - b. Shim or otherwise plumb substrates receiving metal wall panels.



- c. When two rows of metal panels are required, lap panels 4 inches (102 mm) minimum.
 - d. When building height requires two rows of metal panels at gable ends, align lap of gable panels over metal wall panels at eave height.
 - e. Rigidly fasten base end of metal wall panels and allow eave end free movement due to thermal expansion and contraction. Pre-drill panels.
 - f. Flash and seal metal wall panels with weather closures at eaves, rakes, and at perimeter of all openings. Fasten with self-tapping screws.
 - g. Install screw fasteners in pre-drilled holes.
 - h. Install flashing and trim as metal wall panel work proceeds.
 - i. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated; or, if not indicated, as necessary for waterproofing.
 - j. Align bottom of metal wall panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws.
 - k. Provide weatherproof escutcheons for pipe and conduit penetrating exterior walls.
2. Metal Wall Panels: Install metal wall panels on exterior side of girts. Attach metal wall panels to supports with fasteners as recommended by manufacturer.
 3. Insulated Metal Wall Panels: Install insulated metal wall panels on exterior side of girts. Attach panels to supports at each panel joint using concealed clip and fasteners at maximum 42 inches (1067 mm) o.c., spaced not more than manufacturer's recommendation. Fully engage tongue and groove of adjacent insulated metal wall panels.
 - a. Install clips to supports with self-tapping fasteners.
 - b. Apply continuous ribbon of sealant to panel joint on concealed side of insulated metal wall panels as vapor seal; apply sealant to panel joint on exposed side of panels as weather seal.
 4. Installation Tolerances (for highly finished metal wall panel assemblies): Shim and align metal wall panels within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m), nonaccumulative, on level, plumb, and on location lines as indicated, and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.
- G. Translucent Panel Installation
1. Translucent Panels: Attach translucent panels to structural framing with fasteners according to manufacturer's written instructions. Install panels perpendicular to supports unless otherwise indicated. Anchor translucent panels securely in place, with provisions for thermal and structural movement.
 - a. Provide end laps of not less than 6 inches (152 mm) and side laps of not less than 1-1/2-inch (38-mm) corrugations for metal roof panels.
 - b. Provide end laps of not less than 4 inches (102 mm) and side laps of not less than 1-1/2-inch (38-mm) corrugations for metal wall panels.
 - c. Align horizontal laps with adjacent metal panels.
 - d. Seal intermediate end laps and side laps of translucent panels with translucent mastic.
- H. Metal Soffit Panel Installation
1. Provide metal soffit panels the full width of soffits. Install panels perpendicular to support framing.
 2. Flash and seal metal soffit panels with weather closures where panels meet walls and at perimeter of all openings.
- I. Thermal Insulation Installation
1. General: Install insulation concurrently with metal panel installation, in thickness indicated to cover entire surface, according to manufacturer's written instructions.
 - a. Set vapor-retarder-faced units with vapor retarder toward warm side of construction unless otherwise indicated. Do not obstruct ventilation spaces except for firestopping.
 - b. Tape joints and ruptures in vapor retarder, and seal each continuous area of insulation to the surrounding construction to ensure airtight installation.
 - c. Install factory-laminated, vapor-retarder-faced blankets straight and true in one-piece lengths, with both sets of facing tabs sealed, to provide a complete vapor retarder.
- OR**



Install blankets straight and true in one-piece lengths. Install vapor retarder over insulation, with both sets of facing tabs sealed, to provide a complete vapor retarder.

2. Blanket Roof Insulation: Comply with the following installation method:
 - a. Over-Framing Installation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing. Hold in place by metal roof panels fastened to secondary framing.
 - b. Between-Purlin Installation: Extend insulation and vapor retarder between purlins. Carry vapor-retarder-facing tabs up and over purlin, overlapping adjoining facing of next insulation course and maintaining continuity of retarder. Hold in place with bands and crossbands below insulation.
 - c. Over-Purlin-with-Spacer-Block Installation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing. Install layer of filler insulation over first layer to fill space formed by metal roof panel standoffs. Hold in place by panels fastened to standoffs.
 - 1) Thermal Spacer Blocks: Where metal roof panels attach directly to purlins, install thermal spacer blocks.
 - d. Two-Layers-between-Purlin-with-Spacer-Block Installation: Extend insulation and vapor retarder between purlins. Carry vapor-retarder-facing tabs up and over purlin, overlapping adjoining facing of next insulation course and maintaining continuity of retarder. Install layer of filler insulation over first layer to fill space between purlins formed by thermal spacer blocks. Hold in place with bands and crossbands below insulation.
 - 1) Thermal Spacer Blocks: Where metal roof panels attach directly to purlins, install thermal spacer blocks.
 - e. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.
3. Blanket Wall Insulation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing. Hold in place by metal wall panels fastened to secondary framing.
 - a. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.
 - b. Sound-Absorption Insulation: Where sound-absorption requirement is indicated for metal liner panels, cover insulation with polyethylene film and provide inserts of wire mesh to form acoustical spacer grid.
4. Board Wall Insulation: Extend board insulation in thickness indicated to cover entire wall. Hold in place by metal wall panels fastened to secondary framing. Comply with manufacturers' written instructions.
 - a. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.

J. Door And Frame Installation

1. General: Install doors and frames plumb, rigid, properly aligned, and securely fastened in place according to manufacturers' written instructions. Coordinate installation with wall flashings and other components. Seal perimeter of each door frame with elastomeric sealant used for metal wall panels.
2. Personnel Doors and Frames: Install doors and frames according to SDI A250.8. Fit non-fire-rated doors accurately in their respective frames, with the following clearances:
 - a. Between Doors and Frames at Jambs and Head: 1/8 inch (3 mm).
 - b. Between Edges of Pairs of Doors: 1/8 inch (3 mm).
 - c. At Door Sills with Threshold: 3/8 inch (9.5 mm).
 - d. At Door Sills without Threshold: 3/4 inch (19.1 mm).
 - e. At fire-rated openings, install frames according to, and doors with clearances specified in, NFPA 80.
3. Sliding Service Doors: Bolt support angles to opening head members through factory-punched holes. Bolt door tracks to support angles at maximum 24 inches (610 mm) o.c. Set doors and operating equipment with necessary hardware, jamb and head mold stops, continuous hood flashing, anchors, inserts, hangers, and equipment supports.



4. Field Glazing: Comply with installation requirements in Division 8 Section "Glazing."
 5. Door Hardware: Mount units at heights indicated in DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
 - a. Install surface-mounted items after finishes have been completed on substrates involved.
 - b. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
 - c. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.
 - d. Set thresholds for exterior doors in full bed of butyl-rubber sealant complying with requirements specified in Division 07 Section "Joint Sealants".
- K. Window Installation
1. General: Install windows plumb, rigid, properly aligned, without warp or rack of frames or sash, and securely fasten in place according to manufacturer's written instructions. Coordinate installation with wall flashings and other components. Seal perimeter of each window frame with elastomeric sealant used for metal wall panels.
 - a. Separate dissimilar materials from sources of corrosion or electrolytic action at points of contact with other materials by complying with requirements specified in AAMA/WDMA/CSA 101/I.S.2/A440.
 2. Set sill members in bed of sealant or with gaskets, as indicated, for weathertight construction.
 3. Install windows and components to drain condensation, water penetrating joints, and moisture migrating within windows to the exterior.
 4. Mount screens directly to frames with tapped screw clips.
 5. Field Glazing: Comply with installation requirements in Division 08 Section "Glazing".
- L. Accessory Installation
1. General: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
 - a. Install components required for a complete metal roof panel assembly, including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
 - b. Install components for a complete metal wall panel assembly, including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
 - c. Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by manufacturer.
 2. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - a. Install exposed flashing and trim that is without excessive oil-canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
 - b. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (600 mm) of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).
 3. Gutters: Join sections with riveted-and-soldered or lapped-and-sealed joints. Attach gutters to eave with gutter hangers spaced as required for gutter size, but not more than 36 inches (914 mm) o.c. using manufacturer's standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.



4. Downspouts: Join sections with 1-1/2-inch (38-mm) telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch (25 mm) away from walls; locate fasteners at top and bottom and at approximately 60 inches (1524 mm) o.c. in between.
 - a. Provide elbows at base of downspouts to direct water away from building.
OR
Tie downspouts to underground drainage system indicated.
5. Circular Roof Ventilators: Set ventilators complete with necessary hardware, anchors, dampers, weather guards, rain caps, and equipment supports. Mount ventilators on flat level base. Install preformed filler strips at base to seal ventilator to metal roof panels.
6. Continuous Roof Ventilators: Set ventilators complete with necessary hardware, anchors, dampers, weather guards, rain caps, and equipment supports. Join sections with splice plates and end-cap skirt assemblies where required to achieve indicated length. Install preformed filler strips at base to seal ventilator to metal roof panels.
7. Louvers: Locate and place louver units level, plumb, and at indicated alignment with adjacent work.
 - a. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
 - b. Provide perimeter reveals and openings of uniform width for sealants and joint fillers.
 - c. Protect galvanized- and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of corrosion-resistant paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
 - d. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Division 07 Section "Joint Sealants" for sealants applied during louver installation.
8. Roof Curbs: Install curbs at locations indicated on Drawings. Install flashing around bases where they meet metal roof panels.
9. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to panel as recommended by manufacturer.

M. Field Quality Control

1. Special Inspections: Engage, **as directed**, a qualified special inspector to perform the following special inspections:
 - a. Inspection of fabricators.
 - b. Steel construction.
2. Testing Agency: Engage, **as directed**, a qualified testing agency to perform tests and inspections.
3. Tests and Inspections:
 - a. High-Strength, Field-Bolted Connections: Connections shall be tested and inspected during installation according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
 - b. Welded Connections: In addition to visual inspection, field-welded connections shall be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at inspector's option:
 - 1) Liquid Penetrant Inspection: ASTM E 165.
 - 2) Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - 3) Ultrasonic Inspection: ASTM E 164.
 - 4) Radiographic Inspection: ASTM E 94.
4. Product will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

N. Adjusting

1. Doors: After completing installation, test and adjust doors to operate easily, free of warp, twist, or distortion.



2. Door Hardware: Adjust and check each operating item of door hardware and each door to ensure proper operation and function of every unit. Replace units that cannot be adjusted to operate as intended.
 3. Windows: Adjust operating sashes and ventilators, screens, hardware, and accessories for a tight fit at contact points and at weather stripping to ensure smooth operation and weathertight closure. Lubricate hardware and moving parts.
 4. Roof Ventilators and Adjustable Louvers: After completing installation, including work by other trades, lubricate, test, and adjust units to operate easily and be free of warp, twist, or distortion as needed to provide fully functioning units.
 - a. Adjust louver blades to be weathertight when in closed position.
- O. Cleaning And Protection
1. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
 2. Remove and replace glass that has been broken, chipped, cracked, abraded, or damaged during construction period.
 3. Touchup Painting: After erection, promptly clean, prepare, and prime or reprime field connections, rust spots, and abraded surfaces of prime-painted structural framing, bearing plates, and accessories.
 - a. Clean and prepare surfaces by SSPC-SP 2, "Hand Tool Cleaning," or by SSPC-SP 3, "Power Tool Cleaning."
 - b. Apply a compatible primer of same type as shop primer used on adjacent surfaces.
- OR**
- Touchup Painting: Cleaning and touchup painting are specified in Division 9 painting Sections.
4. Metal Panels: Remove temporary protective coverings and strippable films, if any, as metal panels are installed. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.
 - a. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.
 5. Doors and Frames: Immediately after installation, sand rusted or damaged areas of prime coat until smooth and apply touchup of compatible air-drying primer.
 - a. Immediately before final inspection, remove protective wrappings from doors and frames.
 6. Windows: Clean metal surfaces immediately after installing windows. Avoid damaging protective coatings and finishes. Remove excess sealants, glazing materials, dirt, and other substances. Clean factory-glazed glass immediately after installing windows.
 7. Louvers: Clean exposed surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.
 - a. Restore louvers damaged during installation and construction period so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by the Owner, remove damaged units and replace with new units.
 - 1) Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 13 34 19 00



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Task	Specification	Specification Description
13 34 19 00	01 22 16 00	No Specification Required
13 34 23 13	13 34 19 00	Metal Building Systems



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SECTION 13 34 23 16 - PARKING CONTROL EQUIPMENT

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for parking control equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Automatic barrier gates.
 - b. Vehicle detectors.
 - c. Traffic controllers.
 - d. Entry terminal ticket dispensers.
 - e. Exit terminals.
 - f. Pay stations.
 - g. Fee computers.
 - h. Parking facility management software.
 - i. Access control units.

C. System Description

1. Parking Control System: Intended to be used for the following types of parking management:
 - a. Transient Parking: Hourly rated parking, with fee paid while entering **OR** exiting, **as directed**.
 - b. Monthly Parking: Monthly rated parking, with fee paid by the month and access gained by access control card.
 - c. Flat-Rate Parking: Unlimited-duration parking, with free gate entry and fixed-fee amount paid while exiting.
 - d. Special-Event Parking: Duration-of-event parking, with fee paid while entering with gates up or down.
 - e. Limited Date(s) and Time(s) Parking: Limited-duration parking, with predetermined fee access control card.
 - f. Merchant Validated Parking: Fee set, reduced, or waived by merchant validation, with free gate entry and fee paid while exiting.
 - g. Valet Parking: Assisted parking, with fee paid while entering or exiting.
 - h. Hotel Guest Parking: Unlimited access for duration of stay, with access gained by access control card.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For parking control equipment. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Field quality-control reports.
4. Operation and Maintenance Data: For parking control equipment to include in emergency, operation, and maintenance manuals.
5. Software and Firmware Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - c. Device address list.



d. Printout of software application and graphic screens.

E. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Preinstallation Conference: Conduct conference at Project site.

F. Software Service Agreement

1. Technical Support: Beginning with Final Completion, provide software support for two, **as directed**, years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two, **as directed**, years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - a. Provide 30, **as directed**, days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Materials

1. Aluminum: Alloy and temper recommended by aluminum producer and manufacturer for type of use and finish indicated, and as follows:
 - a. Sheet: ASTM B 209 (ASTM B 209M).
 - b. Extruded Shapes: ASTM B 221 (ASTM B 221M).
2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B.
3. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, commercial quality, with G60 (Z180) coating designation; mill phosphatized.
4. Stainless-Steel Sheet: ASTM A 666, Type 304.
5. Anchorages: Anchor bolts, hot-dip galvanized according to ASTM A 153/A 153M and ASTM F 2329.

B. Automatic Barrier Gates

1. General: Provide UL-approved parking control device consisting of operator and controller housed in a weathertight, tamper-resistant cabinet enclosure with gate arm. Device shall be activated by a signal from access or revenue control device. Fabricate unit with gate-arm height in down position of not more than 35 inches (889 mm) above pavement to prevent even small vehicles from passing under gate arm.
2. Standard: Provide barrier gates and gate operators that are listed and labeled according to UL 325 by a qualified testing agency. Provide barrier gates that comply with ASTM F 2200, **as directed**.
3. Controller: Factory-sealed, solid-state, plug-in type, with galvanized-steel box for wiring connections.
 - a. Type: Noncommunicating.
 - 1) Capable of logic for one- and two-way lanes.
 - 2) Separate momentary contacts for transient patrons, monthly patrons, vehicle entries, and vehicle exits.
 - b. Type: Communicating.
 - 1) Real-time communication of lane counts, status messages, and execute commands.
 - 2) Monitor illegal entries and exits, tailgates, tickets, monthlies, and backouts.
 - 3) Status messages for gate up too long, backouts, ticket in chute, and gate-arm rebound.



- 4) Communication commands for resetting loops, turning "Full" signs on/off, raising and lowering gate arm, and disabling ticket dispensers **OR** card readers, **as directed**.
- c. Features: Equip unit with the following:
 - 1) Able to store successive inputs and sequentially processing each one.
 - 2) Automatic instant-reversing obstacle detector mechanism that stops downward motion of gate arm if arm contacts or nears an object and that immediately returns arm to upward position. Include a 0- to 60-second, variable-time reset device.
 - 3) On-off power supply switch.
 - 4) Automatic-manual switch.
 - 5) Differential counter.
 - 6) Directional arming logic.
 - 7) RS-422 communication port.
 - 8) Broken gate-arm monitoring.
 - 9) Programmable automatic, **as directed**, timer.
 - 10) Internal resettable **OR** non-resettable, **as directed**, counters.
 - 11) Thermal-overload protection with manual reset.
 - 12) Plug-in connectors for two **OR** three, **as directed**, vehicle loop detectors.
 - 13) Thermostatically controlled heater with on/off/auto switch.
 - 14) Diagnostic mode for on-site testing, with LEDs for inputs and outputs, **as directed**.
 - 15) Automatic and continuous testing of inputs and outputs.
 - 16) Switch to test motor and limit switches.
 - 17) Emergency manual disconnect.
 - 18) Battery backup.
 - 19) Single, 115-V ac grounded power receptacle.
 - 20) Reversible arm capability for right- or left-handed operation.
4. Cabinets: Fabricated from metal sheet with seams welded and ground smooth; approximately 15 inches square by 40 inches tall (381 mm square by 1016 mm tall). Provide single, gasketed access door for each cabinet with flush-mounted locks. Furnish two keys for each lock, all locks keyed alike, **as directed**. Fabricate cabinet with internal reinforcing and four mounting holes accessible only from inside cabinet.
 - a. Material: Not less than 0.097-inch- (2.5-mm-) thick, galvanized-, **as directed**, steel sheet or 0.125-inch- (3.2-mm-) thick aluminum sheet.
 - 1) Finish cabinet, interior and exterior, with manufacturer's standard white **OR** yellow, **as directed**, baked-enamel finish over primer.
 - b. Material: Not less than 0.109-inch- (2.8-mm-) thick, stainless-steel sheet.
 - 1) Finish cabinet exterior with No. 4 finish.
OR
Finish cabinet, interior and exterior, with manufacturer's standard white **OR** yellow, **as directed**, baked-enamel finish over primer.
5. Straight Gate Arm: 1-by-4-inch nominal- (19-by-89-mm actual-) size pine or redwood **OR** 0.097-inch- (2.5-mm-) thick steel **OR** Fiberglass, PVC, or polycarbonate **OR** Aluminum, **as directed**, with painted finish and black diagonal stripes on traffic-side face. Provide mounting flange with breakaway feature to ensure clean break if arm is struck by vehicle.
 - a. Length: 10 feet (3.0 m) **OR** 12 feet (3.7 m) **OR** As indicated on Drawings, **as directed**.
6. Folding Gate Arm: Two pieces of 1-by-4-inch nominal- (19-by-89-mm actual-) size pine or redwood joined together with metal side brackets; with painted finish and black diagonal stripes on traffic-side face. Provide mounting flange with breakaway feature to ensure clean break if arm is struck by vehicle.
 - a. Length: 10 feet (3.0 m) **OR** 12 feet (3.7 m) **OR** As indicated on Drawings, **as directed**.
7. Straight Gate Arm with Counterbalance: 1-by-6-inch nominal- (19-by-140-mm actual-) size pine or redwood with steel counterweights; with painted finish and black diagonal stripes on traffic-side face. Provide mounting flange with breakaway feature to ensure clean break if arm is struck by vehicle.
 - a. Length: 16 feet (4.9 m) **OR** As indicated on Drawings, **as directed**.
8. Wishbone-Style Gate Arm: 1-by-4-inch nominal- (19-by-89-mm actual-) size pine or redwood **OR** 0.097-inch- (2.5-mm-) thick steel, **as directed**, formed into wishbone configuration, with steel



counterweights; with painted finish and black diagonal stripes on traffic-side face. Provide mounting flange with breakaway feature to ensure clean break if arm is struck by vehicle.

- a. Length: 14 feet (4.3 m) **OR** As indicated on Drawings, **as directed**.
9. Operator: 1/3 **OR** 1/2, **as directed**, hp; 60-Hz, single-phase, instant-reversing, continuous-duty motor for operating gate arm. Transmit power to gate-arm drive shaft through speed reducer to harmonic-acting crank and connecting rod. Fabricate crank, rod, and drive shaft of galvanized solid bar steel. Provide an operable cam for adjusting arm travel.
 - a. Opening Time: Three **OR** Six, **as directed**, seconds.
 - b. Inherently adjustable torque limiting clutch for safety.
10. Accessories:
 - a. Audible alarm that activates as part of a safety device system.
 - b. Additional obstruction detector; noncontact infrared **OR** photoelectric **OR** radio-frequency barrier, **as directed**.
 - c. Barrier-arm warning safety signs on both sides of unit limiting traffic to vehicular traffic.
 - d. Low-voltage yellow **OR** red, **as directed**, warning lights that illuminate when gate is in down position.
 - e. Low-voltage light on cabinet top that flashes or changes from red to green when barrier gate is operating.
 - f. Manually operated crank for emergency operation.
 - g. Local authorities' emergency access as directed by the Owner.
 - h. Gate-arm tip support with electromagnetic lock, **as directed**.

C. Vehicle Detectors

1. Vehicle Loop Detector System: Provide self-tuning electronic presence detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit signal activating gate-arm operator. Include automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and vehicle loop detector designed to open and close gate arm **OR** hold gate arm open until traffic clears, **as directed**. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, as recommended in writing by detection system manufacturer for function indicated.
 - a. Field-Assembled Loop: Wire, in size indicated for field assembly, and sealant; style for pave-over **OR** saw-cut, **as directed**, installation.
 - b. Factory-Formed Loop: Wire, preformed in size indicated; style for pave-over **OR** saw-cut, **as directed**, installation.
 - c. System Performance: Capable of the following:
 - 1) Recognize two vehicles within 6 inches (152 mm) of each other on standard-sized loop.
 - 2) Recognize vehicle direction by detecting vehicle moving from one loop to another.
 - 3) Generate reverse count if vehicle backs up after generating directional count in forward direction.
 - 4) Continuous diagnostic monitoring for intermittently operating and failed loops.
 - 5) Crosstalk test between adjacent loops.
2. Active Infrared Vehicle Detector: Provide retroreflective **OR** emitter/receiver, **as directed**,-type presence detector with adjustable detection zone pattern and sensitivity, designed to detect the presence or transit of vehicle in gate-arm pathway by interrupting infrared beam in zone pattern and to emit signal activating gate-arm operator. Include automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and vehicle presence detector designed to open and close gate arm **OR** hold gate arm open until traffic clears, **as directed**.

D. Traffic Controllers

1. Penetrating Type: Provide directional enforcement system consisting of multiple raised teeth that allow vehicular traffic in one direction and that puncture tires of vehicular traffic in the other direction. Fabricate system from steel plate contained in welded steel frame.



- a. Mounting: Surface **OR** Recessed, **as directed**.
 - b. Operation: Manual, with each tooth controlled by torsion spring **OR** Electromechanical **OR** Hydraulic, **as directed**.
 - c. Latch Down: Allow disarming for two-way traffic flow. Provide one, **as directed**, tool(s) for latch-down operation.
 - d. Illuminated Warning Signs: Single **OR** Double, **as directed**, -faced warning signs consisting of fluorescent lamps with cold-start ballasts contained in welded steel bodies with baked-enamel finish and fiberglass sign faces. Provide base sleeves and posts for post mounting, **as directed**.
 - 1) Sign Copy: "Wrong Way, Stop, Severe Tire Damage" **OR** "Warning, Do Not Back Up, Tire Damage," **as directed**.
2. Nonpenetrating Type: Provide directional enforcement system consisting of spring-activated steel curb that allows traffic in only one direction. Fabricate system from steel plate contained in welded steel frame.
 - a. Mounting: Surface **OR** Recessed, **as directed**.
 - b. Operation: Manual **OR** Electromechanical **OR** Hydraulic, **as directed**.
- E. Entry Terminal Ticket Dispensers
1. General: Provide entry terminal ticket dispensers, consisting of ticket-printing and issuing mechanisms, ticket magazines, thermal printers, and controllers housed in cabinet enclosures.
 - a. Features: Include the following:
 - 1) Time and date display.
 - 2) Time Indicator: 24-hour cycle with A.M. and P.M. **OR** military-time, **as directed**, clock mechanism.
 - 3) Voice annunciation.
 - 4) Tickets: Standard paper **OR** Magnetic-stripe **OR** Barcode, **as directed**, type.
 - 5) Removable ticket tray with capacity of 5000, **as directed**, fan-folded tickets.
 - 6) Operation: Standalone **OR** Online communication to remote computer, **as directed**.
 - 7) Battery backup for clock and RAM memory.
 - 8) RS-422 communication port.
 - 9) Thermostatically controlled heater with on/off/auto switch.
 - 10) Access **OR** Credit, **as directed**, card acceptance with activation slot and "Insert Ticket/Card" message.
 - 11) License plate recognition.
 - 12) Multiple ticket option for valet parking.
 - 13) Intercom.
 2. System Performance: Activation by button with "Push for Ticket" message **OR** vehicle detector **OR** card reader, **as directed**. On activation, unit automatically records entry time and date on ticket, sounds buzzer, **as directed**, and dispenses ticket.
 - a. Automatic ticket validation.
 - b. Program ticket numbering.
 - c. Low-ticket alarm.
 - d. Out-of-ticket alarm.
 - e. Ticket jam detection.
 - f. Print test ticket.
 3. Cabinets: Fabricated from metal sheet with seams welded and ground smooth, approximately 15 inches square by 40 inches tall (381 mm square by 1016 mm tall); consisting of base and top components. Provide single, gasketed access door for each base component with flush-mounted locks. Furnish two keys for each lock, all locks keyed alike, **as directed**. Fabricate cabinet with internal reinforcing and four mounting holes accessible only from inside cabinet. Fabricate top component so it can be unlocked and opened for ticket loading and maintenance. Include flush-mounted lock in rear of top, keyed the same as base component lock.
 - a. Material: Not less than 0.097-inch- (2.5-mm-) thick, galvanized-, **as directed**, steel sheet or 0.125-inch- (3.2-mm-) thick aluminum sheet.
 - 1) Finish cabinet, interior and exterior, with manufacturer's standard white **OR** yellow, **as directed**, baked-enamel finish over primer.



b. Material: Not less than 0.109-inch- (2.8-mm-) thick, stainless-steel sheet.

1) Finish cabinet exterior with No. 4 finish.

OR

Finish cabinet, interior and exterior, with manufacturer's standard white **OR** yellow, **as directed**, baked-enamel finish over primer.

4. Ticket-Dispensing Mechanisms: Removable assembly, with self-sharpening ticket cutter or ticket burster and plug-in controller.

F. Exit Terminals

1. General: Provide exit terminals consisting of ticket collectors, magnetic-stripe ticket readers, LCD, **as directed**, displays, thermal printers, and controllers housed in cabinet enclosures. Provide "Please Insert Ticket" sign on side of cabinet visible to driver.

a. Features: Include the following:

1) Operation: Standalone **OR** Online communication to remote computer, **as directed**.

2) Battery backup for clock and RAM memory.

3) Thermostatically controlled heater with on/off/auto switch.

4) RS-422 communication port.

5) Access **OR** Credit, **as directed**, card acceptance with activation slot and "Insert Ticket/Card" message.

6) Intercom.

2. System Performance: Capable of the following:

a. Activated by vehicle detector **OR** card reader, **as directed**.

b. Print receipts on demand.

c. Voice annunciation.

d. Program facility code.

e. Program grace period.

f. Program display.

g. Program timer for closing barrier gate.

h. Reports for events and exception events.

i. Built-in service diagnostics.

3. Operation: Inserting exit ticket into exit ticket reader results in the following actions:

a. Valid Exit Ticket: Exit ticket reader captures ticket and automatically sends signal to raise barrier gate.

b. Invalid Exit Ticket: Exit ticket reader rejects ticket and displays "Pay Cashier First" message.

c. Exit Ticket with Elapsed Grace Time: Exit ticket reader rejects ticket and displays "Return to Cashier" message.

4. Cabinets: Fabricated from metal sheet with seams welded and ground smooth; approximately 15 inches square by 40 inches tall (381 mm square by 1016 mm tall). Provide single, gasketed access door for each cabinet with flush-mounted locks. Furnish two keys for each lock, all locks keyed alike, **as directed**. Fabricate cabinet with internal reinforcing and four mounting holes accessible only from inside cabinet.

a. Material: Not less than 0.097-inch- (2.5-mm-) thick, galvanized-, **as directed**, steel sheet or 0.125-inch- (3.2-mm-) thick aluminum sheet.

1) Finish cabinet, interior and exterior, with manufacturer's standard white **OR** yellow, **as directed**, baked-enamel finish over primer.

b. Material: Not less than 0.109-inch- (2.8-mm-) thick, stainless-steel sheet.

1) Finish cabinet exterior with No. 4 finish.

OR

Finish cabinet, interior and exterior, with manufacturer's standard white **OR** yellow, **as directed**, baked-enamel finish over primer.

G. Pay Stations

1. General: Provide self-contained cashiering central **OR** entry **OR** exit, **as directed**, pay stations designed for self-service operation; consisting of magnetic-stripe ticket dispensers and, **as**



directed, readers/validators, LCD, **as directed**, displays, fee computers, controllers, **as directed**, and thermal printers housed in a combined enclosure.

- a. Features: Include the following:
 - 1) Operation: Standalone **OR** Online communication to remote computer, **as directed**.
 - 2) Battery backup for clock and RAM memory.
 - 3) Thermostatically controlled heater with on/off/auto switch.
 - 4) Access card acceptance.
 - 5) Intercom.
 2. System Performance: Capable of the following:
 - a. Compute multiple parking fees based on entry times on ticket from ticket dispenser.
 - b. Compute multiple taxes by percent and fixed amount.
 - c. Program lost ticket function.
 - d. Display fee.
 - e. Accept payment by cash credit card **OR** debit card **OR** merchant ticket, **as directed**.
 - f. Compute change.
 - g. Print receipts on demand.
 - h. Print validation on ticket.
 - i. Voice annunciation.
 - j. Print audit trail.
 - k. Program six, **as directed**, fee structures.
 - l. Program time.
 - m. Program merchant validations.
 - n. Test mode to verify accuracy of fee structure program.
 - o. Built-in service diagnostics.
 - p. Print cash audit, revenue, operational, and statistical reports on demand.
 - q. Duress alarm output for emergencies.
 - r. Battery backup.
 3. Cabinets: Fabricated from cold-rolled steel sheet with seams welded and ground smooth, approximately 36 inches wide by 18 inches deep by 60 inches tall (914 mm wide by 457 mm deep by 1524 mm tall). Provide single, gasketed access door with flush-mounted locks. Furnish two keys for each lock, all locks keyed alike, **as directed**. Fabricate cabinet with internal reinforcing and four mounting holes accessible only from inside cabinet.
 - a. Finish cabinet, interior and exterior, with manufacturer's standard white **OR** yellow, **as directed**, baked-enamel finish over primer.
- H. Fee Computers
1. Fee Computer System: Provide modular PC-based, **as directed**, system consisting of fee computer terminal, cash drawer, **OR** two cash drawers, **as directed**, standard ticket reader, **OR** magnetic-stripe ticket reader, **OR** barcode ticket reader, **as directed**, and detachable printer. Register permanent record of each transaction in computer's memory.
 - a. Features: Provide the following:
 - 1) Battery backup for clock and RAM memory.
 - 2) RS-422 communication port.
 - 3) Keyed **OR** Keyless-membrane, **as directed**, keypad.
 2. System Performance: Capable of the following:
 - a. Compute multiple parking fees based on entry times on ticket from ticket dispenser.
 - b. Compute multiple taxes by percent and fixed amount.
 - c. Program lost ticket function.
 - d. Display fee on remote fee display device.
 - e. Accept payment by cash check **OR** credit card **OR** debit card **OR** merchant ticket, **as directed**.
 - f. Control independent cash drawer.
 - g. Compute change.
 - h. Print receipts.
 - i. Print validation on ticket.
 - j. Print audit trail.



- k. Interface to automatic barrier gate.
 - l. Program six, **as directed**, fee structures.
 - m. Program time.
 - n. Program keys.
 - o. Program special events validations.
 - p. Program automatic activation for limited date(s) and time(s) validations.
 - q. Program merchant validations.
 - r. Program valet parking.
 - s. Program hotel guest parking.
 - t. Three levels of security, including cashier, supervisor, and master.
 - u. Recall last transaction.
 - v. Test mode to verify accuracy of fee structure program.
 - w. Built-in service diagnostics.
 - x. View cash audit, revenue, operational, and statistical reports on screen or print on demand.
 - y. Duress alarm output for emergencies.
 - z. Battery backup.
3. Cash Drawer: Fabricated with a removable tray and drawer, with five compartments for paper currency and five compartments for coins.
4. Remote Fee Display: Single-faced signs designed for use with fee computer, consisting of 1-inch- (25-mm-) tall, LCD or LED displays contained in welded steel bodies with baked-enamel finish.
- a. Messages: Amount due, "Thank You," "Closed," and time in A.M./P.M. format.
 - b. Mounting: Front of cashier's booth **OR** 42-inch- (1067-mm-) high pedestal, **as directed**.
- I. Miscellaneous Parking Control Equipment
1. Lot "Full" Signs: Single-faced signs consisting of illumination source contained in welded steel bodies with extended hood and baked-enamel finish. Sign copy shall be 4 inches (102 mm), **as directed**, tall.
- a. Type: Flashing **OR** Nonflashing, **as directed**.
 - b. Operation: Manual by push button **OR** Automatic by barrier gate controller, **as directed**.
 - c. Illumination: Traffic signal lamps and colored **OR** Neon tube and clear, **as directed**, fiberglass sign face.
 - d. Mounting: Top of barrier gate cabinet **OR** 42-inch- (1067-mm-) high pedestal, **as directed**.
- J. Parking Facility Management Software
1. General: Manufacturer's standard software that is compatible with security access control system and that provides automatic facility monitoring, supervision, and remote control of parking control equipment from one or more locations.
- a. System Performance: Capable of the following:
 - 1) Collect data for revenue and activity reporting.
 - 2) Collect data for access and space control.
 - 3) Track tickets.
 - 4) Program parking control equipment.
- K. Access Control Units
1. General: Provide access control unit that activates barrier gates.
- a. Unit Housing: Fabricate from welded cold-rolled steel or aluminum sheet **OR** plastic, **as directed**, with weatherproof front access panel equipped with flush-mounted lock and two keys. Provide face-lighted unit fully visible at night.
 - 1) Steel Finish: Manufacturer's standard baked-enamel coating system.
2. Card Reader Controlled Unit: Functions only when authorized card is presented.
- a. System: Magnetically coded, single-code system activated by coded card **OR** Programmable, multiple-code capability permitting validating or voiding of individual cards, **as directed**.
 - 1) Permit four different access time periods.



- b. Reader: Swipe type for magnetic-stripe **OR** barcode **OR** Wiegand, **as directed**, cards.
OR
Reader: Insertion type for magnetic-stripe **OR** barcode **OR** Wiegand, **as directed**, cards.
OR
Reader: Proximity type for proximity cards.
 - c. Operation: Standalone **OR** Online communication to remote parking control system computer **OR** Online communication to remote security access control system computer, **as directed**.
 - d. Features: Timed antipassback **OR** Limited-time usage **OR** Capable of monitoring and auditing barrier gate activity **OR** LCD display **OR** Programmable by PDA (personal digital assistant) by infrared interface, **as directed**.
 - e. Mounting: With pedestal **OR** Wall **OR** In enclosed cabinet **OR** As indicated on Drawings, **as directed**.
 - f. Cards: Provide number as directed by the Owner..
 - 1) Imprint cards: as directed by the Owner.
3. Digital Keypad Controlled Unit: Functions only when authorized code is entered on keyed **OR** keyless-membrane, **as directed**, keypad.
- a. System: Multiple-code capability of not less than five **OR** 100 **OR** 500, **as directed**, possible individual codes.
OR
System: Programmable, multiple-code capability permitting validating or voiding of not less than 100 **OR** 2500 **OR** 10,000, **as directed**, possible individual codes, consisting of one to six, **as directed**, digits, and permitting four different access time periods, **as directed**.
 - b. Operation: Standalone **OR** Online communication to remote parking control system computer **OR** Online communication to remote security access control system computer, **as directed**.
 - c. Features: Timed antipassback **OR** Limited-time usage **OR** Capable of monitoring and auditing barrier gate activity, **as directed**.
 - d. Mounting: With pedestal **OR** Wall **OR** As indicated on Drawings, **as directed**.
4. Radio-Controlled System: Digital access control system consisting of code-compatible universal coaxial receiver, one per barrier gate, **OR**, where indicated on Drawings, **as directed**, remote antenna with coaxial cable and mounting brackets, and one permanently mounted **OR** four portable, **as directed**, transmitter(s) per receiver designed to operate barrier gates. Provide programmable transmitter with multiple-code capability permitting validating or voiding of not less than 1000 **OR** 10,000, **as directed**, codes per channel configured for the following functions:
- a. Transmitters: Single-button operated, with open **OR** open and close, **as directed**, functions.
OR
Transmitters: Triple-button operated, with open, close, and stop functions.
 - 1) Provide transmitters featuring two **OR** three **OR** four, **as directed**, independent channel settings controlling separate receivers for operating more than one barrier gate from each transmitter.
- L. Aluminum Finishes
- 1. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
- M. Steel Finishes
- 1. Galvanizing: Hot-dip galvanize items as indicated to comply with the following:
 - a. ASTM A 123/A 123M for iron and steel parking control equipment.
 - b. ASTM A 153/A 153M and ASTM F 2329 for iron and steel hardware for parking control equipment.



2. Galvanized-Steel and Steel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - a. Color and Gloss: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.

N. Stainless-Steel Finishes

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

1.3 EXECUTION

A. Preparation

1. Excavation for Traffic Controllers: Saw cut existing pavement for recessed traffic controllers and hand-excavate recesses to dimensions and depths and at locations as required by traffic controller manufacturer's written instructions and as indicated on Drawings.

B. Installation

1. General: Install parking control equipment as required for a complete and integrated installation.
 - a. Rough-in electrical connections according to requirements specified in Division 22..
2. Automatic Barrier Gates: Anchor cabinets to concrete bases with anchor bolts or expansion anchors and mount barrier gate arms.
 - a. Install barrier gates according to UL 325.
3. Vehicle Loop Detectors: Cut grooves in pavement and bury **OR** Bury, **as directed**, and seal wire loop at locations indicated on Drawings according to manufacturer's written instructions. Connect to parking control equipment operated by detector.
4. Traffic Controllers: Anchor controllers to recessed concrete bases **OR** driveway surfaces, **as directed**, with anchor bolts or expansion anchors.
5. Entry Terminal Ticket Dispensers, Pay Stations and Exit Terminals: Attach cabinets to concrete bases with anchor bolts or expansion anchors.
 - a. Connect equipment to remote computer.
 - b. Load ticket dispenser with supply of tickets.
6. Fee Computers: Install computers at locations indicated, including connecting to peripheral equipment and remote computers, **as directed**.
7. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
8. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".

C. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
3. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
4. Tests and Inspections:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.



-
- b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 5. Parking control equipment will be considered defective if it does not pass tests and inspections.
 6. Prepare test and inspection reports.
- D. Adjusting
1. Adjust parking control equipment to function smoothly and lubricate as recommended by manufacturer.
 2. Confirm that locks engage accurately and securely without forcing or binding.
 3. After completing installation of exposed, factory-finished parking control equipment, inspect exposed finishes and repair damaged finishes.
- E. Protection
1. Remove barrier gate arms during the construction period to prevent damage, and install them immediately before Final Completion.

END OF SECTION 13 34 23 16



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**SECTION 13 34 23 16a - PREFABRICATED CONTROL BOOTHS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for prefabricated control booths. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes prefabricated steel and aluminum control booths.

C. Definition

1. ADA-ABA Accessibility Guidelines: U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines."

D. Performance Requirements

1. Structural Performance: Control booths shall withstand the effects of gravity loads and the loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
3. Samples: For control booths with factory-applied color finishes.
4. Delegated-Design Submittal: For control booths indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Welding certificates.
6. Maintenance data.
7. Warranty: Sample of special warranty.

F. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.3, "Structural Welding Code - Sheet Steel."
2. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Safety Glazing Products: Category II materials complying with testing requirements in 16 CFR 1201.
5. Preinstallation Conference: Conduct conference at Project site.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair finish or replace wall panels that fail in materials or workmanship within five years from date of Final Completion.



1.2 PRODUCTS

A. Materials

1. Aluminum: Alloy and temper recommended by aluminum producer and manufacturer for type of use and finish indicated, and as follows:
 - a. Sheet: ASTM B 209 (ASTM B 209M).
 - b. Extruded Shapes: ASTM B 221 (ASTM B 221M).
 - c. Rolled Tread Plate: ASTM B 632/B 632M, Alloy 6061-T4 or Alloy 6061-T6.
2. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, commercial quality, G90 (Z275) coating designation; mill phosphatized.
3. Galvanized, Rolled Steel Tread Plate: ASTM A 786/A 786M, rolled from steel plate complying with ASTM A 572/A 572M, Grade 55 (380); hot-dip galvanized according to ASTM A 123/A 123M.
4. Steel Structural Tubing: ASTM A 500, Grade B.
5. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
6. Steel Mechanical Tubing: ASTM A 513, welded steel mechanical tubing.
7. Zinc-Coated (Galvanized) Steel: Hot-dip galvanized according to ASTM A 123/A 123M.
8. Stainless-Steel Sheet: ASTM A 666, Type 304.
9. Plastic Laminate: NEMA LD 3, HGS or HGL grade.
10. Plywood: DOC PS 1, Exterior grade.
11. Particleboard: ANSI A208.1, Grade M-2.
12. Clear Float Glass: ASTM C 1036, Type I, Class 1, Quality q3.
13. Clear Tempered Float Glass: ASTM C 1048, Kind FT, Condition A, Type I, Class 1, and Quality q3.
14. Insulating Glass: Units complying with ASTM E 774 for Class CBA and consisting of two lites of 2.5-mm-thick clear float glass and dehydrated air space, with a total overall unit thickness of 7/16 inch (11 mm) and with manufacturer's standard dual seal.
15. Ballistics-Resistant Glazing: Comply with requirements specified in Division 08 Section "Security Glazing".
16. Anchorages: Anchor bolts; hot-dip galvanized according to ASTM A 153/A 153M or ASTM F 2329 **OR** stainless steel, **as directed**.

B. Prefabricated Control Booths, General

1. General: Provide a complete, integrated set of mutually dependent components that form a completely assembled, prefabricated control booth, ready for installation on Project site.
 - a. Building Style: Standard square corners **OR** Radius corners **OR** Round corners **OR** Butt-glazed corners **OR** Wraparound type, with single rounded building end **OR** Wraparound type, with both building ends rounded **OR** As indicated on Drawings, **as directed**.
 - b. Doors: Sliding door on one side **OR** Sliding doors on both sides **OR** Swinging door on back **OR** As indicated on Drawings, **as directed**.
2. Windows: Extruded-aluminum sash frames glazed with 6-mm-thick, clear tempered glass **OR** clear insulating glass **OR** ballistics-resistant glazing, UL 752 Level **as directed**.
 - a. Frame Finish: Mill **OR** Clear anodic, **as directed**.
 - b. Provide insect screens for each operable window.
 - c. Provide galvanized-steel security screens for each window.
 - d. Corner Shape: Square **OR** Round, **as directed**.
3. Horizontal Sliding Windows: Extruded-aluminum sash frames glazed with 3-mm-thick, clear tempered float glass. Equip windows with cam locks, weather stripping, and stainless-steel **OR** nylon, **as directed**, ball-bearing rollers.
 - a. Frame Finish: Mill **OR** Clear anodic, **as directed**.
 - b. Provide insect screens for each operable window.
 - c. Corner Shape: Square **OR** Round, **as directed**.
4. Work Counters: Full width of control booth, reinforced; with 16-inch- (406-mm-) wide storage **OR** cash, **as directed**, drawer below each counter, and an access opening for electrical cords at each rear corner of counter.



- a. Material: 0.078-inch- (1.98-mm-) thick, stainless-steel sheet **OR** 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet **OR** 1/2-inch- (13-mm-) thick particleboard with plastic-laminate finish, **as directed**.
 - b. Depth: 22 inches (559 mm) **OR** 20 inches (508 mm) **OR** 18 inches (457 mm), **as directed**.
 5. Electrical Power Service: 125-A, 120/240-V ac, single-phase, three-wire load center, with no fewer than four open circuits **OR** service with 8-16 circuit-breaker panel, **as directed**; located under one end of work counter. Run copper wiring in 1/2-inch (13-mm) EMT conduit.
 - a. Provide one 120-V ground-fault circuit interrupter (GFCI) power receptacle(s).
 6. Lighting Fixtures: One **OR** Two, **as directed**, ceiling-mounted fluorescent lighting fixture(s), 48 inches (1219 mm) long, with acrylic lens and two 40-W lamps in each fixture. Provide single-pole switch mounted adjacent to door to control lighting fixture.
 7. Heating Unit: Wall-mounted **OR** Roof-mounted, **as directed**, thermostatically controlled, 110-V, 1500-W electric heater with fan-forced operation and with capacity of not less than 5000 Btu/h (1465 W). Enclose in enameled-steel cabinet and mount under work counter.
 8. Cooling Unit: Wall-mounted **OR** Roof-mounted, **as directed**, thermostatically controlled air conditioner with cooling capacity of not less than 13,500 Btu/h (3956 W). Enclose in enameled-steel cabinet.
 9. Accessories: Provide the following for each control booth:
 - a. Through-wall transaction drawers and speaking apertures complying with requirements specified in Division 08 Section "Security Windows".
 - b. Antifatigue mats.
 - c. Exterior stainless-steel counter.
 - d. Floor-mounted **OR** Wall-mounted, **as directed**, safe.
 - e. Signage: **<Insert requirements>**.
 - f. Ventilation fan.
 - g. Intercom.
 - h. Traffic control lights.
- C. Prefabricated Steel Control Booths
1. Structural Framework: Fabricated from 2-by-2-by-0.075-inch (50-by-50-by-1.90-mm) steel structural or mechanical tubing. Connect framework by welding.
 2. Base/Floor Assembly: 4-inch- (102-mm-) **OR** 3-inch- (76-mm-), **as directed**, high assembly consisting of perimeter frame welded to structural framework of booth. Fabricate frame from 2-by-4-inch (51-by-102-mm) galvanized-steel structural tubing; 0.108-inch (2.74-mm) nominal-thickness, C-shaped, galvanized-steel sheet channels; or galvanized structural-steel angles. Include anchor clips fabricated from 1/4-inch- (6-mm-) thick galvanized-steel plate, predrilled and welded to exterior of integral floor frame.
 - a. Finished Floor: 0.108-inch (2.74-mm) nominal-thickness, galvanized, rolled steel tread plate.
 - b. Subfloor and Finished Floor: Assembly consisting of 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet underside with rigid insulation core; covered by 0.125-inch- (3.18-mm-) thick, aluminum rolled tread plate; with overall assembly thickness of 2 inches (51 mm).

OR

Subfloor and Finished Floor: Assembly consisting of one **OR** two, **as directed**, layer(s) of 3/4-inch- (19-mm-) thick plywood or oriented strand board with 0.125-inch- (3.18-mm-) thick, aluminum rolled tread plate **OR** vinyl composition flooring **OR** carpeting, **as directed**.

OR

Base/Floor Assembly: No perimeter frame, with finished floor fabricated from 0.108-inch (2.74-mm) nominal-thickness, galvanized, rolled steel tread plate.

OR

Base/Floor Assembly: No perimeter frame, with surface of supporting concrete base as finished floor.
 3. Wall Panel Assembly: Assembly consisting of exterior face panel fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet; and interior face panel fabricated from 0.064-inch (1.63-mm) **OR** 0.052-inch (1.32-mm), **as directed**, nominal-thickness, galvanized-



steel sheet; with 2-inch- (51-mm-) **OR** 3-inch- (76-mm-), **as directed**, thick, rigid fiberglass or polystyrene board insulation in cavity between exterior and interior face panels.

- a. Thermal Resistance Value (R-Value): R-7.
4. Flat Roof/Ceiling Assembly: Consisting of exterior roof panels, interior ceiling panels, and insulation between exterior and interior panels; sloped to drain at booth perimeter.
 - a. Exterior Roof Panel: Fabricated from 0.079-inch (2.01-mm) **OR** 0.064-inch (1.63-mm), **as directed**, nominal-thickness, galvanized-steel sheet; with painted finish **OR** EPDM membrane, **as directed**, continuously welded seams, and full-perimeter gutter.
 - b. Interior Ceiling Panel: Fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet; with fiberglass insulation in cavity between ceiling and roof.
 - 1) Thermal Resistance Value (R-Value): R-17.
 - c. Insulated Exterior/Interior Panel: Fabricated from 0.028-inch (0.71-mm) nominal-thickness, galvanized-steel **OR** 0.032-inch- (0.81-mm-) thick, aluminum, **as directed**, sheet faces and expanded-foam insulation core.
 - 1) Thermal Resistance Value (R-Value): R-17.
 - d. Canopy Fascia: Fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet, of manufacturer's standard design **OR** custom design indicated on Drawings, **as directed**.
 - 1) Height: 6 inches (152 mm) **OR** 8 inches (203 mm), **as directed**.
 - 2) Overhang: 3 inches (76 mm) beyond **OR** Flush with, **as directed**, face of walls below.
 - e. Downspouts: Integral, extending 3 inches (76 mm) beyond booth walls.
 - f. Roof scuppers.
 - g. Rooftop finial.
5. Sliding Door: Top suspended from aluminum track with ball-bearing rollers; 1-3/4 inches (44 mm) thick; tubular-frame design fabricated from clear-anodized aluminum **OR** galvanized steel, **as directed**; with top half of door glazed. Equip door with deadlock, lock support, guide hardware, and full weather stripping.
 - a. Glazing: Fixed **OR** Horizontal sliding, **as directed**, unit with 6-mm-thick, clear tempered float glass.
 - b. Deadlock: Mortised, laminated-hook bolt type with removable cylinder capable of being master keyed.
6. Swinging Door: 1-3/4 inches (44 mm) thick; tubular-frame design fabricated from clear-anodized aluminum **OR** galvanized steel, **as directed**; with top half of door glazed. Equip door with deadlock, three butt hinges, closer, and full weather stripping.
 - a. Glazing: Fixed **OR** Horizontal sliding, **as directed**, unit with 6-mm-thick, clear tempered float glass.
 - b. Deadlock: Mortised, with lever handle and removable cylinder capable of being master keyed.
7. Finish: Finish exposed metal surfaces, including structural framework, walls, canopy, and ceiling with rust-inhibitive primer and one finish coat of industrial air-dry acrylic **OR** polyurethane, **as directed**, enamel.
 - a. Color: As selected from manufacturer's full range.

D. Prefabricated Aluminum Control Booths

1. Structural Framework: Fabricated from 2-by-2-by-0.125-inch (51-by-51-by-3.18-mm) aluminum tubing, channel, angle, or tee extrusions; with clear **OR** color, **as directed**, anodic finish. Connect framework with exposed, **as directed**, mechanical fasteners.
2. Base/Floor Assembly: 4-inch- (102-mm-) high assembly consisting of perimeter frame welded to structural framework of booth. Fabricate frame from 2-by-4-by-0.125-inch (51-by-102-by-3.18-mm) aluminum tubing or aluminum angles. Include anchor clips fabricated from 1/4-inch- (6-mm-) thick aluminum, predrilled and welded to exterior of integral floor frame.
 - a. Subfloor and Finished Floor: Assembly consisting of 0.032-inch- (0.81-mm-) thick, aluminum sheet underside, plywood and rigid insulation core; covered by 0.125-inch-



(3.18-mm-) thick, aluminum rolled tread plate; with overall assembly thickness of 2 inches (51 mm).

OR

Subfloor and Finished Floor: Assembly consisting of one **OR** two, **as directed**, layer(s) of 3/4-inch- (19-mm-) thick plywood or oriented strand board with 0.125-inch- (3.18-mm-) thick, aluminum rolled tread plate **OR** vinyl composition flooring **OR** carpeting, **as directed**.

OR

Base/Floor Assembly: No perimeter frame, with surface of supporting concrete base as finished floor.

3. Wall Panel Assembly: Assembly consisting of exterior face panel fabricated from 0.032-inch- (0.81-mm-) **OR** 0.063-inch- (1.60-mm-), **as directed**, thick aluminum sheet, and interior face panel fabricated from 0.032-inch- (0.81-mm-) **OR** 0.050-inch- (1.27-mm-), **as directed**, thick aluminum sheet; with 2-inch- (51-mm-) thick, polystyrene or polyisocyanurate board insulation in cavity between exterior and interior face panels.
 - a. Thermal Resistance Value (R-Value): R-7.
4. Flat Roof/Ceiling Assembly: Consisting of exterior roof panels, interior ceiling panels, and insulation between exterior and interior panels; sloped to drain at booth perimeter.
 - a. Exterior Roof Panel: Fabricated from 0.032-inch- (0.81-mm-) thick aluminum sheet with protective plastic sheet finish and full-perimeter gutter.
 - b. Interior Ceiling Panel: Fabricated from 0.125-inch- (3.18-mm-) thick hardboard; with polyisocyanurate board insulation in cavity between ceiling and roof.
 - 1) Thermal Resistance Value (R-Value): R-19.
 - c. Insulated Exterior/Interior Panel: Fabricated from 0.032-inch- (0.81-mm-) thick, aluminum **OR** 0.021-inch (0.53-mm) nominal-thickness, galvanized-steel, **as directed**, sheet faces and expanded-foam insulation core.
 - 1) Thermal Resistance Value (R-Value): R-19.
 - d. Canopy Fascia: Fabricated from 0.063-inch- (1.60-mm-) thick aluminum sheet, of manufacturer's standard design **OR** custom design indicated on Drawings, **as directed**.
 - 1) Height: 6 inches (152 mm) **OR** 8 inches (203 mm), **as directed**.
 - 2) Overhang: 3 inches (76 mm) beyond **OR** Flush with, **as directed**, face of walls below.
 - e. Downspouts: Integral, extending 3 inches (76 mm) beyond booth walls.
 - f. Roof scuppers.
 - g. Rooftop finial.
5. Sliding Door: Top suspended from aluminum track with ball-bearing rollers; 1-3/4 inches (44 mm) thick; tubular-frame design fabricated from aluminum matching exterior and interior wall panels; with top half of door glazed and with extruded-aluminum door frame. Equip door with deadlock, lock support, guide hardware, and full weather stripping.
 - a. Glazing: Fixed **OR** Horizontal sliding, **as directed**, unit with 6-mm-thick, clear tempered float glass.
 - b. Deadlock: Mortised, laminated-hook bolt type with removable cylinder capable of being master keyed.
6. Swinging Door: 1-3/4 inches (44 mm) thick; tubular-frame design fabricated from aluminum matching exterior and interior wall panels; with top half of door glazed and with extruded-aluminum door frame. Equip door with deadlock, three butt hinges, closer, and full weather stripping.
 - a. Glazing: Fixed **OR** Horizontal sliding, **as directed**, unit with 6-mm-thick, clear tempered float glass.
 - b. Deadlock: Mortised, with lever handle and removable cylinder capable of being master keyed.
7. Finish: Finish exposed metal surfaces, including structural framework, walls, canopy, and ceiling with clear anodizing **OR** color anodizing **OR** baked enamel or powder coat, **as directed**.
 - a. Color: As selected from manufacturer's full range.

E. Fabrication

1. Fabricate control booths completely in factory.



2. Preglaze windows and doors at factory.
3. Prewire control booths at factory, ready for connection to service at Project site.
4. Fabricate control booths with forklift pockets in base of booth **OR** removable lifting eye centered in roof, **as directed**.
5. Accessible Control Booths: Where indicated to be accessible, fabricate control booths as follows:
 - a. Provide service windows located no higher than 34 inches (865 mm) above exterior grade.
 - b. Provide door opening with minimum 32-inch (813-mm) clear width.
 - c. Provide minimum 60-inch (1525-mm) clear turning spacing within the booth.
 - d. Provide minimum 27-inch (685-mm) clearance beneath interior work surfaces. Locate work surfaces 28 inches (710 mm) minimum and 34 inches (865 mm) maximum above the floor.
 - e. Locate controls and operable parts no lower than 15 inches (381 mm) and no higher than 48 inches (1219 mm) above the floor where reach is unobstructed. Where side reach is obstructed, locate controls and operable parts no lower than 15 inches (381 mm) and no higher than 46 inches (1219 mm) above the floor.

F. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

G. Finishes

1. Steel and Galvanized-Steel Factory Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - a. Color and Gloss: As selected from manufacturer's full range.

H. Aluminum Finishes

1. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
2. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - a. Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from full range of industry colors and color densities, **as directed**.
3. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - a. Color and Gloss: As selected from manufacturer's full range.

1.3 EXECUTION

A. Installation

1. Install control booths according to manufacturer's written instructions.
2. Accessible Control Booths: Install with interior floor surface at same elevation as adjacent paved surfaces.
3. Set control booths plumb and aligned. Level baseplates true to plane with full bearing on concrete bases.
4. Fasten control booths securely to cast-in anchor bolts **OR** concrete bases with expansion anchors, **as directed**.
5. Connect electrical power service to power distribution system according to requirements specified in Division 22.



B. Adjusting

1. Adjust doors, operable windows, and hardware to operate smoothly, easily, properly, and without binding. Confirm that locks engage accurately and securely without forcing or binding.
2. Lubricate hardware and other moving parts.
3. After completing installation, inspect exposed finishes and repair damaged finishes.

END OF SECTION 13 34 23 16a



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Task	Specification	Specification Description
13 34 23 31	13 34 19 00	Metal Building Systems



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SECTION 13 42 63 16 - SECURITY CEILING SYSTEMS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of material for security ceiling systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Downward-locking-panel security ceiling systems.
 - b. Security-plank security ceiling systems.

C. Performance Requirements

1. General Performance: Security ceiling systems shall withstand normal thermal movement and structural loads without failure, including permanent deformation of security ceiling system components including pans and suspension system; noise or metal fatigue caused by vibration, deflection, and displacement of security ceiling units; and permanent damage to fasteners and anchors.
2. Acoustical Performance: Provide security ceiling systems with acoustical ratings indicated, as determined according to ASTM E 1264 and the following:
 - a. Noise Reduction Coefficient: ASTM C 423 and ASTM E 795 in Type E-400 mounting.
 - b. Ceiling Attenuation Class: ASTM E 1414.
3. Structural Performance: Security ceiling systems shall withstand the effects of gravity loads and loads and stresses within limits and under conditions indicated:

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Data for Credit MR 4.1 and MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - 1) Include statement indicating costs for each product having recycled content.
 - b. Product Data for Credit EQ 4.1: For sealants, including printed statement of VOC content.
3. Coordination Drawings: Reflected ceiling plans.
4. Welding certificates.
5. Product test reports.
6. Research/evaluation reports.
7. Field quality-control reports documenting inspections of installed products.
8. Field quality-control certification signed by Contractor and Detention Specialist.

E. Quality Assurance

1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
2. Source Limitations: Obtain each security ceiling system from single source from single manufacturer.
3. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - c. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - d. AWS D1.6, "Structural Welding Code - Stainless Steel."
4. Seismic Standard: Provide ceilings designed and installed to withstand the effects of earthquake motions according to the following:



- a. Standard for Ceiling Suspension Systems Requiring Seismic Restraint: Comply with ASTM E 580.
 - b. CISCA's Recommendations for Acoustical Ceilings: Comply with CISCA's "Recommendations for Direct-Hung Acoustical Tile and Lay-in Panel Ceilings - Seismic Zones 0-2."
 - c. CISCA's Guidelines for Systems Requiring Seismic Restraint: Comply with CISCA's "Guidelines for Seismic Restraint of Direct-Hung Suspended Ceiling Assemblies - Seismic Zones 3 & 4."
 - d. IBC Standard for Metal Suspension Systems for Acoustical Tile and for Lay-in Panel Ceilings.
 - e. SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."
5. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Deliver acoustical metal panels, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
2. Handle acoustical metal panels, suspension system components, and accessories carefully to avoid damaging units and finishes in any way.

1.2 PRODUCTS

A. Materials

1. Recycled Content: Provide products made from steel with average recycled content such that postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Steel Sheet: Uncoated or electrolytic zinc-coated, ASTM A 591/A 591M with cold-rolled steel sheet substrate complying with ASTM A 1008/A 1008M, Commercial Steel (CS), exposed.
3. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, CS (Commercial Steel), Type B; with G60 (Z180) zinc (galvanized) or A60 (ZF180) zinc-iron-alloy (galvannealed) coating designation.
4. Steel Tubing: ASTM A 513, Type B.
5. Stainless-Steel Sheet: ASTM A 666, Type 302 or 304.
6. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, as standard with manufacturer.
7. Concealed Bolts: ASTM A 307, Grade A, unless otherwise indicated.
8. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
9. Attachment Devices: Size for 5 times the design load indicated in ASTM C 635, Table 1, Direct Hung, unless otherwise indicated.
 - a. Cast-in-Place and Postinstalled Expansion Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to 5 times the load imposed by security ceiling construction, as determined by testing per ASTM E 488, conducted by a qualified testing agency.
 - 1) Type: Cast-in-place **OR** Postinstalled expansion **OR** Chemical, **as directed**, anchors.
 - 2) Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC service condition (mild).
 - 3) Corrosion Protection: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2 (ASTM F 738M and ASTM F 836M, Alloy Group 1 or 4) for bolts and nuts; ASTM A 666 or ASTM A 276, Type 304 or 316, for anchors.



- 4) Corrosion Protection: Components fabricated from nickel-copper-alloy rods complying with ASTM B 164 for UNS No. N04400 alloy.
 - b. Powder-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to 10 times the load imposed by security ceiling construction, as determined by testing per ASTM E 1190, conducted by a qualified testing and inspecting agency.
- B. Downward-Locking-Panel Security Ceiling System
1. Provide a complete, integrated system, including security ceiling panels, exposed suspension system, perimeter supports, and accessories.
 2. Panels: Fabricated from a single sheet of metal, with formed upturned edges on all four sides designed to continuously engage with and lock under rectangular bulb of suspension system.
 - a. Steel Panels: Cold-rolled **OR** Electrolytic zinc-coated **OR** Metallic-coated, **as directed**, steel with minimum uncoated sheet thickness of 0.043 inch (1.09 mm) **OR** 0.033 inch (0.84 mm) **OR** 0.021 inch (0.53 mm), **as directed**.
 - 1) Finish: Factory-applied, baked enamel **OR** powder coating, **as directed**.
 - b. Aluminum Panels: Nominal sheet thickness of 0.040 inch (1.0 mm).
 - 1) Finish: Factory-applied, baked enamel **OR** powder coating, **as directed**.
 - c. Stainless-Steel Panels: Nominal sheet thickness of 0.050 inch (1.27 mm) **OR** 0.025 inch (0.65 mm), **as directed**.
 - 1) Finish: No. 2b **OR** 4, **as directed**.
 - d. Panel Size: 12 by 24 inches (305 by 610 mm) **OR** 12 by 48 inches (305 by 1220 mm) **OR** 24 by 24 inches (610 by 610 mm) **OR** 24 by 48 inches (610 by 1220 mm), **as directed**.
 - e. Perforation Pattern: Perforated **OR** Unperforated, **as directed**.
 - f. Noise Reduction Coefficient (NRC): NRC 0.70 **OR** NRC 0.80 **OR** NRC 0.85 **OR** NRC 0.90 **OR** NRC 0.95 **OR** NRC 1.00, **as directed**.
 3. Sound-Absorptive Pads: Provide sound-absorptive pads for placement over ceiling panels.
 - a. Spacer Grids: Metallic-coated-steel **OR** Aluminum, **as directed**, grid units that provide an air cushion between security ceiling panels and sound-absorptive pads and that act to improve sound absorption.
 - b. Support Clips: Metal clips designed to hold sound-absorptive pads above bottom face sheet.
 4. Backer Plates: Unperforated units formed from metallic-coated steel **OR** aluminum, **as directed**, sheet that reduces travel of sound through panel and that makes panel assembly comply with the following performance:
 - a. Ceiling Attenuation Class (CAC): CAC 40 **OR** CAC 45, **as directed**.
 - b. Sound-Absorptive Pads: Provide secondary sound-absorptive pads, same as specified for primary pads, for placement over backer plates to reduce plenum sound.
 5. Access Panels: Material, perforation pattern, and finish same as security ceiling panels; designed to be accessible by high-security locks with keyways coordinated to building master key system **OR** removal of security fasteners, **as directed**.
 - a. Size: 24 by 24 inches (610 by 610 mm) **OR** 24 by 48 inches (610 by 1220 mm) **OR** As indicated, **as directed**.
 6. Suspension System: ASTM C 635, heavy-duty exposed system consisting of snap-in main runners supported by hangers attached to building structure.
 - a. Provide system complete with main runners, splice plates, connector and alignment clips, hangers, trim, seismic- and wind-load clips and struts, and other suspension components required to support security ceiling units and other security ceiling-supported construction.
 - b. Main Runners and Cross Tees: Formed from metal sheet, 1-1/2 inches (38 mm) high, with 15/16-inch (23.8-mm) flange width and with oversized rectangular bulb for engaging panels.
 - 1) Material: Galvanized steel, G90 (Z275) zinc coating **OR** Electrolytic zinc-coated steel, 40Z (12G) zinc coating **OR** Aluminum **OR** Stainless steel, **as directed**.



- c. Wire Hangers, Braces, and Ties: Zinc-coated carbon-steel wire, ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
 - 1) Size: Select wire diameter so its stress at 3 times the hanger design load (ASTM C 635, Table 1, Direct Hung) will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) diameter wire.
 - d. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.
 - e. Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.
 - f. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide, formed with 0.04-inch- (1.0-mm-) thick, galvanized-steel sheet, G90 (Z275) zinc coating, with bolted connections and 5/16-inch- (8-mm-) diameter bolts.
 - g. Compression Struts: Fabricated from 3/4-inch- (19-mm-) diameter steel tubing, designed to fit over rectangular bulb of suspension system.
 - h. Security Clips: Steel wire, designed to slip over suspension system and through holes in flanges of panel to prevent panel removal.
- 7. Perimeter Supports: Wall-mounted channel moldings and wall angles; fabricated from 0.042-inch- (1.06-mm-) thick galvanized steel **OR** 0.016-inch- (0.4-mm-) thick galvanized steel **OR** 0.040-inch- (1.0-mm-) thick aluminum, **as directed**; finished to match suspension system.
 - 8. Exposed Edge Moldings and Trim: Provide exposed members as indicated or required for edges of security ceiling, fixture trim, beams, fasciae at changes in security ceiling height, and other conditions; of metal and finish matching security ceiling panels.

C. Security-Plank Security Ceiling System

- 1. Single-Configuration Panels: Fabricated from a single sheet of metal, with a self-locking male/female lap joint for joining panels.
 - a. Steel Panels: Cold-rolled **OR** Electrolytic zinc-coated **OR** Metallic-coated, **as directed**, steel with minimum uncoated sheet thickness of 0.097 inch (2.45 mm) **OR** 0.068 inch (1.72 mm) **OR** 0.053 inch (1.34 mm) **OR** 0.043 inch (1.09 mm) **OR** 0.033 inch (0.84 mm), **as directed**.
 - 1) Finish: Factory-applied, baked enamel **OR** powder coating, **as directed**.
 - b. Aluminum Panels: Nominal sheet thickness of 0.125 inch (3.2 mm) **OR** 0.100 inch (2.5 mm) **OR** 0.080 inch (2.0 mm) **OR** 0.063 inch (1.6 mm) **OR** 0.050 inch (1.2 mm) **OR** 0.040 inch (1.0 mm), **as directed**.
 - 1) Finish: Factory-applied, baked enamel **OR** powder coating, **as directed**.
 - c. Stainless-Steel Panels: Nominal sheet thickness of 0.109 inch (2.78 mm) **OR** 0.078 inch (1.98 mm) **OR** 0.062 inch (1.59 mm) **OR** 0.050 inch (1.27 mm), **as directed**.
 - 1) Finish: No. 2b **OR** 4, **as directed**.
 - d. Panel Width: 12 inches (305 mm) **OR** 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**.
 - e. Panel Length: Minimum 8 feet (2.4 m) **OR** Minimum 10 feet (3.0 m) **OR** Minimum 12 feet (3.7 m) **OR** Custom lengths to fit areas indicated, **as directed**.
 - f. Perforation Pattern: Perforated **OR** Unperforated, **as directed**.
 - g. Noise Reduction Coefficient (NRC): NRC 0.70 **OR** NRC 0.80 **OR** NRC 0.85 **OR** NRC 0.90 **OR** NRC 0.95 **OR** NRC 1.00, **as directed**.
- 2. Double-Configuration Panels: Factory-assembled units with cold-rolled steel top face sheet and metallic-coated steel bottom face sheet, welded to a truss core. Fabricate panels with a self-locking male/female lap joint for joining panels.
 - a. Panel Width: 12 inches (305 mm) **OR** 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**, wide by length indicated.
 - b. Overall Panel Thickness: As required by indicated spans **OR** indicated on Drawings, **as directed**.
 - c. Minimum Uncoated Top Face Sheet Thickness: 0.068 inch (1.72 mm) **OR** 0.053 inch (1.34 mm) **OR** 0.043 inch (1.09 mm) **OR** 0.033 inch (0.84 mm), **as directed**.
 - d. Minimum Uncoated Bottom Face Sheet Thickness: 0.068 inch (1.72 mm) **OR** 0.053 inch (1.34 mm) **OR** 0.043 inch (1.09 mm) **OR** 0.033 inch (0.84 mm), **as directed**.



- e. Truss Core: Fabricated from 0.015-inch- (0.38-mm-) thick, cold-rolled steel sheet bent into corrugated shape; welded to top and bottom face sheets at even spacings across and along length of panel.
 - f. Perforation Pattern for Bottom Face Sheet: Perforated **OR** Unperforated, **as directed**.
 - g. Noise Reduction Coefficient (NRC): NRC 0.65 **OR** NRC 0.90 **OR** NRC 1.00, **as directed**.
 - h. Finish of Bottom Face: Factory-applied prime paint.
 3. Sound-Absorptive Pads: Provide sound-absorptive pads for placement over ceiling planks.
 - a. Spacer Grids: Metallic-coated-steel **OR** Aluminum, **as directed**, grid units that provide an air cushion between security ceiling panels and sound-absorptive pads and that act to improve sound absorption.
 - b. Support Clips: Metal clips designed to hold sound-absorptive pads above bottom face sheet.
 4. Backer Plates: Unperforated units formed from metallic-coated steel **OR** aluminum, **as directed**, sheet that reduces travel of sound through panel and that makes panel assembly comply with the following performance:
 - a. Ceiling Attenuation Class (CAC): CAC 40 **OR** CAC 45, **as directed**.
 - b. Sound-Absorptive Pads: Provide secondary sound-absorptive pads, same as specified for primary pads, for placement over backer plates to reduce plenum sound.
 5. Access Panels: Material, perforation pattern, and finish same as security ceiling panels; designed to be held in place by high-security locks with keyways coordinated to building master key system **OR** security fasteners screwed through suspension system, **as directed**.
 - a. Size: 24 by 24 inches (610 by 610 mm) **OR** 24 by 48 inches (610 by 1220 mm) **OR** As indicated, **as directed**.
 6. Closures: Fabricated from minimum 0.053-inch- (1.34-mm-) thick steel sheet, finished to match security ceiling panels. Fasten with security fasteners or by welding.
 7. Suspension System: Heavy-duty exposed system consisting of intermediate carriers supported by secondary support system attached to building structure.
 - a. Intermediate Carriers: Formed from tees with a nominal 4-inch- (102-mm-) wide exposed face or built up from back-to-back angles or channels each with a nominal 2-inch- (51-mm-) wide exposed face; fabricated from 0.068-inch- (1.72-mm-) **OR** 0.053-inch- (1.34-mm-), **as directed**, thick, cold-rolled steel sheet.
 - 1) Finish: Match security ceiling panels.
 - b. Secondary Support System:
 - 1) Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.
 - 2) Angle Hangers: 1-1/2-by-1-1/2-inch (38-by-38-mm) galvanized-steel angles, G90 (Z275) zinc coating, bolted to intermediate carriers and building structure.
 8. Perimeter Supports: Wall-mounted angles, tees, and bearing plates; fabricated from minimum 0.068-inch- (1.72-mm-) thick, cold-rolled steel sheet; finished to match security ceiling panels.
 9. Exposed Edge Moldings and Trim: Provide exposed members as indicated or required for edges of security ceiling, fixture trim, beams, fasciae at changes in security ceiling height, and other conditions, of metal and finish matching security ceiling panels.
- D. Sound-Absorptive Pads
1. Plastic-Sheet-Wrapped, Mineral-Fiber Insulation: Pads consisting of nonrigid, vinyl chloride plastic sheet encapsulating unfaced mineral-fiber insulation.
 - a. Plastic Sheet: Not less than 0.003 inch (0.076 mm) thick; flat black.
 - b. Mineral Fiber: Glass fiber or fiber made from slag (mineral wool), complying with ASTM C 553, Type I, II, or III.
 - 1) Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm) **OR** 4 inches (102 mm) **OR** As required to meet NRC rating, **as directed**.
 - c. Mineral-Fiber Density: 1.0 lb/cu. ft. (16 kg/cu. m) **OR** 1.5 lb/cu. ft. (24 kg/cu. m) **OR** As required to meet NRC rating, **as directed**.
 - d. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1) Flame-Spread Index: 25 or less.



- 2) Smoke-Developed Index: 50 **OR** 450, **as directed**, or less..

E. Sealants

1. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), complying with ASTM C 834 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction, as demonstrated by testing representative assemblies according to ASTM E 90.
2. Acoustical Sealant for Concealed Joints: Manufacturer's standard nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), recommended for sealing interior concealed joints to reduce airborne sound transmission.
3. Security Sealant: Manufacturer's standard, high-modulus, nonsag, two-part, pick-proof, epoxy sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), recommended for sealing nonmoving interior joints in security applications.

F. Security Fasteners

1. Security Fasteners: Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator.
2. Drive-System Type, Head Style, Material, and Protective Coating: Provide as required for assembly, installation, and strength, and as follows:
 - a. Drive-System Types: Pinned Torx-Plus **OR** Pinned Torx, **as directed**.
 - b. Fastener Strength: Grade 8 (Class 10.9).
 - c. Socket Button Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - d. Socket Flat Countersunk Head Fasteners:
 - 1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
 - e. Socket Head Cap Fasteners:
 - 1) Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
 - 2) Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
 - f. Protective Coatings for Heat-Treated Alloy Steel:
 - 1) Zinc and clear trivalent chromium, for exterior applications and interior applications where indicated.
 - 2) Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

G. Fabrication

1. Panels: Form metal panels from sheet metals selected for their surface flatness, smoothness, and freedom from surface blemishes where exposed to view in finished unit. Do not use materials whose exposed surfaces exhibit pitting, seam marks, roller marks, or variations in flatness exceeding those permitted by referenced standards for stretcher-leveled metal sheet.
 - a. Factory fabricate double-configuration security planks and join top and bottom face sheets by welding.

H. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Noticeable variations in the same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.



- I. Aluminum Finishes
 - 1. Color-Coated Finish: Manufacturer's standard powder-coat, **as directed**, baked paint complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.
- J. Steel Sheet Finishes
 - 1. Color-Coated Finish: Manufacturer's standard powder-coat, **as directed**, baked paint complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.
- K. Stainless-Steel Finishes
 - 1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 - 2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

1.3 EXECUTION

- A. Preparation
 - 1. Coordination: Furnish layouts for cast-in-place anchors, clips, and other security ceiling anchors whose installation is specified in other Sections.
 - a. Furnish cast-in-place anchors and similar devices to other trades for installation well in advance of time needed for coordinating other work.
 - 2. Measure each security ceiling area and establish layout of security ceiling panels to balance border widths at opposite edges of each security ceiling. Avoid using less-than-half-width panels at borders and comply with layout shown on reflected ceiling plans and Coordination Drawings.
- B. General Installation
 - 1. Comply with Cisca's "Ceiling Systems Handbook" for installation of security ceiling systems.
 - 2. Install perimeter supports around perimeter of security ceiling area.
 - a. Apply acoustical **OR** security, **as directed**, sealant in a continuous ribbon concealed on back of vertical legs of supports before they are installed.
 - b. Attach supports with anchor bolts or expansion anchors spaced not more than 12 inches (305 mm) o.c. and not more than 3 inches (76 mm) from ends. Miter corners accurately.
 - 1) Level perimeter supports with suspension system to a tolerance of 1/8 inch in 12 feet (3 mm in 3.7 m).
 - c. Do not use exposed fasteners, including pop rivets, on moldings and trim. If exposed fasteners are unavoidable, obtain approval from the Owner for their use and use security fasteners.
 - 3. Install accessories where indicated and as required to comply with performance requirements.
 - a. Sound-Absorptive Pads: For security ceiling panels indicated, provide sound-absorptive pads of width and length to completely fill inside of each security ceiling panel.
 - 1) Install sound-absorptive pads over metal spacer grids **OR** with support clips, **as directed**.
 - b. Backer Plates: Install plates in areas indicated on reflected ceiling plans or in room finish schedules. Lay backer plates directly on security ceiling system in manner indicated and close major openings to form complete coverage in required areas. Lay second sound-absorptive pad on backer plate, **as directed**.
- C. Downward-Locking-Panel Security Ceiling System Installation
 - 1. Comply with ASTM C 636 **OR** IBC Standard, **as directed**, and seismic requirements indicated, per manufacturer's written instructions and Cisca's "Ceiling Systems Handbook."
 - 2. Ceiling Hangers: Suspend from building's structural members and as follows:



- a. Install hangers plumb and free from contact with insulation or other objects within security ceiling plenum that are not part of supporting structure or of security ceiling suspension system.
 - b. Splay hangers only where required to avoid obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 - c. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
 - d. Secure wire hangers to security ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
- OR**
- Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
- e. Do not support security ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
 - f. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
 - g. Do not attach hangers to steel deck tabs.
 - h. Do not attach hangers to steel roof deck. Attach hangers to structural members.
 - i. Space hangers not more than 48 inches (1220 mm) o.c. along each member supported directly from hangers, unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
 - j. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
 - k. Install compression struts extending from main runners to structure above and spaced at 48 inches (1220 mm) o.c.
3. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
 4. Panel Installation: Install panels to continuously engage with and lock under rectangular bulb of suspension system. Attach panels to perimeter supports with security fasteners not more than 3 inches (76 mm) from edges of panel. Fasten through exposed face of supports into panel.
 - a. Align joints in adjacent courses to form uniform, straight joints parallel to room axis in both directions unless otherwise indicated.
 - b. Fit adjoining units to form flush, tight joints. Scribe and cut units for accurate fit at borders and around construction penetrating security ceiling.
 - c. Install directionally patterned panels in directions indicated.
 - d. Scribe and cut security ceiling panels for accurate fit at borders and at interruptions and penetrations by other work through security ceilings. Stiffen edges of cut panels as required to eliminate evidence of buckling or variations in flatness.
 5. Install each access panel within one security ceiling panel and attach with security fasteners **OR** by continuously welding access panel frame to security ceiling panel, **as directed**.

D. Security-Plank Security Ceiling System Installation

1. Install security planks with long edges continuously interlocked. Adjust security planks to final position before permanently fastening. Provide minimum 1-1/2-inch (38-mm) end bearing.
 - a. Attach adjacent security planks to each other with security fasteners spaced not more than 12 inches (305 mm) o.c. and not more than 6 inches (152 mm) from ends.



- b. Continuously weld ends of security planks to perimeter supports. Remove exposed projecting burrs, edges, and rough spots resulting from welding operations by grinding smooth.
OR
Attach ends of security planks to perimeter supports with security fasteners not more than 3 inches (76 mm) from edges of security plank. Fasten through exposed face of supports into security planks.
 - c. Provide intermediate carriers for ends of security planks that are not supported by perimeter supports. To attach security planks to intermediate carriers, use same method as that used for attaching security planks to perimeter supports.
 - 1) Support intermediate carriers from structure above by secondary support system spaced at 48 inches (1220 mm) o.c. and bolted to carriers.
 2. Install each access panels within one security plank and attach with security fasteners **OR** by continuously welding access panel frame to security plank, **as directed**.
 3. Provide steel angle reinforcement on each side of openings that exceed 12 inches (305 mm) in any direction.
- E. Field Quality Control
1. Detention Specialist shall inspect **OR** Inspect, **as directed**, installed products to verify compliance with requirements. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents.
 2. Remove and replace security ceiling systems where inspections indicate that work does not comply with specified requirements.
 3. Perform additional inspections to determine compliance of replaced or additional work. Prepare inspection reports.
 4. Prepare field quality-control certification that states installed products and their installation comply with requirements in the Contract Documents.
 5. Field Quality-Control Testing: Engage a qualified independent testing agency to perform field quality-control testing.
 6. Extent and Testing Frequency: Testing will take place in successive stages in areas described below. Proceed with installation of security ceiling systems only after test results for previously installed hangers comply with requirements.
 - a. Extent of Each Test Area: When installation of security ceiling suspension systems on each floor has reached 20 percent completion but no security panel units have been installed.
 - b. Within each test area, testing agency will select 1 of every 10 powder-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf (890 N) of tension; it will also select 1 of every 2 postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf (1957 N) of tension.
 - c. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those fasteners and anchors not previously tested until 20 consecutively pass and then will resume initial testing frequency.
 7. Fasteners and anchors will be considered defective if they do not pass tests and inspections.
 8. Prepare test and inspection reports.
 9. Additional Testing: Where fasteners and anchors are removed and replaced, additional testing will be performed to determine compliance with specified requirements.
- F. Cleaning
1. Remove and replace work that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage, including dented and bent units.
 2. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as that used for shop painting; comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum dry film thickness of 2 mils (0.05 mm).
 3. Metallic-Coated Steel Surfaces: Clean field welds, bolted connections, and abraded areas and repair zinc or zinc-iron coating to comply with ASTM A 780.



END OF SECTION 13 42 63 16



Task	Specification	Specification Description
13 42 63 16	11 98 12 00a	Detention Enclosures
13 42 63 16	11 98 12 00b	Detention Furniture



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SECTION 13 47 13 13 - CATHODIC PROTECTION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for cathodic protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes passive cathodic protection systems that use magnesium or zinc anodes to protect iron and steel piping and tanks.

C. Performance Requirements

1. Delegated Design: Design, supervise, test, and inspect the installation of cathodic protection systems, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - a. Design cathodic protection for pipelines according to NACE RP0169.
 - b. Design cathodic protection for metal underground storage tanks according to NACE RP0285.
2. Survey site and determine soil or water corrosivity (resistivity), current requirements, potential surveys, stray currents, and water chemistry/corrosivity (pH).
3. Select anodes and accessories relevant to level of protection. Design anodes for an estimated life of 15 **OR** 30, **as directed**, years before replacement.
4. Cathodic protection systems shall provide protective potential that complies with referenced NACE standards. Insulators are required if needed to insulate protected metals from other structures.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For cathodic protection. Include plans, evaluations, sections, details, and attachments to other work.
 - a. Detail locations of cathodic protection equipment, devices, and outlets, with characteristics and cross-references to products.
 - b. Include calculations and details of anode designs.
 - c. Include labeling and identifying scheme for wires, cables, and test boxes.
3. Delegated-Design Submittal: For cathodic protection system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified corrosion engineer responsible for their preparation.
 - a. Conduct site tests necessary for design, including soil resistivity, close-interval potential surveys, testing during construction, interference testing, and training of the Owner's personnel.
 - b. Provide system design calculations, stating the maximum recommended anode current output density, and the rate of gaseous production, if any, at that current density.
4. Coordination Drawings: Plans, drawn to scale, and coordinating connections to piping and tanks.
5. Qualification Data: For qualified professional engineer. Submit evidence of current license, corporate authorization (if applicable) of the engineering business, and NACE certifications.
6. Field quality-control reports.
7. Operation and Maintenance Data: Include the following:
 - a. Basic system operation, outlining the step-by-step procedures required for system startup, operation, adjustment of current flow, and shutdown.
 - b. Instructions for pipe-to-reference cell and tank-to-reference cell potential measurements and frequency of monitoring.



- c. Instructions for dielectric connections, interference and sacrificial-anode bonds; and precautions to ensure safe conditions during repair of pipe, tank or other metallic systems. Instructions shall be neatly bound.
 - d. Locations of all anodes, test stations, and insulating joints.
 - e. Structure-to-reference cell potentials as measured during the tests required by "Field Quality Control" Article.
 - f. Recommendations for maintenance testing, including instructions for pipe-to-reference cell potential measurements and frequency of testing.
 - g. Precautions to ensure safe conditions during repair of pipe system.
8. Warranty: Sample of special warranty.
- E. Quality Assurance
- 1. Corrosion Engineer Qualifications: A qualified professional engineer who has education and experience in cathodic protection of buried and submerged metal structures and has NACE accreditation or certification as a Corrosion Specialist or Cathodic Protection Specialist.
- F. Delivery, Storage, And Handling
- 1. Protect anodes from exposure to rain and direct sunlight.
- G. Warranty
- 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace permanent reference electrodes that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period: 15 **OR** 30, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

- A. Magnesium Anodes, Type II
- 1. Comply with ASTM B 843.
 - 2. Chemical composition as percent of weight shall be as follows:
 - a. Aluminum: 0.010 maximum.
 - b. Manganese: 0.50 to 1.3.
 - c. Zinc: 0.05 maximum.
 - d. Silicon: 0.50 maximum.
 - e. Copper: 0.02 maximum.
 - f. Nickel: 0.001 maximum.
 - g. Iron: 0.03 maximum.
 - h. Other Impurities: 0.05 each; 0.3 maximum total.
 - i. Magnesium: Remainder.
 - 3. Anode Core: Galvanized steel with anode wire silver-soldered to the core. Connection shall be recessed and epoxy insulated for 600-V rating. Connection shall be covered with heat-shrinkable tubing, and insulation shall be extended over connection.
 - 4. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.
 - 5. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:
 - a. Hydrated Gypsum: 75 percent.
 - b. Bentonite Clay: 20 percent.
 - c. Anhydrous Sodium Sulfate: 5 percent.



- B. Magnesium/Manganese Alloy Anodes
1. Chemical composition as percent of weight shall be as follows:
 - a. Aluminum: 0.01 maximum.
 - b. Manganese: 0.50 to 1.3.
 - c. Copper: 0.02 maximum.
 - d. Nickel: 0.001 maximum.
 - e. Iron: 0.03 maximum.
 - f. Other Impurities: 0.05 each; 0.3 maximum total.
 - g. Magnesium: Remainder.
 2. Bare Anode Weight: 40 lb (18 kg), not including core, and a nominal length of 60 inches (1520 mm).
 3. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.
 4. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:
 - a. Hydrated Gypsum: 75 percent.
 - b. Bentonite Clay: 20 percent.
 - c. Anhydrous Sodium Sulfate: 5 percent.
- C. Zinc Anodes For Buried Service, Type Z-1
1. Comply with ASTM B 418, Type II.
 2. Chemical composition as percent of weight shall be as follows:
 - a. Aluminum: 0.005 maximum.
 - b. Cadmium: 0.003 maximum.
 - c. Iron: 0.0014 maximum.
 - d. Zinc: Remainder.
 3. Bare Anode Ingot Weight: 30 lb (13.6 kg), 2 inches (50 mm) square and 30 inches (760 mm) long. Packaged weight of anode bag shall be 70 lb (32 kg).
 4. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.
 5. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:
 - a. Hydrated Gypsum: 75 percent.
 - b. Bentonite Clay: 20 percent.
 - c. Anhydrous Sodium Sulfate: 5 percent.
- D. Permanent Reference Electrodes
1. Copper/copper sulfate (Cu/CuSO₄), suitable for direct burial. Electrode shall be guaranteed by supplier for 15 **OR** 30, **as directed**, years' service in the installed environment.
- E. Wire And Cable
1. Anode Header Cable: Single-conductor, Type HMWPE, insulated cable specifically designed for direct-buried dc service in cathodic protection installations.
 - a. Conductor: Stranded, annealed, uncoated copper, not less than No. 8 AWG, complying with ASTM B 3 and ASTM B 8.



- b. Insulation: High-molecular-weight polyethylene, complying with NEMA WC 70/ICEA S-95-658.
 - c. Minimum Average Thickness of Insulation: 110 mils (2.8 mm) for Nos. 8 through 2 AWG, and 125 mils (3.2 mm) for Nos. 1 through 4/0 AWG; rated at 600 V.
 - d. Connectors: Copper-compression type or exothermic welds.
 2. Conductors and Cables: Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
 - a. Bonding Conductors for Joint and Continuity Bonds: Not less than No. 8 AWG, stranded, Type THWN copper conductors.
 - b. Flexible Pipe Coupling Bonds: Flexible copper straps with electrical resistance equal to No. 1/0 AWG stranded copper wire and with five holes for five exothermic welds to pipe.
 - c. Test Wires: No. 12 AWG, Type THWN copper conductors.
 - d. Resistance Wires: No. 16 or No. 22 AWG nickel-chromium wire.
 - e. Cables for Installation in Conduit: Type THWN copper conductors.
- F. Test Stations
1. Plastic Test Stations: Flush-mounted type, manufactured of high-impact-resistant PVC or polycarbonate with watertight conduit connections and cover and removable terminal board having at least five terminals.
 2. Test Station Mounting Enclosures:
 - a. Non-Traffic-Area Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems".
 - b. Traffic-Area Boxes: Comply with requirements in Division 26 Section "Underground Ducts And Raceways For Electrical Systems". Boxes shall have cast-iron covers with a welded bead legend "CP TEST."
- G. Sealing, Potting, And Dielectric Compounds
1. Sealing and Dielectric Insulating Compound: Comply with NACE RP0188. Black, rubber based, soft, permanently pliable, tacky, moldable, and unbacked; 0.125 inch (3 mm) **OR** 0.5 inch (13 mm), **as directed**, thick.
 2. Potting Compound: Comply with NACE RP0188. Cast-epoxy, two-package type; fabricated for this purpose and covered with heat-shrinkable tape.
 3. Pressure-Sensitive, Vinyl-Plastic Electrical Tape: Comply with UL 510.
- H. Exothermic Welding Materials
1. Exothermic Weld Kits: Specifically designed by manufacturer for welding materials and shapes required.
 2. Exothermic Weld Caps: Dome of high-density polyethylene, 10-mil (0.254-mm) minimum thickness, filled with mastic and containing a tunnel portion to separate lead wire from exothermic weld.
- I. Coating Repair Materials
1. Touchup Coating Materials: Comply with requirements in Division 09 Section "High-performance Coatings" for coating systems for touchup of factory-applied coatings.
 2. Adhesive-Applied Coating Materials: Coating materials shall be compatible with factory-applied coating system.
 - a. Nominal thickness of coating materials shall be not less than 8 mils (0.2 mm) **OR** 16 mils (0.4 mm) **OR** 24 mils (0.6 mm) **OR** 40 mils (1.0 mm) **OR** 60 mils (1.5 mm), **as directed**, plus or minus 5 percent.
 - b. Coating materials shall be one of the following supplied by factory-applied coating system manufacturer:
 - 1) Polyvinyl-chloride, pressure-sensitive, adhesive tape.
 - 2) High-density polyethylene/bituminous rubber compound tape.
 - 3) Butyl rubber tape.
 - 4) Coal-tar epoxy.



1.3 EXECUTION

A. General Installation Requirements

1. Comply with ANSI/IEEE C2 and NFPA 70.
2. Make connections to ferrous pipe and metal tanks using exothermic welding.
3. Coat welds with the coating repair material and apply an exothermic weld cap.

B. Magnesium Anode Installation

1. Install magnesium anodes at locations that clear obstructions. Install at least 36 inches (900 mm) and no more than 10 feet (3 m) from pipe or tank to be protected. Install in augered holes with top of anode 24 inches (600 mm) below pipe invert elevation **OR** a minimum of 36 inches (900 mm) below finished grade. In soils that will collapse into augered holes, use casing of galvanized sheet steel.
2. Install anodes in a dry condition after plastic or waterproof protective covering has been completely removed from water-permeable permanent container that houses anode metal. Do not use anode-connecting wire for lowering anode into hole. Backfill annular space around anode with fine earth in 6-inch (150-mm) layers; compact each layer using hand tools. Do not strike anode or connecting wire during backfilling and compacting. After backfilling and compacting to within 6 inches (150 mm) of finished grade, pour approximately 5 gal. (20 L) of water into each filled hole. After water has been absorbed by earth, complete backfilling to finished level.
3. If rock strata are encountered before achieving specified augered hole depth, install anodes horizontally at depth at least as deep as bottom of pipe to be protected.
4. Install anodes spaced as indicated, directly connected **OR** connected through a test station, **as directed**, to the pipeline, allowing slack in connecting wire to compensate for movement during backfill operation.
5. For tank protection, connect groups of anodes to collector cable. Make contact, through a test station, with tank to be protected.
6. Do not use resistance wires to reduce current output of individual or group anodes.

C. Zinc Anode Installation

1. Install zinc anode horizontally in a hole at least 3 inches (76 mm) larger than anode. Install anode under new copper water tubing, including service lines, blowoffs, and air releases. Separate piping and anode by at least 24 inches (600 mm), but not more than 60 inches (1520 mm).
2. Install anode midway between both ends of piping. Install anode wire in piping trench and connect to piping at an accessible location. Install anode wire in PVC conduit where rising out of the ground to the aboveground connection.

D. Installation Of Reference Electrodes

1. Install directly beneath the buried metallic component being protected.

E. Cable And Wire Installation

1. Install conductors, except anode wires, in PVC conduit with waterproof PVC junction boxes. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for conduit and its installation.
2. Anode Wire Installation: Cover trench bottom for the anode wire with 3-inch (76-mm) layer of sand or stone-free earth. Center wire on backfill layer and do not stretch or kink the conductor. Place backfill over wire in layers not exceeding 6 inches (150 mm) deep, and compact each layer. Use clean fill, free from roots, vegetable matter, and refuse. Place cable underground-line warning tape within 18 inches (460 mm) of finished grade, above cable and conduit.
3. Bonding Conductors: Install conductors on metallic pipe and tanks, to and across buried flexible couplings, mechanical joints, and flanged joints except at places where insulating joints are specified. Welded and threaded joints are considered electrically continuous and do not require bonding.
 - a. Install at least two bonds between parts requiring bonding.



- b. Bonding conductors must contain sufficient slack for anticipated movement between structures. Bonding conductors across pipe joints shall have not less than a 4-inch (100-mm) slack for pipe expansion, contraction, and soil stress.
 - c. Connect bonding conductors to pipe, coupling follower rings and coupling middle ring or sleeve. Connect bonding conductors with exothermic welds.
4. For wire splicing, use compression connectors or exothermic welds.

F. Test Stations

1. Install test stations as follows:
 - a. At 1000-foot (300-m) intervals.
 - b. At insulating joints.
 - c. At both ends of casings when casing material is included in the cathodic protection system.
 - d. Where pipe crosses other metal pipes.
 - e. Where pipe connects to existing piping system.
 - f. Where pipe connects to dissimilar metal pipe.
 - g. At each tank component.
2. Install test stations on backfill complying with requirements for trench bottom fill for anode wires unless otherwise indicated.
3. Terminate test conductors on terminal boards and install a spare set of test leads at each testing location.

G. Pipe Joints

1. Insulating Flange Sets: Cover flanges with sealing and dielectric compound.
2. Insulating Unions: Install electrical isolation at each building entrance and at other locations indicated on approved Delegated-Design Drawings. Cover unions with sealing and dielectric compound.

H. Insulating Pipe Sleeves

1. Install insulating sleeves between metallic piping and metal buildings, hangers, supports, and other metal structures. Completely surround the metallic pipe for the full length of the steel contact and effectively prevent contact between the cathodically protected metallic pipe and other metallic structures. Support insulating sleeve to prevent damage to coating and to accommodate relative movement, vibrations, and temperature differentials.

I. Dissimilar Metals

1. Underground Dissimilar Piping: Coat insulating joint and pipe at joints of dissimilar piping material with sealing and dielectric compound for a minimum distance of 10 pipe diameters on both sides of joint.
2. Underground Dissimilar Valves: Coat dissimilar ferrous valves and pipe with sealing and dielectric compound for a minimum distance of 10 pipe diameters on both sides of valve.
3. Aboveground Dissimilar Pipe and Valves: If dissimilar metal pipe joints and valves are not buried and are exposed only to atmosphere, coat connection or valve, including pipe, with sealing and dielectric compound for a minimum distance of three pipe diameters on both sides of junction.

J. Coatings

1. Field Joints: Apply adhesive-applied coating system in a thickness to achieve corrosion protection equal to adjacent factory-applied coating.

K. Identification

1. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
 - a. Identify anode wires and anode header cables with marker tape.
 - b. Identify underground wires and cables with underground-line warning tape.
 - c. Identify text boxes with engraved, laminated acrylic or melamine label, permanently attached to text box.



- L. Field Quality Control
1. Comply with NACE RP0169 and NACE RP0285.
 2. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 3. Tests and Inspections:
 - a. Static Pull Test: Choose, at random, one completed anode of each type for this destructive test. Demonstrate that anode wire connections have enough strength to withstand a minimum tensile load of 300 lb (136 kg). If test fails, replace all anodes and repeat test at another randomly selected anode.
 - b. Insulation Testing: Before anode system is connected to pipe and tank, test insulation at each insulating joint and fitting. Demonstrate that no metallic contact, or short circuit, exists between the two insulated sections of pipe and tank. Replace defective joints or fittings.
 - c. Bonding Tests: Test for electrical continuity across all bonded joints. Repair or add additional bonds until electrical continuity is achieved.
 - d. Baseline Potentials: After backfilling of pipe, tank, and anodes is completed, but before anodes are connected to pipe and tank, measure the static potential of pipe and tank to soil. Record initial measurements.
 - e. Anode Output: Measure electrical current as anodes or groups of anodes are connected to pipe and tank. Use a low-resistance ammeter. Record current, date, time, and location of each measurement.
 - f. Pipe- and- Tank-to-Reference Electrode Potential Measurements: On completion of installation of entire cathodic protection system, make electrode potential measurements according to NACE RP0169, using a copper/copper-sulfate reference electrode and a potentiometer-voltmeter, or a dc voltmeter with an internal resistance (sensitivity) of not less than 100,000 ohms per volt and a full scale of 1 or 2 V. Make measurements at same locations as those used for baseline potentials. Record voltage, date, time, and location of each measurement, using one of the following two methods:
 - 1) 0.85 V Negative Voltage: With cathodic system in operation, measure a negative voltage of at least minus 0.85 V between pipe or tank and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe or tank.
 - 2) 100-mV Polarization Voltage: Determine polarization voltage shift by interrupting protective current and measuring polarization decay. An immediate voltage shift will occur if protective current is interrupted. Use voltage reading, after immediate shift, as base reading from which to measure polarization decay. Measure at least a minimum polarization voltage shift of 100 mV between pipe or tank and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe or tank.
 4. Location of Measurements for Piping: For coated piping or conduit, measure from reference electrode in contact with the earth directly over pipe. Measure at intervals not exceeding 400 feet (120 m). Make additional measurements at each distribution service riser, with reference electrode placed directly over service line.
 5. Location of Measurements for Tanks: For underground tanks, measure from reference electrode located as follows:
 - a. Directly over center of tank.
 - b. At a point directly over tank and midway between each pair of anodes.
 - c. At each end of tank.
 6. Interference Testing: Test interference with cathodic protection from any foreign pipes and tanks in cooperation with the Owner of foreign pipes and tanks. Report results and recommendations.
 7. Stray Current Measurements: Perform at each test station. Mitigate stray currents due to lightning or overhead ac power transmission lines as provided for in NACE standards.
 8. Inspect coatings; comply with NACE RP0188. Repair imperfections of factory-applied coatings as specified in "Coatings" Article.



- a. Use electronic holiday detectors to detect coating imperfections.
- b. All damage to the protective coating during transit and handling shall be repaired before installation.
- c. Repair factory-applied coatings to have equal or better corrosion resistance than the factory-applied coating system. Field-repair material shall be of the type approved by, and shall be applied as recommended by, manufacturer of the coating material.

M. Adjusting

1. Adjust cathodic current using resistors as recommended by corrosion engineer who prepared the Delegated-Design Submittal in Part 1.1.
2. During the first year after Final Completion, test, inspect, and adjust cathodic protection system every three months to ensure its continued compliance with specified requirements.

N. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain cathodic protection system.

END OF SECTION 13 47 13 13



Task	Specification	Specification Description
13 48 63 00	01 22 16 00	No Specification Required
13 49 13 00	08 34 49 13	Radiation Protection
13 49 16 00	08 34 49 13	Radiation Protection
13 49 19 16	08 34 49 13	Radiation Protection



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SECTION 14 01 20 71 - ELECTRIC TRACTION ELEVATORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for electric traction elevators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes electric traction passenger and service elevators.

C. Definitions

1. Definitions in ASME A17.1 apply to work of this Section.
2. Defective Elevator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.
3. Service Elevator: A passenger elevator that is also used to carry freight.

D. Submittals

1. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include product data for the following:
 - a. Car enclosures and hoistway entrances.
 - b. Operation, control, and signal systems.
2. Shop Drawings: Show plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment and signals. Include large-scale layout of car control station and standby power operation control panel, **as directed**. Indicate variations from specified requirements, maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.
3. Samples: For exposed finishes of cars, hoistway doors and frames, and signal equipment; 3-inch- (75-mm-) square Samples of sheet materials; and 4-inch (100-mm) lengths of running trim members.
4. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator system being provided.
5. Qualification Data: For Installer.
6. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.
8. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Installer Qualifications: Elevator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Source Limitations: Obtain elevators, including hydraulic passenger elevators specified in another Division 14 Section, through one source from a single manufacturer.
 - a. Provide major elevator components, including driving machines, controllers, signal fixtures, door operators, car frames, cabs, and entrances, manufactured by a single manufacturer.
3. Regulatory Requirements: Comply with ASME A17.1 and elevator design requirements for earthquake loads in ASCE 7.



- a. Effective peak velocity acceleration (A_v) for Project's location is less than 0.10 (seismic risk zones 0 and 1) **OR** greater than or equal to 0.10, but less than 0.20 (seismic risk zone 2) **OR** greater than or equal to 0.20 (seismic risk zones 3 and 4), **as directed**.
 - b. Provide earthquake equipment required by ASME A17.1.
 - c. Design earthquake spectral response acceleration, short period (Sds) for Project is determined by Project's location and site classification.
 - d. Project's seismic design category is A **OR** B **OR** C **OR** D, **as directed**.
 - e. Elevator importance factor is 1.5 **OR** 1.0, **as directed**.
4. Accessibility Requirements: Comply with Section 4.10 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** 407 in ICC A117.1, **as directed**.
 5. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** IBC Standard 3002.4 **OR** UL 10B, **as directed**.

F. Delivery, Storage, And Handling

1. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's written recommendations to prevent damage, deterioration, or soiling.

G. Coordination

1. Coordinate installation of sleeves, block outs, elevator equipment with integral anchors, and other items that are embedded in concrete or masonry for elevator equipment. Furnish templates, sleeves, elevator equipment with integral anchors, and installation instructions and deliver to Project site in time for installation.
2. Coordinate sequence of elevator installation with other work to avoid delaying the Work.
3. Coordinate locations and dimensions of other work relating to electric traction elevators including pit ladders, sumps, and floor drains in pits; entrance subsills; machine beams, **as directed**; and electrical service, electrical outlets, lights, and switches in pits and machine rooms **OR** hoistways, **as directed**.

H. Warranty

1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective elevator work within specified warranty period.
 - a. Warranty Period: One year from date of Final Completion.

1.2 PRODUCTS

A. Systems And Components

1. General: Provide manufacturer's standard elevator systems. Where components are not otherwise indicated, provide standard components published by manufacturer as included in standard preengineered elevator systems and as required for complete system.
2. Elevator Machines: Provide variable-voltage, variable-frequency, ac-type hoisting machines **OR** At manufacturer's option, provide either variable-voltage, variable-frequency, ac-type or variable-voltage, dc-type hoisting machines, **as directed**. Provide solid-state power converters.
 - a. Provide regenerative **OR** nonregenerative, **as directed**, system.
 - b. Limit total harmonic distortion of regenerated power to 5 percent per IEEE 519.
 - c. Provide means for absorbing regenerated power when elevator system is operating on standby power.
 - d. Provide line filters or chokes to prevent electrical peaks or spikes from feeding back into building power system.



3. Fluid for Oil Buffers: If oil buffers are used, use only fire-resistant hydraulic fluid containing antioxidant, anticorrosive, antifoaming, and metal-passivating additives.
 4. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Section.
 5. Machine Beams: Provide framing to support elevator hoisting machine and deflector sheaves from the building structure. Comply with Division 5 Section "Metal Fabrications" for materials and fabrication.
 6. Car Frame and Platform: Welded steel units.
 7. Guides: Provide roller guides **OR** polymer-coated, nonlubricated sliding guides, **as directed**, at top and bottom of car and counterweight frames.
- B. Operation Systems
1. General: Provide manufacturer's standard microprocessor operation system for each elevator **OR** for each group of elevators, **as directed**, as required to provide type of operation system indicated.
 2. Group Automatic Operation with Demand-Based Dispatching: Provide reprogrammable, **as directed**, group automatic system that assigns cars to hall calls based on a dispatching program designed to minimize passenger waiting time. System automatically adjusts to changes in demand for different traffic conditions including heavy incoming, heavy two-way, heavy outgoing, and light off-hours as variations of normal two-way traffic.
 3. Destination-Based Group Automatic Operation: Provide reprogrammable group automatic system that assigns elevators leaving the main lobby in the up direction to a selected group of floors and directs passengers to an elevator serving their destination floor. System dispatches cars in a regulated sequence for optimum system efficiency; dispatch is based on origin and destination of calls. System automatically adjusts to changes in demand for different traffic conditions including heavy incoming, heavy two-way, heavy outgoing, and light off-hours as variations of normal two-way traffic.
 4. Auxiliary **OR** Single-Car Auxiliary, **as directed**, Operations: In addition to primary operation system features, provide the following operational features for elevators where indicated:
 - a. Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby **OR** fire command station, **as directed**. Manual operation causes automatic operation to cease.
 - b. Standby Powered Lowering: On activation of standby power, if car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to the next floor below, opens its doors, and shuts down.
 - c. Battery-Powered Lowering: If power fails and car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to the next floor below, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
 - d. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors will begin closing.
 - e. Nuisance Call Cancel: When car calls exceed a preset number while car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight, **as directed**, can be adjusted.
 5. Group Auxiliary Operations: In addition to primary operation system features, provide the following operational features for elevators and elevator groups where indicated:
 - a. Standby Power Operation: On activation of standby power, cars are returned to a designated floor and parked with doors open. One car is returned at a time, with priority given to loaded cars. If a car cannot be returned after two attempts, it is removed from the system. When all cars have been returned or removed from the system, one car is automatically placed in service. If car selected for service cannot operate within 60 seconds, the system removes car from service and places another car in service. Cars can be manually put in service on standby power, either for return operation or for regular



- operation, by switches in control panel located at main lobby **OR** fire command station, **as directed**. Manual operation causes automatic operation to cease.
- b. Standby Power Operation: On activation of standby power, cars are returned, one at a time, to a designated floor and parked with doors open. If a car cannot be returned, it is removed from the system. When all cars have been returned or removed from the system, one car can be put in service on standby power by a selector switch in control panel located at main lobby **OR** fire command station, **as directed**.
 - c. Battery-Powered Lowering: If power fails, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are lowered one at a time to the next floor below, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.
 - d. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors will begin closing.
 - e. Nuisance Call Cancel: When car calls exceed a preset number while the car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight, **as directed**, can be adjusted.
 - f. Emergency Hospital **OR** Priority, **as directed**, Service: Service is initiated by a keyswitch **OR** card reader **OR** remote switch, **as directed**, at designated floors. One elevator is removed from group operation and directed to the floor where service was initiated. On arriving at the floor, elevator opens its doors and parks and a lighted sign directs passengers to exit elevator, **as directed**. Car is placed in operation by selecting a floor and pressing door close button or by operating keyswitch to put car in independent service. After responding to floor selected or being removed from independent service, car is returned to group operation. If car is not placed in operation within a preset time after being called, it is returned to group operation.
 - g. Independent Service: Keyswitch in car control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from keyswitch when car is in independent service. When in independent service, doors close only in response to door close button.
 - h. Loaded-Car Bypass: When car load exceeds 80 percent of rated capacity, car will respond only to car calls, not to hall calls.
 - i. Distributed Parking: When cars are not required for response to calls, they are parked with doors closed, distributed in predetermined zones throughout the building. One zone shall include the main floor and adjacent floors; remaining floors shall be divided into approximately equal zones.
6. Security Features: Provide the following security features, where indicated. Security features shall not affect emergency firefighters' service.
- a. Card-Reader Operation: System uses card readers at car control stations **OR** hall push-button stations, **as directed**, to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Provide required conductors in traveling cable and panel in machine room for interconnecting card readers, other security access system equipment, and elevator controllers. Allow space as indicated for card reader in car **OR** Provide stripe-swipe card reader integral with each car control station, **as directed**.
 - 1) Security access system equipment is specified in Division 28 Section "Access Control".
OR
Security access system equipment is not in the Contract.
 - b. Keyswitch Operation: Push buttons are activated and deactivated by security keyswitches at car control stations **OR** hall push-button stations, **as directed**. Key is removable only in deactivated position **OR** in either position, **as directed**.
 - c. Keypad Operation: Allows each landing to be restricted or unrestricted. When a restricted landing button is pressed, a "Restricted Floor" lamp lights and remains lit until landing access code has been entered into a keypad or predetermined time period has elapsed.



Car calls for restricted landings do not register until landing access code is entered into keypad within predetermined time period after landing button is pressed.

- 1) Access codes are programmed at each car operating panel using a security keyswitch. Keypad operation can be activated and deactivated by security keyswitch at main landing.
 - d. Car-to-Lobby Feature: Feature, activated by keyswitch at main lobby, that causes car **OR** all cars in a group, **as directed**, to return immediately to lobby and open doors for inspection. On deactivation by keyswitch, calls registered before keyswitch activation are completed and normal operation is resumed.
- C. Door Reopening Devices
1. Infrared Array: Provide door reopening devices with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.
 2. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.
- D. Finish Materials
1. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.
 2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
 3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.
 4. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.
 - a. Textured Stainless-Steel Sheet: Product with coined **OR** embossed, **as directed**, texture rolled into exposed surface.
 - 1) Metal surface is satin polished **OR** satin relieved **OR** titanium nitride colored **OR** oxide colored **OR** satin polished and titanium nitride colored **OR** satin relieved and titanium nitride colored **OR** satin polished and oxide colored **OR** satin relieved and oxide colored **OR** color coated and satin relieved **OR** color coated and bright relieved, **as directed**, after rolling.
 5. Stainless-Steel Bars: ASTM A 276, Type 304.
 6. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.
 7. Bronze Plate and Sheet: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal).
 8. Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (architectural bronze).
 9. Bronze Tubing: ASTM B 135 (ASTM B 135M), Alloy UNS No. C23000 (red brass, 85 percent copper).
 10. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063.
 11. Nickel Silver Extrusions: ASTM B 151/B 151M, Alloy UNS No. C74500 or No. C77600.
 12. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS for flat applications **OR** Type HGL for flat applications, **as directed**, Type HGP for postformed applications and Type BKV for panel backing.
- E. Car Enclosures
1. General: Provide enameled-steel car enclosures to receive removable **OR** steel-framed car enclosures with nonremovable, **as directed**, wall panels, with car **OR** removable car, **as directed**, roof, access doors, power door operators, and ventilation.
 - a. Provide standard railings complying with ASME A17.1 on car tops where required by ASME A17.1.
 - b. Provide finished car including materials and finishes specified below.
 2. Materials and Finishes: Provide manufacturer's standards, but not less than the following:
 - a. Subfloor: Underlayment grade, exterior plywood, 5/8-inch (16-mm) nominal thickness.
 - b. Floor Finish: Specified in a Division 9 Section **OR** Elevator manufacturer's standard level-loop nylon carpet; color as selected from manufacturer's full range, **as directed**.



- c. Enameled-Steel Wall Panels: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - d. Stainless-Steel Wall Panels: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
 - e. Bronze Wall Panels: Flush, hollow-metal construction; fabricated from bronze sheet.
 - f. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to 1/2-inch (13-mm) fire-retardant-treated particleboard **OR** manufacturer's standard honeycomb core, **as directed**, with plastic-laminate panel backing and, **as directed**, manufacturer's standard protective edge trim. Panels have a flame-spread index of 25 **OR** 75, **as directed**, or less, when tested according to ASTM E 84. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
 - g. Fabricate car with recesses and cutouts for signal equipment.
 - h. Fabricate car door frame integrally with front wall of car.
 - i. Enameled-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - j. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet **OR** by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning, **as directed**.
 - k. Bronze Doors: Flush, hollow-metal construction; fabricated by laminating bronze sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
 - l. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim matching return panels, **as directed**. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
 - m. Sight Guards: Provide sight guards on car doors.
 - n. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick.
 - o. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.
 - p. Metal **OR** Metallic-Finish, Plastic-Laminate, **as directed**, Ceiling: Flush panels, with incandescent downlights in the center of **OR** four low-voltage downlights in, **as directed**, each panel. Align ceiling panel joints with joints between wall panels, **as directed**.
 - q. Handrails: Manufacturer's standard handrails, of shape, metal, and finish indicated.
- F. Hoistway Entrances
- 1. General: Provide manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Provide frame size and profile to coordinate with hoistway wall construction.
 - a. Where gypsum board wall construction is indicated, provide self-supporting frames with reinforced head sections.
 - 2. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:
 - a. Enameled-Steel Frames: Formed from cold-rolled or hot-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - b. Steel Subframes: Formed from cold-rolled or hot-rolled steel sheet with factory-applied enamel finish or corrosion-inhibiting primer. Fabricate to receive applied finish as indicated.
 - c. Stainless-Steel Frames: Formed from stainless-steel sheet.
 - d. Bronze Frames: Formed from cold-rolled or hot-rolled steel sheet, with enamel finish, and with formed-bronze sheet laminated to steel frames using adhesive that fully bonds metal to metal without telegraphing or oil-canning.



- e. Enameled-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
- f. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet **OR** by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning, **as directed**.
- g. Bronze Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating bronze sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
- h. Plastic-Laminate Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim matching door frames, **as directed**. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
- i. Sight Guards: Provide sight guards on doors matching door edges.
- j. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick.
- k. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.

G. Signal Equipment

- 1. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with long-life incandescent lamps and acrylic or other permanent, nonyellowing translucent plastic diffusers **OR** LEDs, **as directed**.
OR
General: Provide signal equipment designed for destination-based system. Fabricate lighted elements with long-life incandescent lamps and acrylic or other permanent, nonyellowing translucent plastic diffusers **OR** LEDs, **as directed**.
- 2. Car Control Stations: Provide manufacturer's standard recessed **OR** semirecessed, **as directed**, car control stations. Mount in return panel adjacent to car door, unless otherwise indicated.
OR
Swing-Return Car Control Stations: Provide car control stations mounted on rear of hinged return panel adjacent to car door and with buttons, switches, controls, and indicator lights projecting through return panel but substantially flush with face of return panel.
 - a. Mark buttons and switches with standard identification for required use or function that complies with ASME A17.1. Use both tactile symbols and Braille.
 - b. Provide "No Smoking" sign matching car control station, either integral with car control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.
- 3. Emergency Communication System: Provide system that complies with ASME A17.1 and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)." On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System provides two-way voice communication without using a handset and provides visible signals that indicate when system has been activated and when monitoring station has responded. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.
- 4. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet **OR** telephone jack, **as directed**, in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" **OR** "Zoned (dc Loop) Fire-alarm System".
- 5. Car Position Indicator: Provide illuminated, **as directed**, digital-type car position indicator, located above car door or above car control station. Also provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served.
 - a. Include travel direction arrows if not provided in car control station.



6. Hall Push-Button Stations: Provide one hall push-button station at each landing for each single elevator or group of elevators, but not less than one station for each four elevators in a group, **as directed**.
OR
Hall Push-Button Stations: Provide hall push-button stations at each landing as indicated.
- a. Provide manufacturer's standard wall-mounted units.
OR
Provide units with flat faceplate for mounting with body of unit recessed in wall.
 - b. Equip units with buttons for calling elevator and for indicating desired direction of travel.
OR
Equip units with buttons **OR** touch screen, **as directed**, for calling elevator and for indicating direction of travel or destination as required by system. Provide a signaling system to verify floor selection, where destination registration is required, and to direct passengers to appropriate car.
 - 1) Provide a means for passengers to indicate that they have disabilities so control system can allow extra room in assigned car.
 - 2) Provide for connecting units that require destination registration to building security access system so a card reader can be used to register calls.
 - c. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" **OR** "Zoned (dc Loop) Fire-alarm System".
7. Hall Lanterns: Units with illuminated arrows; but provide single arrow at terminal landings. Provide one of the following:
- a. Manufacturer's standard wall-mounted units, for mounting above entrance frames.
 - b. Units with flat faceplate for mounting with body of unit recessed in wall and with illuminated elements projecting from faceplate for ease of angular viewing.
 - c. Units mounted in both jambs of entrance frame for each elevator, **as directed**.
 - d. Units mounted in both car door jambs; may be used only for single elevators or for two-car groups, **as directed**.
8. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
- a. At manufacturer's option, audible signals may be placed on car **OR** each car, **as directed**.
9. Hall Position Indicators: Provide illuminated, **as directed**, digital-display-type position indicators, located above each, **as directed**, hoistway entrance at ground floor. Provide units with flat faceplate for mounting with body of unit recessed in wall.
- a. Integrate ground-floor hall lanterns with hall position indicators.
10. Standby Power Elevator Selector Switches: Provide switches, as required by ASME A17.1, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open.
OR
Fire Command Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby power elevator selector switch(es), as required by ASME A17.1, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.
11. Corridor Call Station Pictograph Signs: Provide signs matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station, unless otherwise indicated.

H. Elevators

1. Elevator Description:



- a. Group Number: **<Insert a different number for each group of elevators that share a group operation system.>**
- b. Elevator Number(s): **<Insert elevator number(s) as shown on Drawings.>**
- c. Service Elevator Number(s): **<Insert elevator number(s) as shown on Drawings.>**
- d. Type: Geared **OR** Gearless, **as directed**, traction.
- e. Machine Location: Machine room above hoistway **OR** Hoistway; no machine room is provided, **as directed**.
- f. Rated Load: 2000 lb (908 kg) **OR** 2100 lb (953 kg) **OR** 2500 lb (1135 kg) **OR** 3000 lb (1362 kg) **OR** 3500 lb (1589 kg) **OR** 4000 lb (1816 kg) **OR** 4500 lb (2043 kg) **OR** 5000 lb (2270 kg), **as directed**.
- g. Freight Loading Class for Service Elevator(s): Class A.
- h. Rated Speed: 200 fpm (1.0 m/s) **OR** 350 fpm (1.8 m/s) **OR** 400 fpm (2.0 m/s) **OR** 450 fpm (2.3 m/s) **OR** 500 fpm (2.5 m/s) **OR** 700 fpm (3.6 m/s) **OR** 800 fpm (4.1 m/s) **OR** 1000 fpm (5.1 m/s) **OR** 1200 fpm (6.1 m/s) **OR** 1400 fpm (7.1 m/s), **as directed**.
- i. Operation System: Selective collective automatic operation **OR** Group automatic operation **OR** Group automatic operation with demand-based dispatching **OR** Destination-based group automatic operation, **as directed**.
- j. Auxiliary Operations:
 - 1) Standby power operation.
 - 2) Standby powered lowering.
 - 3) Battery-powered lowering.
 - 4) Earthquake Emergency Operation: Comply with requirements in ASME A17.1.
 - 5) Automatic dispatching of loaded car.
 - 6) Nuisance call cancel.
 - 7) Emergency hospital **OR** Priority, **as directed**, service at designated floors **OR** all floors, **as directed**.
 - 8) Independent service for service elevator **OR** all cars in group, **as directed**.
 - 9) Loaded-car bypass.
 - 10) Distributed parking.
- k. Security Features: Card-reader operation **OR** Keyswitch operation **OR** Keypad operation **OR** Car-to-lobby feature, **as directed**.
- l. Dual Car Control Stations: Provide two car control stations in each elevator, **as directed**; equip only one with required keyswitches if any.
- m. Car Enclosures:
 - 1) Inside Width: 64 inches (1626 mm) **OR** 68 inches (1727 mm) **OR** 80 inches (2032 mm) **OR** 92 inches (2337 mm), **as directed**, from side wall to side wall.
 - 2) Inside Depth: 51 inches (1295 mm) **OR** 53 inches (1346 mm) **OR** 57 inches (1448 mm) **OR** 65 inches (1651 mm) **OR** 87-1/2 inches (2222 mm) **OR** 90 inches (2286 mm) **OR** 93 inches (2362 mm) **OR** 93-1/2 inches (2375 mm) **OR** 96 inches (2438 mm) **OR** 101 inches (2565 mm) **OR** 102 inches (2591 mm), **as directed**, from back wall to front wall (return panels).
 - 3) Inside Height: 88 inches (2235 mm) **OR** 92 inches (2337 mm) **OR** 94 inches (2388 mm) **OR** 100 inches (2540 mm) **OR** 104 inches (2642 mm) **OR** 108 inches (2743 mm) **OR** 112 inches (2845 mm), **as directed**, to underside of ceiling.
 - 4) Front Walls (Return Panels): Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
 - 5) Car Fixtures: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
 - 6) Side and Rear Wall Panels: Enameled steel **OR** Plastic laminate **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel, **as directed**.
 - 7) Reveals: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.



- 8) Door Faces (Interior): Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
 - 9) Door Sills: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
 - 10) Ceiling: Luminous ceiling **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Reflective metallic-finish, plastic-laminate, stainless steel **OR** Reflective metallic-finish, plastic-laminate, bronze, **as directed**.
 - 11) Handrails: 1-1/2 inches (38 mm) round **OR** 1/2 by 2 inches (13 by 50 mm) rectangular, **as directed**, mirror-polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish **OR** mirror-polished bronze, lacquered **OR** satin bronze, lacquered, **as directed**, at sides **OR** rear **OR** sides and rear, **as directed**, of car.
 - 12) Floor: Manufacturer's standard carpet.
OR
 Floor prepared to receive carpet (specified in Division 09 Section "Sheet Carpeting").
OR
 Floor prepared to receive resilient tile (specified in Division 09 Section "Resilient Tile Flooring").
OR
 Floor prepared to receive sheet vinyl (specified in Division 09 Section "Resilient Sheet Flooring").
OR
 Floor recessed and prepared to receive dimension stone tile (specified in Division 09 Section "Stone Tiling") **OR** ceramic tile (specified in Division 09 Section "Tiling"), **as directed**.
 - 13) Floor Thickness, Including Setting Materials: **<Insert thickness>** above plywood subfloor.
- n. Hoistway Entrances: As follows:
- 1) Width: 36 inches (914 mm) **OR** 42 inches (1067 mm) **OR** 48 inches (1219 mm) **OR** 54 inches (1372 mm), **as directed**.
 - 2) Height: 84 inches (2134 mm) **OR** 96 inches (2438 mm), **as directed**.
 - 3) Type: Single-speed side sliding **OR** Two-speed side sliding **OR** Single-speed center opening **OR** Two-speed center opening, **as directed**.
 - 4) Fire-Protection Rating: 1 hour **OR** 1-1/2 hours, **as directed**, with 30-minute temperature rise of 450 deg F (250 deg C), **as directed**.
 - 5) Frames at First Floor **OR** at Basement Floors, **as directed**: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
 - 6) Frames at Other Floors: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
 - 7) Doors and Transoms at First Floor **OR** at Basement Floors, **as directed**: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
 - 8) Doors and Transoms at Other Floors: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
 - 9) Sills at First Floor **OR** at Basement Floors, **as directed**: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
 - 10) Sills at Other Floors: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.



- o. Hall Fixtures at First Floor **OR** at Basement Floors, **as directed**: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Recessed type with no exposed-metal surfaces, **as directed**.
- p. Hall Fixtures at Other Floors: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Recessed type with no exposed-metal surfaces, **as directed**.
- q. Additional Requirements:
 - 1) Provide inspection certificate in each car, mounted under acrylic cover with frame made from polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish **OR** polished bronze, lacquered **OR** satin bronze, lacquered, **as directed**.
 - 2) Provide blanket hooks in all cars, **as directed**, and one **OR** two, **as directed**, complete set(s) of full-height protective blankets.

1.3 EXECUTION

A. Examination

- 1. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Examine hoistways, hoistway openings, pits, and machine rooms as constructed; verify critical dimensions; and examine supporting structure and other conditions under which elevator work is to be installed.
 - a. For the record, prepare a written report, endorsed by Installer, listing dimensional discrepancies and conditions detrimental to performance or indicating that dimensions and conditions were found to be satisfactory.
 - b. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

- 1. Comply with manufacturer's written instructions.
- 2. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.
- 3. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to minimize transmission of vibrations to structure and thereby minimize structure-borne noise from elevator system.
- 4. Lubricate operating parts of systems, including ropes, as recommended by manufacturers.
- 5. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay final adjustment of sills and doors until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.
- 6. Leveling Tolerance: 1/8 inch (3 mm), up or down, regardless of load and direction of travel.
- 7. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.
- 8. Locate hall signal equipment for elevators as follows, unless otherwise indicated:
 - a. For groups of elevators, locate hall push-button stations between two elevators at center of group or at location most convenient for approaching passengers.
 - b. Place hall lanterns either above or beside each hoistway entrance.
 - c. Mount hall lanterns at a minimum of 72 inches (1829 mm) above finished floor.

C. Field Quality Control

- 1. Acceptance Testing: On completion of elevator installation and before permitting use (either temporary or permanent) of elevators, perform acceptance tests as required and recommended by ASME A17.1 and by governing regulations and agencies.
- 2. Operating Test: Load elevator **OR** each elevator **OR** one elevator of each type, capacity, speed, and travel distance, **as directed**, to rated capacity and operate continuously for 30 minutes over full travel distance, stopping at each level and proceeding immediately to the next. Record



temperature rise of elevator machine during 30-minute test period. Record failure to perform as required.

3. Advise Owner and authorities having jurisdiction in advance of dates and times tests are to be performed on elevators.

D. Protection

1. Temporary Use: Limit temporary use for construction purposes to one elevator **as directed**. Comply with the following requirements for each, **as directed**, elevator used for construction purposes:
 - a. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
 - b. Provide strippable protective film on entrance and car doors and frames.
 - c. Provide padded wood bumpers on entrance door frames covering jambs and frame faces.
 - d. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
 - e. Do not load elevators beyond their rated weight capacity.
 - f. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
 - g. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

E. Demonstration

1. Train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).
2. Check operation of each elevator with Owner's personnel present and before date of Final Completion. Determine that operation systems and devices are functioning properly.
3. Check operation of each elevator with Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

END OF SECTION 14 01 20 71



SECTION 14 01 20 71a - HYDRAULIC ELEVATORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for hydraulic elevators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes hydraulic passenger and service elevators.

C. Definitions

1. Definitions in ASME A17.1 apply to work of this Section.
2. Defective Elevator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.
3. Service Elevator: A passenger elevator that is also used to carry freight.

D. Submittals

1. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include product data for the following:
 - a. Car enclosures and hoistway entrances.
 - b. Operation, control, and signal systems.
2. Shop Drawings: Show plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment and signals. Include large-scale layout of car control station and standby power operation control panel, **as directed**. Indicate variations from specified requirements, maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.
3. Samples: For exposed finishes of cars, hoistway doors and frames, and signal equipment; 3-inch- (75-mm-) square Samples of sheet materials; and 4-inch (100-mm) lengths of running trim members.
4. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator system being provided.
5. Qualification Data: For Installer.
6. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.
8. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Installer Qualifications: Elevator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Source Limitations: Obtain elevators, including electric traction passenger elevators specified in another Division 14 Section, through one source from a single manufacturer.
 - a. Provide major elevator components, including pump-and-tank units, plunger-cylinder assemblies, controllers, signal fixtures, door operators, car frames, cabs, and entrances, manufactured by a single manufacturer.



3. Regulatory Requirements: Comply with ASME A17.1 and elevator design requirements for earthquake loads in ASCE 7.
 - a. Effective peak velocity acceleration (A_v) for Project's location is less than 0.10 (seismic risk zones 0 and 1) **OR** greater than or equal to 0.10, but less than 0.20 (seismic risk zone 2) **OR** greater than or equal to 0.20 (seismic risk zones 3 and 4), **as directed**.
 - b. Design earthquake spectral response acceleration, short period (S_d s) for Project is determined by Project's location and site classification.
 - c. Project's seismic design category is A **OR** B **OR** C **OR** D, **as directed**.
 - d. Elevator importance factor is 1.5 **OR** 1.0, **as directed**.
4. Accessibility Requirements: Comply with Section 4.10 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** 407 in ICC A117.1, **as directed**.
5. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** IBC Standard 3002 **OR** UL 10B, **as directed**.

F. Delivery, Storage, And Handling

1. Deliver, store, and handle materials, components and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's written recommendations to prevent damage, deterioration, or soiling.

G. Coordination

1. Coordinate installation of sleeves, block outs, and items that are embedded in concrete or masonry for elevator equipment. Furnish templates and installation instructions and deliver to Project site in time for installation.
2. Furnish well casing and coordinate delivery with related excavation work.
3. Coordinate sequence of elevator installation with other work to avoid delaying the Work.
4. Coordinate locations and dimensions of other work relating to hydraulic elevators including pit ladders, sumps, and floor drains in pits; entrance subsills; and electrical service, electrical outlets, lights, and switches in pits and machine rooms.

H. Warranty

1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective elevator work within specified warranty period.
 - a. Warranty Period: One year from date of Final Completion.

1.2 PRODUCTS

A. Systems And Components

1. General: Provide manufacturer's standard elevator systems. Where components are not otherwise indicated, provide standard components published by manufacturer as included in standard preengineered elevator systems and as required for complete system.
2. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations. Provide the following, **as directed**:
 - a. Pump, with fan-cooled squirrel-cage induction motor, mounted on oil tank with vibration isolation mounts. Enclose pump in prime-painted steel enclosure lined with 1-inch- (25-mm-) thick, glass-fiber insulation board.
 - b. Submersible pump, with submersible squirrel-cage induction motor, suspended inside oil tank from vibration isolation mounts.
 - c. Provide motor with wye-delta **OR** solid-state, **as directed**, starting.
 - d. Provide variable-voltage variable-frequency motor control.



3. Hydraulic Silencers: Provide hydraulic silencer containing pulsation-absorbing material in a blowout-proof housing at pump unit.
4. Piping: Provide size, type, and weight piping recommended by manufacturer, and provide flexible connectors to minimize sound and vibration transmissions from power unit.
 - a. Provide dielectric couplings at cylinder units.
 - b. Casing for Underground Piping: PVC pipe complying with ASTM D 1785, joined with PVC fittings complying with ASTM D 2466 and solvent cement complying with ASTM D 2564.
5. Hydraulic Fluid: Elevator manufacturer's standard fire-resistant, **as directed**, fluid with additives as needed to prevent oxidation of fluid, corrosion of cylinder and other components, and other adverse effects.

OR

Hydraulic Fluid: Nontoxic, readily biodegradable, fire-resistant, **as directed**, fluid made from vegetable oil with antioxidant, anticorrosive, antifoaming, and metal-passivating additives. Hydraulic fluid is approved by elevator manufacturer for use with elevator equipment.
6. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Section.
7. Protective Cylinder Casing: PVC or HDPE pipe casing complying with ASME A17.1, of sufficient size to provide not less than 1-inch (25-mm) clearance from cylinder and extending above pit floor. Provide means to monitor casing effectiveness to comply with ASME A17.1.
8. Corrosion Protective Filler: A nontoxic, petroleum-based gel formulated for filling the space between hydraulic cylinder and protective casing. Filler is electrically nonconductive, displaces or absorbs water, and gels or solidifies at temperatures below 60 deg F (16 deg C).
9. Car Frame and Platform: Welded steel units.
10. Guides: Provide either roller guides or sliding guides at top and bottom of car and counterweight frames. If sliding guides are used, provide guide-rail lubricators or polymer-coated, nonlubricated guides.

B. Operation Systems

1. General: Provide manufacturer's standard microprocessor operation system for each elevator **OR** for each group of elevators, **as directed**, as required to provide type of operation system indicated.
2. Auxiliary **OR** Single-Car Auxiliary, **as directed**, Operations: In addition to primary operation system features, provide the following operational features for elevators where indicated:
 - a. Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby **OR** fire command station, **as directed**. Manual operation causes automatic operation to cease.

OR

Standby-Powered Lowering: On activation of standby power, if car is at a floor it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to a preselected floor, opens its doors, and shuts down. If car is below the preselected floor, it is lowered to the next lower floor, opens its doors, and shuts down.

OR

Standby-Powered Lowering: On activation of standby power, car is lowered to the lowest floor, opens its doors, and shuts down.

OR

Battery-Powered Lowering: If power fails and car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to a preselected floor, opens its doors, and shuts down. If car is below the preselected floor, it is lowered to the next lower floor, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.

OR



- Battery-Powered Lowering: When power fails, car is lowered to the lowest floor, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
- b. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors will begin closing.
 - c. Nuisance Call Cancel: When car calls exceed a preset number while car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight, **as directed**, can be adjusted.
3. Group Auxiliary Operations: In addition to primary operation system features, provide the following operational features for elevators and elevator groups where indicated:
- a. Standby Power Operation: On activation of standby power, cars are returned to a designated floor and parked with doors open. Only one car is moved upward at a time, with priority given to loaded cars. If a car cannot be returned after two attempts, it is removed from the system. When all cars have been returned or removed from the system, one car is automatically placed in service. If car selected for service cannot operate within 60 seconds, the system removes car from service and places another car in service. Cars can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby **OR** fire command station, **as directed**. Manual operation causes automatic operation to cease.
OR
Standby Power Operation: On activation of standby power, cars are returned to lowest floor and parked with doors open. If a car cannot be returned, it is removed from the system. One car is selected for service on standby power by a switch located at main lobby **OR** fire command station, **as directed**.
OR
Standby-Powered Lowering: On activation of standby power, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are lowered to a preselected floor, open their doors, and shut down. Cars that are below the preselected floor are lowered to the next lower floor, open their doors, and shut down.
OR
Standby-Powered Lowering: On activation of standby power, cars are lowered to the lowest floor, open their doors, and shut down.
OR
Battery-Powered Lowering: If power fails, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are lowered to a preselected floor, open their doors, and shut down. Cars that are below the preselected floor are lowered to the next lower floor, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.
OR
Battery-Powered Lowering: When power fails, cars are lowered to the lowest floor, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.
 - b. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors will begin closing.
 - c. Nuisance Call Cancel: When car calls exceed a preset number while car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight, **as directed**, can be adjusted.
 - d. Emergency Hospital **OR** Priority, **as directed**, Service: Service is initiated by a keyswitch **OR** card reader **OR** remote switch, **as directed**, at designated floors. One elevator is removed from group operation and directed to the floor where service was initiated. On arriving at the floor, elevator opens its doors and parks and a lighted sign directs passengers to exit elevator, **as directed**. Car is placed in operation by selecting a floor and pressing door close button or by operating keyswitch to put car in independent service. After responding to floor selected or being removed from independent service, car is



- returned to group operation. If car is not placed in operation within a preset time after being called, it is returned to group operation.
- e. Independent Service: Keyswitch in car control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from keyswitch when car is in independent service. When in independent service, doors close only in response to door close button.
 - f. Loaded-Car Bypass: When car load exceeds 80 percent of rated capacity, car will respond only to car calls, not to hall calls.
4. Security Features: Provide the following security features, where indicated. Security features shall not affect emergency firefighters' service.
- a. Card-Reader Operation: System uses card readers at car control stations **OR** hall push-button stations, **as directed**, to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Provide required conductors in traveling cable and panel in machine room for interconnecting card readers, other security access system equipment, and elevator controllers. Allow space as indicated for card reader in car **OR** Provide stripe-swipe card reader integral with each car control station, **as directed**.
 - 1) Security access system equipment is specified in Division 28 Section "Access Control".
OR
Security access system equipment is not in the Contract.
 - b. Keyswitch Operation: Push buttons are activated and deactivated by security keyswitches at car control stations **OR** hall push-button stations, **as directed**. Key is removable only in deactivated position **OR** in either position, **as directed**.
 - c. Keypad Operation: Allows each landing to be restricted or unrestricted. When a restricted landing button is pressed, a "Restricted Floor" lamp lights and remains lit until landing access code has been entered into a keypad or predetermined time period has elapsed. Car calls for restricted landings do not register until landing access code is entered into keypad within predetermined time period after landing button is pressed.
 - 1) Access codes are programmed at each car operating panel using a security keyswitch. Keypad operation can be activated and deactivated by security keyswitch at main landing.
 - d. Car-to-Lobby Feature: Feature, activated by keyswitch at main lobby, that causes car **OR** all cars in a group, **as directed**, to return immediately to lobby and open doors for inspection. On deactivation by keyswitch, calls registered before keyswitch activation are completed and normal operation is resumed.
- C. Door Reopening Devices
1. Infrared Array: Provide door reopening devices with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.
 2. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.
- D. Finish Materials
1. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.
 2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
 3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.
 4. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.
 - a. Textured Stainless-Steel Sheet: Product with coined **OR** embossed, **as directed**, texture rolled into exposed surface.
 - 1) Metal surface is satin polished **OR** satin relieved **OR** titanium nitride colored **OR** oxide colored **OR** satin polished and titanium nitride colored **OR** satin relieved and



titanium nitride colored **OR** satin polished and oxide colored **OR** satin relieved and oxide colored **OR** color coated and satin relieved **OR** color coated and bright relieved, **as directed**, after rolling.

5. Stainless-Steel Bars: ASTM A 276, Type 304.
6. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.
7. Bronze Plate and Sheet: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal).
8. Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (architectural bronze).
9. Bronze Tubing: ASTM B 135 (ASTM B 135M), Alloy UNS No. C23000 (red brass, 85 percent copper).
10. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063.
11. Nickel Silver Extrusions: ASTM B 151/B 151M, Alloy UNS No. C74500 or No. C77600.
12. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS for flat applications **OR** Type HGL for flat applications, **as directed**, Type HGP for postformed applications and Type BKV for panel backing.

E. Car Enclosures

1. General: Provide enameled-steel car enclosures to receive removable **OR** steel-framed car enclosures with nonremovable, **as directed**, wall panels, with car **OR** removable car, **as directed**, roof, access doors, power door operators, and ventilation.
 - a. Provide standard railings complying with ASME A17.1 on car tops where required by ASME A17.1.
 - b. Provide finished car including materials and finishes specified below.
2. Materials and Finishes: Provide manufacturer's standards, but not less than the following:
 - a. Subfloor: Underlayment grade, exterior plywood, 5/8-inch (16-mm) nominal thickness.
 - b. Floor Finish: Specified in a Division 07 **OR** Elevator manufacturer's standard level-loop nylon carpet; color as selected from manufacturer's full range, **as directed**.
 - c. Enameled-Steel Wall Panels: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - d. Stainless-Steel Wall Panels: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
 - e. Bronze Wall Panels: Flush, hollow-metal construction; fabricated from bronze sheet.
 - f. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to 1/2-inch (13-mm) fire-retardant-treated particleboard **OR** manufacturer's standard honeycomb core, **as directed**, with plastic-laminate panel backing and, **as directed**, manufacturer's standard protective edge trim. Panels have a flame-spread index of 25 **OR** 75, **as directed**, or less, when tested according to ASTM E 84. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
 - g. Fabricate car with recesses and cutouts for signal equipment.
 - h. Fabricate car door frame integrally with front wall of car.
 - i. Enameled-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - j. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet **OR** by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning, **as directed**.
 - k. Bronze Doors: Flush, hollow-metal construction; fabricated by laminating bronze sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
 - l. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim matching return panels, **as directed**. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.



- m. Sight Guards: Provide sight guards on car doors.
 - n. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick.
 - o. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.
 - p. Metal **OR** Metallic-Finish, Plastic-Laminate, **as directed**, Ceiling: Flush panels, with incandescent downlights in the center of **OR** four low-voltage downlights in, **as directed**, each panel. Align ceiling panel joints with joints between wall panels, **as directed**.
 - q. Handrails: Manufacturer's standard handrails, of shape, metal, and finish indicated.
- F. Hoistway Entrances
- 1. General: Provide manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Provide frame size and profile to coordinate with hoistway wall construction.
 - a. Where gypsum board wall construction is indicated, provide self-supporting frames with reinforced head sections.
 - 2. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:
 - a. Enameled-Steel Frames: Formed from cold-rolled or hot-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - b. Steel Subframes: Formed from cold-rolled or hot-rolled steel sheet with factory-applied enamel finish or corrosion-inhibiting primer. Fabricate to receive applied finish as indicated.
 - c. Stainless-Steel Frames: Formed from stainless-steel sheet.
 - d. Bronze Frames: Formed from cold-rolled or hot-rolled steel sheet, with enamel finish, and with formed-bronze sheet laminated to steel frames using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
 - e. Enameled-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - f. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet **OR** by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning, **as directed**.
 - g. Bronze Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating bronze sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
 - h. Plastic-Laminate Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim matching door frames, **as directed**. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
 - i. Sight Guards: Provide sight guards on doors matching door edges.
 - j. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick.
 - k. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.
- G. Signal Equipment
- 1. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with long-life incandescent lamps and acrylic or other permanent, nonyellowing translucent plastic diffusers **OR** LEDs, **as directed**.
 - 2. Car Control Stations: Provide manufacturer's standard recessed **OR** semirecessed, **as directed**, car control stations. Mount in return panel adjacent to car door, unless otherwise indicated.
OR
Swing-Return Car Control Stations: Provide car control stations mounted on rear of hinged return panel adjacent to car door and with buttons, switches, controls, and indicator lights projecting through return panel but substantially flush with face of return panel.



- a. Mark buttons and switches with standard identification for required use or function that complies with ASME A17.1. Use both tactile symbols and Braille.
 - b. Provide "No Smoking" sign matching car control station, either integral with car control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.
3. Emergency Communication System: Provide system that complies with ASME A17.1 and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)." On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System provides two-way voice communication without using a handset and provides visible signals that indicate when system has been activated and when monitoring station has responded. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.
 4. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet **OR** telephone jack, **as directed**, in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" **OR** "Zoned (dc Loop) Fire-alarm System"
 5. Car Position Indicator: Provide illuminated, **as directed**, digital-type car position indicator, located above car door or above car control station. Also provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served.
 - a. Include travel direction arrows if not provided in car control station.
 6. Hall Push-Button Stations: Provide one hall push-button station at each landing for each single elevator or group of elevators, but not less than one station for each four elevators in a group, **as directed**.
OR
Hall Push-Button Stations: Provide hall push-button stations at each landing as indicated.
 - a. Provide manufacturer's standard wall-mounted units.
 - b. Provide units with flat faceplate for mounting with body of unit recessed in wall.
 - c. Equip units with buttons for calling elevator and for indicating desired direction of travel.
 - d. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" **OR** "Zoned (dc Loop) Fire-alarm System".
 7. Hall Lanterns: Units with illuminated arrows; but provide single arrow at terminal landings. Provide one of the following, **as directed**:
 - a. Manufacturer's standard wall-mounted units, for mounting above entrance frames.
 - b. Units with flat faceplate for mounting with body of unit recessed in wall and with illuminated elements projecting from faceplate for ease of angular viewing.
 - c. Units mounted in both jambs of entrance frame for each elevator, **as directed**.
 - d. Units mounted in both car door jambs; may be used only for single elevators or for two-car groups, **as directed**.
 8. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
 - a. At manufacturer's option, audible signals may be placed on car **OR** each car, **as directed**.
 9. Hall Position Indicators: Provide illuminated, **as directed**, digital-display-type position indicators, located above each, **as directed**, hoistway entrance at ground floor. Provide units with flat faceplate for mounting and with body of unit recessed in wall.
 - a. Integrate ground-floor hall lanterns with hall position indicators.
 10. Standby Power Elevator Selector Switches: Provide switches, as required by ASME A17.1, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open, **as directed**.
OR
Fire Command Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal



that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby power elevator selector switch(es), as required by ASME A17.1, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.

11. Corridor Call Station Pictograph Signs: Provide signs matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station, unless otherwise indicated.

H. Elevators

1. Elevator Description:

- a. Group Number: Insert a different number for each group of elevators that share a group operation system, as directed by the Owner.
- b. Elevator Number(s): Insert elevator number(s) as shown on Drawings, as directed by the Owner.
- c. Service Elevator Number(s): Insert elevator number(s) as shown on Drawings, as directed by the Owner.
- d. Type: Under-the-car single cylinder.
OR
Type: Holeless, beside-the-car, single-acting, single **OR** dual, **as directed**, cylinder.
OR
Type: Holeless, beside-the-car, telescoping, single **OR** dual, **as directed**, cylinder.
OR
Type: Holeless, beside-the-car, roped hydraulic, single **OR** dual, **as directed**, cylinder.
- e. Rated Load: 2000 lb (908 kg) **OR** 2100 lb (953 kg) **OR** 2500 lb (1135 kg) **OR** 3000 lb (1362 kg) **OR** 3500 lb (1589 kg) **OR** 4000 lb (1816 kg) **OR** 4500 lb (2043 kg) **OR** 5000 lb (2270 kg), **as directed**.
- f. Freight Loading Class for Service Elevators: Class A.
- g. Rated Speed: 75 or 80 fpm (0.38 or 0.41 m/s) **OR** 100 fpm (0.51 m/s) **OR** 125 fpm (0.64 m/s) **OR** 150 fpm (0.76 m/s) **OR** 175 fpm (0.89 m/s) **OR** 200 fpm (1.0 m/s), **as directed**.
- h. Operation System: Single automatic **OR** Selective collective automatic **OR** Group automatic, **as directed**, operation.
- i. Auxiliary Operations:
 - 1) Standby power operation.
 - 2) Standby-powered lowering.
 - 3) Battery-powered lowering.
 - 4) Automatic dispatching of loaded car.
 - 5) Nuisance call cancel.
 - 6) Emergency hospital **OR** Priority, **as directed**, service at designated floors **OR** all floors, **as directed**.
 - 7) Independent service for service elevator **OR** all cars in group, **as directed**.
 - 8) Loaded-car bypass.
- j. Security Features: Card-reader operation **OR** Keyswitch operation **OR** Keypad operation **OR** Car-to-lobby feature, **as directed**.
- k. Dual Car Control Stations: Provide two car control stations in each elevator, **as directed**; equip only one with required keyswitches, if any.
- l. Car Enclosures:
 - 1) Inside Width: 64 inches (1626 mm) **OR** 68 inches (1727 mm) **OR** 80 inches (2032 mm) **OR** 92 inches (2337 mm), **as directed**, from side wall to side wall.
 - 2) Inside Depth: 51 inches (1295 mm) **OR** 53 inches (1346 mm) **OR** 57 inches (1448 mm) **OR** 65 inches (1651 mm) **OR** 87-1/2 inches (2222 mm) **OR** 90 inches (2286 mm) **OR** 93 inches (2362 mm) **OR** 93-1/2 inches (2375 mm) **OR** 96 inches (2438 mm) **OR** 101 inches (2565 mm) **OR** 102 inches (2591 mm), **as directed**, from back wall to front wall (return panels).



- 3) Inside Height: 88 inches (2235 mm) **OR** 92 inches (2337 mm) **OR** 94 inches (2388 mm) **OR** 100 inches (2540 mm) **OR** 104 inches (2642 mm) **OR** 108 inches (2743 mm) **OR** 112 inches (2845 mm), **as directed**, to underside of ceiling.
 - 4) Front Walls (Return Panels): Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**, with integral car door frames.
 - 5) Car Fixtures: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
 - 6) Side and Rear Wall Panels: Enameled steel **OR** Plastic laminate **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel, **as directed**.
 - 7) Reveals: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
 - 8) Door Faces (Interior): Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
 - 9) Door Sills: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
 - 10) Ceiling: Luminous ceiling **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Reflective metallic-finish, plastic-laminate, stainless steel **OR** Reflective metallic-finish, plastic-laminate, bronze, **as directed**.
 - 11) Handrails: 1-1/2 inches (38 mm) round **OR** 1/2 by 2 inches (13 by 50 mm) rectangular, **as directed**, mirror-polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish **OR** mirror-polished bronze, lacquered **OR** satin bronze, lacquered, **as directed**, at sides **OR** sides and rear, **as directed**, of car.
 - 12) Floor: Manufacturer's standard carpet.
OR
Floor prepared to receive carpet (specified in Division 09 Section "Sheet Carpeting").
OR
Floor prepared to receive resilient tile (specified in Division 09 Section "Resilient Tile Flooring").
OR
Floor prepared to receive sheet vinyl (specified in Division 09 Section "Resilient Sheet Flooring").
OR
Floor recessed and prepared to receive dimension stone tile (specified in Division 09 Section "Stone Tiling") **OR** ceramic tile (specified in Division 09 Section "Tiling"), **as directed**.
OR
Floor Thickness, Including Setting Materials: Thickness above plywood subfloor, shall be as directed by the Owner.
- m. Hoistway Entrances:
- 1) Width: 36 inches (914 mm) **OR** 42 inches (1067 mm) **OR** 48 inches (1219 mm) **OR** 54 inches (1372 mm), **as directed**.
 - 2) Height: 84 inches (2134 mm) **OR** 96 inches (2438 mm), **as directed**.
 - 3) Type: Single-speed side sliding **OR** Two-speed side sliding **OR** Single-speed center opening **OR** Two-speed center opening, **as directed**.
 - 4) Fire-Protection Rating: 1 hour **OR** 1-1/2 hours, **as directed**, with 30-minute temperature rise of 450 deg F (250 deg C), **as directed**.
 - 5) Frames at First Floor **OR** at Basement Floors, **as directed**: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.



- 6) Frames at Other Floors: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
 - 7) Doors and Transoms at First Floor **OR** at Basement Floors, **as directed**: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
 - 8) Doors and Transoms at Other Floors: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
 - 9) Sills at First Floor **OR** at Basement Floors, **as directed**: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
 - 10) Sills at Other Floors: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
- n. Hall Fixtures at First Floor **OR** at Basement Floors, **as directed**: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Recessed type with no exposed-metal surfaces, **as directed**.
 - o. Hall Fixtures at Other Floors: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Recessed type with no exposed-metal surfaces, **as directed**.
 - p. Additional Requirements:
 - 1) Provide inspection certificate in each car, mounted under acrylic cover with frame made from polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish **OR** polished bronze, lacquered **OR** satin bronze, lacquered, **as directed**.
 - 2) Provide blanket hooks in all cars, **as directed**, and one **OR** two, **as directed**, complete set(s) of full-height protective blankets.

1.3 EXECUTION

A. Examination

1. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Verify critical dimensions and examine supporting structure and other conditions under which elevator work is to be installed.
 - a. For the record, prepare a written report, endorsed by Installer, listing dimensional discrepancies and conditions detrimental to performance or indicating that dimensions and conditions were found to be satisfactory.
 - b. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Excavation for Cylinder: Drill well hole in each, **as directed**, elevator pit to accommodate installation of cylinder; comply with applicable requirements in Division 31 Section "Earth Moving".
2. Provide waterproof well casing as necessary to retain walls of well hole.
3. Install cylinder in protective casing within well hole. Before installing protective casing, remove water and debris from well hole and provide permanent waterproof seal at bottom of well casing, **as directed**.
 - a. Fill void space between protective casing and cylinder with corrosion protective filler.
 - b. Align cylinders and fill space around protective casing with fine sand.
4. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor. Seal between well **OR** protective, **as directed**, casing and pit floor with 4 inches (100 mm) of nonshrink, nonmetallic grout.
5. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.



6. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.
7. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to effectively prevent transmission of vibrations to structure and thereby eliminate sources of structure-borne noise from elevator system.
8. Install piping above the floor, where possible. Where not possible, install underground piping in Schedule 40 PVC pipe casing assembled with solvent-cemented fittings.
OR
Install piping above the floor, where possible. Where not possible, cover underground piping with permanent protective wrapping before backfilling.
9. Lubricate operating parts of systems as recommended by manufacturers.
10. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay installation of sills and frames until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.
11. Leveling Tolerance: 1/4 inch (6 mm), up or down, regardless of load and direction of travel.
12. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.
13. Locate hall signal equipment for elevators as follows, unless otherwise indicated:
 - a. For groups of elevators, locate hall push-button stations between two elevators at center of group or at location most convenient for approaching passengers.
 - b. Place hall lanterns either above or beside each hoistway entrance.
 - c. Mount hall lanterns at a minimum of 72 inches (1829 mm) above finished floor.

C. Field Quality Control

1. Acceptance Testing: On completion of elevator installation and before permitting use (either temporary or permanent) of elevators, perform acceptance tests as required and recommended by ASME A17.1 and by governing regulations and agencies.
2. Advise Owner and authorities having jurisdiction in advance of dates and times tests are to be performed on elevators.

D. Protection

1. Temporary Use: Limit temporary use for construction purposes to one elevator, **as directed**. Comply with the following requirements for each, **as directed**, elevator used for construction purposes:
 - a. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
 - b. Provide strippable protective film on entrance and car doors and frames.
 - c. Provide padded wood bumpers on entrance door frames covering jambs and frame faces.
 - d. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
 - e. Do not load elevators beyond their rated weight capacity.
 - f. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
 - g. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

E. Demonstration

1. Train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).



2. Check operation of each, **as directed**, elevator with Owner's personnel present and before date of Final Completion. Determine that operation systems and devices are functioning properly.
3. Check operation of each, **as directed**, elevator with Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

END OF SECTION 14 01 20 71a



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Task	Specification	Specification Description
14 01 20 71	01 22 16 00	No Specification Required
14 01 30 71	14 01 20 71	Electric Traction Elevators
14 01 30 71	14 01 20 71a	Hydraulic Elevators
14 01 30 71	14 31 00 00	Escalators



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SECTION 14 24 13 00 - HYDRAULIC FREIGHT ELEVATORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for hydraulic freight elevators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes hydraulic freight elevators.

C. Definitions

1. Definitions in ASME A17.1 apply to work of this Section.
2. Defective Elevator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

D. Submittals

1. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information.
2. Shop Drawings: Show plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment and signals. Indicate variations from specified requirements, maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.
3. Samples for Initial Selection: For finishes involving color selection.
4. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator system being provided.
5. Qualification Data: For Installer.
6. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.
8. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Installer Qualifications: Elevator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Source Limitations: Obtain freight elevators, including electric traction freight elevators specified in another Division 14 Section, through one source from a single manufacturer.
 - a. Provide major elevator components, including pump-and-tank units, plunger-cylinder assemblies, controllers, signal fixtures, door operators, car frames, cabs, and entrances, manufactured by a single manufacturer.
3. Regulatory Requirements: Comply with ASME A17.1 and elevator design requirements for earthquake loads in ASCE 7.
 - a. Effective peak velocity acceleration (A_v) for Project's location is less than 0.10 (seismic risk zones 0 and 1) **OR** greater than or equal to 0.10, but less than 0.20 (seismic risk zone 2) **OR** greater than or equal to 0.20 (seismic risk zones 3 and 4), **as directed**.
 - b. Design earthquake spectral response acceleration, short period (S_d s) for Project is determined by Project's location and site classification.



- c. Project's seismic design category is A **OR** B **OR** C **OR** D, **as directed**.
- d. Elevator importance factor is 1.5 **OR** 1.0, **as directed**.
- 4. Accessibility Requirements: Comply with Section 4.10 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** 407 in ICC A117.1, **as directed**.
- 5. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** IBC Standard 3002 **OR** UL 10B, **as directed**.

F. Delivery, Storage, And Handling

- 1. Deliver, store, and handle materials, components and equipment in manufacturer's protective packaging.
- 2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's written recommendations to prevent damage, deterioration, or soiling.

G. Coordination

- 1. Coordinate installation of sleeves, block outs, and items that are embedded in concrete or masonry for elevator equipment. Furnish templates and installation instructions and deliver to Project site in time for installation.
- 2. Furnish well casing and coordinate delivery with related excavation work.
- 3. Coordinate sequence of freight elevator installation with other work to avoid delaying the Work.
- 4. Coordinate locations and dimensions of other work relating to hydraulic freight elevators including pit ladders, sumps, and floor drains in pits; entrance subsills; and electrical service, electrical outlets, lights, and switches in pits and machine rooms.

H. Warranty

- 1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective elevator work within specified warranty period.
 - a. Warranty Period: One year from date of Final Completion.

1.2 PRODUCTS

A. Systems And Components

- 1. General: Provide manufacturer's standard freight elevator systems. Where components are not otherwise indicated, provide standard components published by manufacturer as included in standard preengineered freight elevator systems and as required for complete system.
- 2. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations. Provide either of the following:
 - a. Pump, with fan-cooled squirrel-cage induction motor, mounted on oil tank with vibration isolation mounts. Enclose pump in prime-painted steel enclosure lined with 1-inch- (25-mm-) thick, glass-fiber insulation board.
 - b. Submersible pump, with submersible squirrel-cage induction motor, suspended inside oil tank from vibration isolation mounts.
 - c. Provide motor with wye-delta or solid-state starting.
- 3. Hydraulic Silencers: Provide hydraulic silencer containing pulsation-absorbing material in a blowout-proof housing at pump unit.
- 4. Piping: Provide size, type, and weight piping recommended by manufacturer, and provide flexible connectors to minimize sound and vibration transmissions from power unit.
 - a. Provide dielectric couplings at cylinder units.
 - b. Casing for Underground Piping: PVC pipe complying with ASTM D 1785, joined with PVC fittings complying with ASTM D 2466 and solvent cement complying with ASTM D 2564.



5. Hydraulic Fluid: Elevator manufacturer's standard fluid **OR** fire-resistant fluid, **as directed**, with additives as needed to prevent oxidation of fluid, corrosion of cylinder and other components, and other adverse effects.
OR
Hydraulic Fluid: Nontoxic, readily biodegradable, fluid **OR** fire-resistant fluid, **as directed**, made from vegetable oil with antioxidant, anticorrosive, antifoaming, and metal-passivating additives. Hydraulic fluid is approved by elevator manufacturer for use with elevator equipment.
 6. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Section.
 7. Protective Cylinder Casing: PVC or HDPE pipe casing complying with ASME A17.1, of sufficient size to provide not less than 1-inch (25-mm) clearance from cylinder and extending above pit floor. Provide means to monitor casing effectiveness to comply with ASME A17.1.
 8. Corrosion Protective Filler: A nontoxic, petroleum-based gel formulated for filling the space between hydraulic cylinder and protective casing. Filler is electrically nonconductive, displaces or absorbs water, and gels or solidifies at temperatures below 60 deg F (16 deg C).
 9. Car Frame and Platform: Welded steel units.
 - a. Provide special heavy-duty units where indicated for power truck loading, designed to withstand impacts and wheel loadings indicated.
 10. Guides: Provide either roller guides or sliding guides at top and bottom of car and counterweight frames. If sliding guides are used, provide guide-rail lubricators or polymer-coated, nonlubricated guides.
- B. Operation Systems
1. General: Provide manufacturer's standard microprocessor operation system for each elevator **OR** for each group of elevators, **as directed**, as required to provide type of operation system indicated.
 2. Battery-Powered Lowering: When power fails, car is lowered to the lowest floor, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
 3. Load-Weighing Device: When car load exceeds 80 percent of rated capacity, a signal light is lit in the car control station; when car load exceeds rated capacity, car will not respond to car or hall calls.
 4. Security Features: Provide the following security features, where indicated. Security features shall not affect emergency firefighters' service.
 - a. Card-Reader Operation: System uses card readers at car control stations **OR** hall push-button stations, **as directed**, to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Provide required conductors in traveling cable and panel in machine room for interconnecting card readers, other security access system equipment, and elevator controllers. Allow space as indicated for card reader in car **OR** Provide stripe-swipe card reader integral with each car control station, **as directed**.
 - 1) Security access system equipment is specified in Division 28 Section "Access Control".
OR
Security access system equipment is not in the Contract.

OR
Keyswitch Operation: Push buttons are activated and deactivated by security keyswitches at car control stations **OR** hall push-button stations, **as directed**. Key is removable only in deactivated position **OR** in either position, **as directed**.
- C. Door Reopening Devices
1. Infrared Array: Provide door reopening devices with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.

D. Finish Materials



1. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.
2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.
4. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, commercial steel, with G60 (Z180) zinc coating (galvanized) or A60 (ZF180) zinc-iron-alloy coating (galvannealed).
5. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.
 - a. Textured Stainless-Steel Sheet: Product with coined **OR** embossed, **as directed**, texture rolled into exposed surface.
6. Stainless-Steel Bars: ASTM A 276, Type 304.
7. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.
8. Rolled Steel Floor Plate: ASTM A 786/A 786M.
9. Rolled Stainless-Steel Floor Plate: ASTM A 793.
10. Aluminum-Alloy Rolled Tread Plate: ASTM B 632/B 632M, Pattern 1, Alloy 6061-T6.

E. Car Enclosures

1. General: Provide car enclosures as indicated, including ventilation, lighting, finishes, access doors, thresholds, trim, and accessories. Fabricate with recesses and cutouts for signal equipment.
 - a. Provide power door operators with linkages for hoistway door operation.
 - b. Provide standard railings complying with ASME A17.1 on car tops where required by ASME A17.1.
2. Materials and Fabrication: Provide manufacturer's standard, flush panel, welded construction made from metal sheet, of metal indicated, not less than 0.067 inch (1.7 mm) and reinforced at 16-inch (406-mm) maximum spacing.
 - a. Provide perforated panels for ceiling and for walls above 72 inches (1829 mm) from car floor unless required to be solid by ASME A17.1.

F. Hoistway Entrances

1. General: Structural-steel frames and sills for hoistway entrances are specified in Division 05 Section(s) "Structural Steel Framing" OR "Metal Fabrications", **as directed**. Unless otherwise indicated, provide hoistway entrance doors of type indicated below, with truckable sill bars and resilient safety meeting-rail gaskets.
 - a. Equip for power operation by means of coordinated linkage with power-operated car door.
 - b. Where gypsum board wall construction is indicated, provide fire-resistance-rated, hollow-metal, door-and-frame hoistway entrances. Provide self-supporting frames with reinforced head sections.
2. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:
 - a. Metal Door Panels: Constructed of metal sheets, flush on room side, welded and reinforced in steel framing with vertical reinforcing spaced not more than 24 inches (610 mm) o.c. Fabricate panel faces from metal sheet, of metal indicated, not less than 0.097 inch (2.5 mm) thick.

G. Signal Equipment

1. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements of acrylic or other permanent, nonyellowing translucent plastic.
2. Car Control Stations: Provide manufacturer's standard car control station. Mount adjacent to car door, unless otherwise indicated.
 - a. Mark buttons and switches with manufacturer's standard identification for required use or function that complies with ASME A17.1. Use both tactile symbols and Braille.
 - b. Mount controls at heights complying with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** ICC A117.1, **as directed**.



3. Emergency Communication System: Provide system that complies with ASME A17.1 and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Building and Facilities (ADAAG)." On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System provides two-way voice communication without using a handset and provides visible signals that indicate when system has been activated and when monitoring station has responded. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.
4. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet **OR** telephone jack, **as directed**, in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" **OR** "Zoned (dc Loop) Fire-alarm System".
5. Car Position Indicator: Provide illuminated digital-type car position indicator, located above car door or above car control station.
6. Hall Push-Button Stations: Provide hall push-button stations at each landing as indicated.
 - a. Provide single-button stations with position **OR** "In-Use", **as directed**, indicator.

H. Elevators

1. Elevator No(s).: **<Insert elevator number(s) as shown on Drawings.>**
 - a. Type: Under-the-car single or dual cylinder.
OR
Type: Holeless, beside-the-car, single-acting, single **OR** dual, **as directed**, cylinder.
OR
Type: Holeless, beside-the-car, telescoping, single **OR** dual, **as directed**, cylinder.
OR
Type: Holeless, beside-the-car, roped hydraulic, single **OR** dual, **as directed**, cylinder.
 - b. Rated Load: 2000 lb (908 kg) **OR** 2500 lb (1135 kg) **OR** 3000 lb (1362 kg) **OR** 4000 lb (1816 kg) **OR** 5000 lb (2270 kg) **OR** 6000 lb (2720 kg) **OR** 8000 lb (3632 kg) **OR** 10 000 lb (4540 kg), **as directed**.
 - c. Freight Loading Class: Class A **OR** B **OR** C1 **OR** C2 **OR** C3, **as directed**.
 - d. Rated Speed (Up): 50 fpm (0.25 m/s) **OR** 75 or 80 fpm (0.38 or 0.41 m/s) **OR** 100 fpm (0.51 m/s), **as directed**.
 - e. Operational Speed (Down): Approximately 30 percent more than **OR** Same as, **as directed**, rated speed (up).
 - f. Operation System: Single automatic **OR** Car-switch automatic floor-stop **OR** Selective collective automatic, **as directed**, operation.
 - g. Auxiliary Operations: Battery-powered lowering **OR** Card-reader operation **OR** Keyswitch operation **OR** Load-weighing device, **as directed**.
 - h. Auxiliary Car Control Station: Provide additional car control station mounted on side of car at height to facilitate operation by forklift-truck operator without leaving truck.
 - i. Car Enclosures:
 - 1) Platform Width: 60 inches (1524 mm) **OR** 64 inches (1626 mm) **OR** 66 inches (1676 mm) **OR** 76 inches (1930 mm) **OR** 78 inches (1981 mm) **OR** 88 inches (2235 mm) **OR** 100 inches (2540 mm) **OR** 102 inches (2591 mm) **OR** 124 inches (3150 mm) **OR** 126 inches (3200 mm), **as directed**.
 - 2) Platform Depth: 72 inches (1829 mm) **OR** 84 inches (2134 mm) **OR** 96 inches (2438 mm) **OR** 120 inches (3048 mm) **OR** 144 inches (3658 mm) **OR** 168 inches (4267 mm), **as directed**.
 - 3) Ceiling Height: 84 inches (2134 mm) **OR** 96 inches (2438 mm) **OR** 108 inches (2743 mm), **as directed**.
 - 4) Walls and Ceiling: Prime-painted steel **OR** Prime-painted, metallic-coated steel **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel, **as directed**.
 - 5) Car Fixtures: Satin stainless steel, No. 4 finish.
 - 6) Floor: Rolled steel floor plate **OR** Aluminum-alloy rolled tread plate **OR** Rolled stainless-steel floor plate, **as directed**.



- 7) Car Gate Type: Vertical biparting **OR** Single-speed vertical lift **OR** Two-speed vertical lift, **as directed**.
 - 8) Car Gate Operation: Manual **OR** Power operated, **as directed**.
 - 9) Car Gate Material: Prime-painted steel **OR** Satin stainless steel, No. 4 finish, **as directed**.
 - 10) Car Sill: Steel angle.
 - 11) Lighting: One **OR** Two **OR** Three, **as directed**, 48-inch (1219-mm), suspended, **OR** surface-mounted, **as directed**, 2-tube fluorescent light fixture(s) with white reflectors **OR** wire lamp guards, **as directed**.
OR
Lighting: One **OR** Two, **as directed**, 48-inch (1219-mm), recessed, 2 **OR** 3, **as directed**, -tube fluorescent light fixture(s) with UV stabilized acrylic diffusers not less than 0.125 inch (3.2 mm) thick.
- j. Hoistway Entrances:
- 1) Width: 56 inches (1422 mm) **OR** 60 inches (1524 mm) **OR** 62 inches (1575 mm) **OR** 72 inches (1829 mm) **OR** 96 inches (2438 mm) **OR** 98 inches (2489 mm) **OR** 120 inches (3048 mm) **OR** 122 inches (3099 mm), **as directed**.
 - 2) Height: 84 inches (2134 mm) **OR** 96 inches (2438 mm), **as directed**.
 - 3) Door Type: Vertical biparting **OR** Single-speed vertical lift **OR** Two-speed vertical lift, **as directed**.
 - 4) Fire-Protection Rating: 1 hour **OR** 1-1/2 hours, **as directed**, with 30-minute temperature rise of 450 deg F (250 deg C), **as directed**.
 - 5) Door Operation: Manual **OR** Power operated, **as directed**.
 - 6) Door Material: Prime-painted steel **OR** Satin stainless steel, No. 4 finish, **as directed**.
 - 7) Door Frame Material: Prime-painted steel **OR** Satin stainless steel, No. 4 finish, **as directed**.
 - 8) Door frames and sills are specified in Division 05 Section(s) "Structural Steel Framing" **OR** "Metal Fabrications", **as directed**.
- k. Hall Fixtures: Satin stainless steel, No. 4 finish.
- l. Auxiliary Hall Stations: Provide additional pendant-mounted, hall push-button stations where indicated mounted at height to facilitate operation by forklift-truck operator without leaving truck.
- m. Additional Requirements:
- 1) Provide door reopening device.

1.3 EXECUTION

A. Examination

1. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Verify critical dimensions and examine supporting structure and other conditions under which elevator work is to be installed.
 - a. For the record, prepare a written report, endorsed by Installer, listing dimensional discrepancies and conditions detrimental to performance or indicating that dimensions and conditions were found to be satisfactory.
 - b. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Excavation for Cylinder: Drill well hole in each elevator pit to accommodate installation of cylinder; comply with applicable requirements in Division 31 Section "Earth Moving".
2. Provide waterproof well casing as necessary to retain walls of well hole.
3. Install cylinder in protective casing within well hole. Before installing protective casing, remove water and debris from well hole and provide permanent waterproof seal at bottom of well casing.
 - a. Fill void space between protective casing and cylinder with corrosion-protective filler.



- b. Align cylinders and fill space around protective casing with fine sand.
 4. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor. Seal between well **OR** protective, **as directed**, casing and pit floor with 4 inches (100 mm) of nonshrink, nonmetallic grout.
 5. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.
 6. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.
 7. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to effectively prevent transmission of vibrations to structure and thereby eliminate sources of structure-borne noise from elevator system.
 8. Install piping above the floor, where possible. Where not possible, install underground piping in Schedule 40 PVC pipe casing assembled with solvent-cemented fittings.
OR
Install piping above the floor, where possible. Where not possible, cover underground piping with permanent protective wrapping before backfilling.
 9. Lubricate operating parts of systems as recommended by manufacturers.
 10. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay installation of sills and frames until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.
- C. Field Quality Control
1. Acceptance Testing: On completion of elevator installation and before permitting use (either temporary or permanent) of elevators, perform acceptance tests as required and recommended by ASME A17.1 and by governing regulations and agencies.
 2. Advise the Owner and authorities having jurisdiction in advance of dates and times tests are to be performed on elevators.
- D. Protection
1. Temporary Use: Limit temporary use for construction purposes to one elevator, **as directed**. Comply with the following requirements for each, **as directed**, elevator used for construction purposes:
 - a. Provide protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
 - b. Do not load elevators beyond their rated weight capacity.
 - c. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
 - d. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.
- E. Demonstration
1. Train the Owner's maintenance personnel to operate, adjust, and maintain elevator(s).
 2. Check operation of each elevator with the Owner's personnel present and before date of Final Completion. Determine that operation systems and devices are functioning properly.
 3. Check operation of each elevator with the Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.



END OF SECTION 14 24 13 00



Task	Specification	Specification Description
14 24 13 00	14 01 20 71a	Hydraulic Elevators
14 24 23 00	14 01 20 71a	Hydraulic Elevators



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**SECTION 14 26 00 00 - LIMITED-USE/LIMITED-APPLICATION ELEVATORS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for limited-use/limited-application elevators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes limited-use/limited-application (LU/LA) elevators.

C. Definitions

1. Definitions in ASME A17.1 apply to Work of this Section.
2. Defective Elevator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

D. Performance Requirements

1. Rated Load: 1400 lb (635 kg).
2. Rated Speed: 25 to 30 fpm (0.13 to 0.15 m/s).

E. Submittals

1. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information.
2. Shop Drawings: Show plans, elevations, sections, and large-scale details indicating coordination with building structure, relationships with other construction, and locations of equipment and signals.
3. Samples: For exposed finishes.
4. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator being provided.
5. Qualification Data: For Installer.
6. Operation and maintenance data.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction, for normal, unrestricted elevator use.
8. Warranty: Special warranty specified in this Section.

F. Quality Assurance

1. Installer Qualifications: Elevator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Regulatory Requirements: Comply with ASME A17.1 and elevator design requirements for earthquake loads in ASCE 7.
 - a. Affected peak velocity acceleration (A_v) for Project's location is less than 0.10 (Seismic Risk Zones 0 and 1) **OR** greater than or equal to 0.10, but less than 0.20 (Seismic Risk Zone 2) **OR** greater than or equal to 0.20 (Seismic Risk Zones 3 and 4), **as directed**.
 - b. Project's Seismic Design Category is A **OR** B **OR** C **OR** D, **as directed**.
 - c. Elevator's Importance Factor is 1.5 **OR** 1.0, **as directed**.
3. Accessibility Requirements: Comply with Sections 407.4.1 through 407.4.10 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** ICC A117.1, **as directed**.



4. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** IBC Standard 3002 **OR** UL 10B, **as directed**.

G. Delivery, Storage, And Handling

1. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's written recommendations to prevent damage, deterioration, or soiling.

H. Warranty

1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective elevator work within one year from date of Final Completion.

1.2 PRODUCTS

A. Components

1. General: Provide manufacturer's standard LU/LA elevator. Where components are not otherwise indicated, provide standard components, published by manufacturer as included in standard LU/LA elevators and as required for complete system.
2. Machine Type: Hydraulic, holeless, beside the car; either roped hydraulic or direct-acting hydraulic.
3. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations. Provide the following:
 - a. Submersible pump, with submersible squirrel-cage induction motor, **as directed**, suspended inside oil tank from vibration isolation mounts.
 - b. Pump motor with solid-state starting **OR** variable-voltage, variable-frequency motor control, **as directed**.
 - c. Hydraulic silencer and flexible piping connectors at pump unit.
4. Hydraulic Fluid: Fire-resistant fluid with antioxidant, anticorrosive, antifoaming, and metal-passivating additives. Hydraulic fluid is approved by elevator manufacturer for use with elevator equipment.
5. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Section.

B. Operation Systems

1. General: Provide manufacturer's standard microprocessor, **as directed**, operation system for single automatic operation **OR** selective collective automatic operation, **as directed**.
2. Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put into service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby, **as directed**. Manual operation causes automatic operation to cease.
3. Battery-Powered Lowering: Provide system that, when power fails, lowers car to the lowest floor, opens car and hoistway door, and shuts down. System includes rechargeable battery and automatic recharging system.
4. Emergency Operation: None required **OR** Phase I emergency recall operation **OR** Phase I emergency recall operation and Phase II emergency in-car operation, **as directed**.

C. Door Reopening Devices



1. Photoelectric Device: Provide photoelectric device that projects light beam across car entrance. Device is capable of sensing objects at 5 and 29 inches (125 and 735 mm) above the floor, **as directed**. Interruption of light beam shall cause doors to stop and reopen.
 2. Infrared Array: Provide door-reopening devices with a uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.
- D. Finish Materials
1. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.
 2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
 3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.
 4. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.
 5. Stainless-Steel Bars: ASTM A 276, Type 304.
 6. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.
 7. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063.
 8. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS for flat applications **OR** Type HGL for flat applications, **as directed**, and Type BKV for panel backing.
- E. Elevator Car Enclosures
1. General: Provide steel-framed car enclosures with wall panels, car roof, access doors, power door operators, and ventilation. Provide finished car including materials and finishes specified below.
 2. Clear Inside Dimensions:
 - a. Inside Width: 36 inches (915 mm) **OR** 42 inches (1065 mm) **OR** 48 inches (1219 mm), **as directed**, from sidewall to sidewall.
 - b. Inside Depth: 48 inches (1219 mm) **OR** 54 inches (1370 mm) **OR** 60 inches (1524 mm), **as directed**, from back wall to front wall (return panels).
 - c. Inside Height: 84 inches (2134 mm) to underside of ceiling.
 3. Materials and Finishes: Provide manufacturer's standards, but not less than the following:
 - a. Floor Finish: Specified in a Division 07 **OR** Elevator manufacturer's standard level-loop nylon carpet; color as selected from manufacturer's full range, **as directed**.
 - b. Enameled-Steel Wall Panels: Flush construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected from manufacturer's full range.
 - c. Stainless-Steel Wall Panels: Flush, hollow-metal construction; fabricated from stainless-steel sheet; polished, No. 8 **OR** satin, No. 4, **as directed**, finish.
 - d. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to manufacturer's standard core with plastic-laminate panel backing and manufacturer's standard protective edge trim. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
 - e. Sills: Extruded aluminum, with grooved surface, 1/4 inch (6.4 mm) thick.
 - f. Metal Ceiling: Flush panels, fabricated from cold-rolled steel sheet. Provide panels with factory-applied enamel or powder-coat finish; colors as selected from manufacturer's full range.
 - g. Lighting: Not less than two incandescent downlights. Provide battery backup power source with automatic charging, **as directed**.
 - h. Handrail: 1-1/2 inches (38 mm) round **OR** 1/2 by 2 inches (13 by 50 mm) rectangular **OR** Manufacturer's standard, **as directed**, polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish, **as directed**, on one side **OR** on both sides **OR** at rear, **as directed**, of car.
 4. Car Doors: Manufacturer's standard units complete with track systems, hardware, sills, and accessories.
 - a. Operation: Manual **OR** Automatic, **as directed**.
 - b. Type: Horizontal sliding **OR** Folding, **as directed**.



- c. Clear Opening Width: 32 inches (815 mm) **OR** 36 inches (914 mm), **as directed**.
- d. Door Height: 80 inches (2032 mm) **OR** 84 inches (2134 mm), **as directed**.
- e. Enameled-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected from manufacturer's full range.
- f. Primed-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer for field painting.
- g. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning. Polished, No. 8 **OR** Satin, No. 4, **as directed**, finish.
- h. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
- i. Aluminum Folding Doors: Aluminum extrusions with edges forming full-height hinges connected by stainless-steel rod.

F. Hoistway Entrances

- 1. General: Provide manufacturer's standard door-and-frame hoistway entrances, same size as car doors, complete with track systems, hardware, sills, and accessories.
 - a. Operation: Manual **OR** Automatic, **as directed**.
 - b. Type: Horizontal sliding **OR** Side hinged, **as directed**.
- 2. Provide frame size and profile to coordinate with hoistway wall construction.
 - a. Where gypsum board wall construction is indicated, provide self-supporting frames with reinforced head sections.
- 3. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:
 - a. Enameled-Steel Frames: Formed from cold-rolled or hot-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - b. Primed-Steel Frames: Formed from cold-rolled or hot-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer for field painting.
 - c. Stainless-Steel Frames: Formed from stainless-steel sheet; polished, No. 8 **OR** satin, No. 4, **as directed**, finish.
 - d. Enameled-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
 - e. Primed-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer for field painting.
 - f. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning. Polished, No. 8 **OR** Satin, No. 4, **as directed**, finish.
 - g. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
 - h. Sills: Extruded aluminum, with grooved surface, 1/4 inch (6.4 mm) thick.
 - i. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.
- 4. Fire-Protection Rating: 1 hour **OR** 1-1/2 hours, **as directed**, with 30-minute temperature rise of 450 deg F (250 deg C).

G. Signal Equipment



1. General: Provide buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with long-life incandescent lamps and acrylic or other permanent, nonyellowing translucent plastic diffusers **OR** LEDs, **as directed**.
 - a. Finish: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish, **as directed**.
2. Car Control Stations: Provide manufacturer's standard car control stations. Mount in side panel adjacent to car door, unless otherwise indicated.
 - a. Mark buttons and switches with standard identification for required use or function that complies with ASME A17.1. Use both tactile symbols and Braille.
 - b. Provide "No Smoking" sign matching car control station, either integral with car control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.
3. Emergency Communication System: Provide system that complies with ASME A17.1 and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** ICC A117.1, **as directed**. On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System indicates when it has been activated and when monitoring station has responded. System provides for two-way communication, by both voice and visual display, together with push buttons. System is contained in cabinet, with identification, instructions for use, and battery backup power supply.

OR

Emergency Telephone: Provide telephone cabinet with emergency telephone. On activation, telephone dials preprogrammed number of monitoring station **OR** 911, **as directed**, and identifies elevator location. Telephone provides two-way voice communication.
4. Car Position Indicator: Provide digital-type position indicator in elevator car. Also provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car control station.
5. Hall Push-Button Stations: Manufacturer's standard wall-mounted units, equipped with buttons for calling elevator and for indicating desired direction of travel where applicable.
6. Hall Lanterns: Manufacturer's standard units with illuminated arrows, but provide single arrow at terminal landings.
7. Hall Annunciator: Provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
8. Emergency Signs: Provide signs matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire the elevators are out of service and exit stairs should be used instead. Provide one sign at each hall push-button station, unless otherwise indicated.

1.3 EXECUTION

A. Installation

1. Install cylinder plumb and accurately located for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.
2. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to effectively prevent transmission of vibrations to structure and thereby eliminate sources of structure-borne noise from elevator system.
3. Lubricate operating parts of systems as recommended by manufacturers.
4. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Reduce clearances to minimum safe workable dimension at each landing.
5. Leveling Tolerance: 1/4 inch (6 mm), up or down, regardless of load and direction of travel.
6. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.



7. Locate hall lanterns either above or beside hoistway entrance at a minimum of 72 inches (1829 mm) above finished floor unless hall lanterns are built into entrance frames.

B. Field Quality Control

1. Acceptance Testing: On completion of elevator installation and before permitting use of elevator, perform acceptance tests as required and recommended by ASME A17.1 and by authorities having jurisdiction.
2. Advise the Owner and authorities having jurisdiction in advance of dates and times tests are to be performed.

C. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to operate, adjust, and maintain elevator.
2. Check operation of elevator with the Owner's personnel present and before date of Final Completion. Determine that operation systems and devices are functioning properly.
3. Check operation of elevator with the Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

END OF SECTION 14 26 00 00

**SECTION 14 31 00 00 - ESCALATORS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for escalators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes high-traffic, interior and exterior escalators.

C. Definitions

1. High-Traffic Escalators: Escalators designed specifically for use where high-traffic volumes produce dense occupancy resulting in structural, machinery, and brake loads much higher than normal.
2. Defective Escalator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; the need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

D. Performance Requirements

1. Rated Speed: 90 fpm (0.46 m/s) or 100 fpm (0.5 m/s).
2. Braking Performance: Provide brakes that stop escalator in up-running mode at a rate no greater than 3 ft./s² (0.91 m/s²).
OR
Braking Performance: Provide brakes that produce a stopping force on escalator in up-running mode that is one-third that used in down-running mode.
3. Step/Skirt Performance Index: Not more than 0.15.
4. Structural and Mechanical Performance for High-Traffic Escalators: For the purpose of structural design, driving machine and power transmission calculations, and brake calculations, design high-traffic escalators for loads not less than 2 times the design loads required by ASME A17.1.
5. Structural Performance of Balustrades, Deck Barricades, and Handrails: Provide components and assemblies capable of withstanding the effects of loads indicated in ASCE 7 for handrail assemblies and guardrail systems.

E. Submittals

1. Product Data: Include capacities, sizes, performances, safety features, finishes, and similar information.
2. Shop Drawings: Show plans, elevations, sections, and details indicating coordination with building structure and relationships with other construction. Indicate variations from specified requirements, maximum loads imposed on building structure at points of support, and power requirements. Indicate access and ventilation for escalator machine space.
3. Samples: For exposed finishes, 3-inch- (75-mm-) square Samples of sheet materials, and 4-inch (100-mm) lengths of running trim members.
4. Manufacturer Certificates: Signed by manufacturer certifying that escalator layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for escalator system being provided.
5. Qualification Data: For Installer.
6. Operation and Maintenance Data: For escalators to include in emergency, operation, and maintenance manuals.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted escalator use.



8. Warranty: Special warranty specified in this Section.

F. Quality Assurance

1. Installer Qualifications: Escalator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Source Limitations: Obtain escalators and moving walks, specified in another Division 14 Section, through one source from a single manufacturer.
3. Regulatory Requirements: Comply with ASME A17.1.

G. Delivery, Storage, And Handling

1. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's recommendations to prevent damage, deterioration, or soiling.

H. Coordination

1. Coordinate installation of sleeves, block outs, escalator equipment with integral anchors, and other items that are embedded in concrete or masonry for escalator equipment. Furnish templates, sleeves, escalator equipment with integral anchors, and installation instructions and deliver to Project site in time for installation.
2. Coordinate sequence of escalator installation with other work to avoid delaying the Work.
3. Coordinate locations and dimensions of other work relating to escalators including sumps and floor drains in pits, electrical service, and electrical outlets, lights, and switches in pits.

I. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective escalator work within specified warranty period.
 - a. Warranty Period: One year from date of Final Completion.

1.2 PRODUCTS

A. Materials

1. Stainless Steel: ASTM A 240/A 240M, Type 304 **OR** 316 **OR** 304, except use Type 316 for exterior escalators, **as directed**.
 - a. Satin Finish: No. 4 directional satin.
 - b. Polished Finish: No. 8 mirror polish.
 - c. Gold-Colored Satin Finish: No. 4 directional satin with gold-colored oxide or titanium nitride finish.
 - d. Gold-Colored Mirror Finish: No. 8 mirror polish with gold-colored oxide or titanium nitride finish.
2. Satin Bronze Sheet: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal), fine satin finish, lacquered.
3. Satin Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (architectural bronze), fine satin finish, lacquered.
4. Steel Sheet: Cold-rolled steel sheet, ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
5. Clear Tempered Glass: ASTM C 1048, Condition A (uncoated surfaces), Type 1 (transparent glass, flat), Class 1 (clear), Quality q3 (glazing, select), Kind FT (fully tempered), **[10.0] [12.0]** mm thick.
6. Tinted Tempered Glass: ASTM C 1048, Condition A (uncoated surfaces), Type 1 (transparent glass, flat), Class 2 (tinted), Quality q3 (glazing, select), Kind FT (fully tempered), **[10.0] [12.0]** mm thick.
 - a. Color: Bronze **OR** Gray **OR** Green, **as directed**.



B. Components

1. General: Provide preengineered escalators complying with requirements. Unless otherwise indicated, provide standard components as indicated in manufacturers' publications and as required for a complete escalator.
2. General: Provide high-traffic escalators complying with requirements. Unless otherwise indicated, provide heavy-duty components as indicated in manufacturers' publications and as required for a complete escalator.
 - a. Provide escalators with two **OR** three **OR** four, **as directed**, flat steps at top and bottom landings.
 - b. Fabricate exposed metalwork, including deck covers, balustrade panels, and trim to provide surface flatness equivalent to stretcher-leveled standard of flatness and sufficient strength for indicated use; increase metal thickness or reinforce with concealed stiffeners, backing materials, or both, as necessary. Support joints with concealed stiffeners as needed to hold exposed faces of adjoining sheets in flush alignment.
3. Opaque Balustrades: Manufacturer's standard profile or arrangement of moving handrails on fully paneled guide rail with interior balustrade panels, deck covers, skirts, trim, and accessories. Prepare for exterior finish below the deck covers, specified in another Section.
4. Transparent Balustrades: Manufacturer's standard profile or arrangement of moving handrails on guide rail that is supported by tempered glass panels, with deck covers, skirts, trim, and accessories. Prepare for exterior finish below the deck covers, specified in another Section.
5. Guards at Ceiling Intersection: Clear plastic.
6. Handrails: Smooth, jointless, reinforced neoprene.
 - a. Color: Black **OR** As selected from manufacturer's full range, **as directed**.
7. Deck Covers and Trim: Satin stainless steel **OR** Polished stainless steel **OR** Gold-colored satin stainless steel **OR** Gold-colored polished stainless steel **OR** Satin bronze, **as directed**.
8. Antislip Devices: Satin stainless steel **OR** Polished stainless steel **OR** Gold-colored satin stainless steel **OR** Gold-colored polished stainless steel **OR** Satin bronze, **as directed**.
9. Balustrade Interior Panels: Satin stainless steel **OR** Polished stainless steel **OR** Gold-colored satin stainless steel **OR** Gold-colored polished stainless steel **OR** Satin bronze, **as directed**.
10. Balustrade Exterior Panels and Escalator Soffits: Satin stainless steel **OR** Polished stainless steel **OR** Gold-colored satin stainless steel **OR** Gold-colored polished stainless steel **OR** Satin bronze, **as directed**.
11. Skirt Panels, if Applicable: Satin stainless steel **OR** Polished stainless steel **OR** Satin stainless steel with exposed surface coated with clear PTFE **OR** Steel panels with exposed surface coated with PTFE **OR** Manufacturer's standard low-friction material, **as directed**.
12. Steps: One-piece, die-cast aluminum with demarcation grooves at front and rear of tread surface.
 - a. Finish: Powder-coated, gray **OR** black, **as directed**.
 - b. Step Demarcation: Yellow inserts at sides and back of step treads.
 - c. Nosing Demarcation: 2-inch- (50-mm-) wide yellow stripe at nosings of step treads.
13. Combs: Integrally colored structural plastic **OR** Cast aluminum **OR** Cast aluminum with powder-coated finish, **as directed**.
 - a. Comb Color: Yellow.
14. Floor Plates: Cast or extruded aluminum with grooved or patterned surface and mill finish.
15. Abrasive-Surface Floor Plates: Cast or extruded aluminum **OR** Stainless steel, **as directed**, with grooved or patterned surface and with abrasive material embedded in or metallurgically bonded to floor-plate surface and having a coefficient of friction of 0.6 or higher when tested according to ASTM C 1028.
16. Operational Control: Provide escalators designed and equipped to run equally in either direction. Provide key-operated switches for directional control and key-operated starter switches located on exterior deck above newel base at both upper and lower landings of escalators.

C. Features

1. Fault Indicator: Provide escalators with a microprocessor unit that monitors safety devices, motor temperature, and escalator speed and records in nonvolatile memory date, time, and device identification if a safety device is activated or escalator malfunctions.



- a. Provide built-in or plug-in unit to display recorded information.
2. Reduced-Current Starting: Provide escalator motors with wye-delta or solid-state starting.
3. Energy-Saving Feature: Provide escalator motors and controls designed for motors to run on partial windings (at reduced power) when not under full load.
4. Provide motors complying with NEMA MG 1, Insulation Class B.
5. Brake-Saving Feature: Provide stopping mechanism that allows escalator to coast to a stop before applying brakes, unless stopping is initiated by a safety device.
6. Equip step drive mechanism with automatic step-chain lubricators.
7. Oil Drip Pan: Provide metal pan under full width and length of escalator to collect and hold oil and grease drippings from lubricated components. Design and fabricate drip pan to sustain a load of 250 lbf (1.1 kN) on a 1.0-sq. ft. (0.9-sq. m) area at any location without permanent deflection.
8. Direction Indicator Lights: Provide red and green indicator lights at least 2 inches (50 mm) in diameter in right-hand **OR** both, **as directed**, balustrade newels at both upper and lower landings. Green light indicates entrance end, and red light indicates exit end. When escalator is stopped, red lights are illuminated at both ends.
9. Combplate Lights: Provide recessed light fixtures with flush lenses mounted in skirt panels at each side of combplates designed to illuminate steps at combplate.
10. Overspeed Governor: Provide units with overspeed governor that is activated if speed of steps exceeds rated speed by more than 20 percent.
11. Upper-Landing, Step Upthrust Device: Activated if a step is displaced against upthrust track at upper curve in passenger-carrying line of track system.
12. Comb-Step Impact Device: Activated if a horizontal force in direction of travel is applied exceeding 112 lbf (500 N) at either side or exceeding 225 lbf (1000 N) at center of front edge of combplate, or a resultant force in upward direction is applied exceeding 150 lbf (688 N) at center of front edge of combplate.

D. Exterior Escalators

1. Fabricate exposed components from stainless steel **OR** bronze, **as directed**, unless otherwise indicated.
2. Hot-dip galvanize escalator trusses and other structural components to comply with ASTM A 123/A 123M. Use only stainless-steel or zinc-plated fasteners for assembly of escalator components.
3. Fabricate oil drip pan from galvanized steel sheet. Provide drain and oil/water separator in oil drip pan.
4. Provide drains, weeps, and drips to prevent water accumulation on horizontal surfaces and to direct water away from electrical equipment and moving parts.
5. Provide enclosures complying with NEMA 250, Type 4 for electrical connections, switches, and equipment.
6. Provide totally enclosed motors complying with NEMA MG 1, Insulation Class B.
7. Equip step drive mechanism with automatic step-chain lubricators.
8. Provide electric heaters with integral thermostats in escalator truss space to maintain temperature above 40 deg F (4.4 deg C).
9. Equip combplates with 400-W electric heaters to prevent ice and snow accumulation.

1.3 EXECUTION

A. Examination

1. Examine escalator areas, with Installer present, for compliance with requirements, installation tolerances, and other conditions affecting performance. Examine supporting structure, machine spaces, and pits; verify critical dimensions; and examine conditions under which escalators are to be installed.
 - a. Proceed with installation only after unsatisfactory conditions have been corrected.



- b. For the record, prepare written report, endorsed by Installer, listing dimensional discrepancies and conditions detrimental to performance or indicating that dimensions and conditions were found to be satisfactory.

B. Installation

1. Comply with manufacturer's written instructions.
2. Set escalators true to line and level, properly supported, and anchored to building structure. Use established benchmarks, lines, and levels to ensure dimensional coordination of the Work.
3. Adjust installed components for smooth, efficient operation, complying with required tolerances and free of hazardous conditions. Lubricate operating parts, including bearings, tracks, chains, guides, and hardware. Test operating devices, equipment, signals, controls, and safety devices. Install oil drip pans and verify that no oil drips outside of pans.
4. Repair damaged finishes so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

C. Field Quality Control

1. Acceptance Testing: On completion of escalator installation and before permitting use of escalators, perform acceptance tests as required and recommended by ASME A17.1 and by authorities having jurisdiction.
 - a. For escalators specified to comply with requirements more stringent than those of ASME A17.1, perform tests for compliance with specified requirements. Test optional safety devices.
2. Advise the Owner and authorities having jurisdiction in advance of dates and times tests are to be performed.

D. Demonstration

1. Train the Owner's maintenance personnel to operate, adjust, and maintain escalators.
2. Check operation of escalators with the Owner's personnel present and before date of Final Completion. Determine that operation systems and devices are functioning properly.
3. Check operation of escalators with the Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

END OF SECTION 14 31 00 00



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SECTION 14 32 00 00 - MOVING WALKS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for moving walks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes interior and exterior moving walks.

C. Definition

1. Defective Moving Walk Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; the need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

D. Performance Requirements

1. Rated Speed: 90 fpm (0.45 m/s) **OR** 100 fpm (0.5 m/s) **OR** 120 fpm (0.6 m/s) **OR** 130 fpm (0.66 m/s) **OR** 150 fpm (0.76 m/s), **as directed**.
2. Structural Performance of Balustrades, Deck Barricades, and Handrails: Provide components and assemblies capable of withstanding the effects of loads indicated in ASCE 7 for handrail assemblies and guardrail systems.

E. Submittals

1. Product Data: Include capacities, sizes, performances, safety features, finishes, and similar information.
2. Shop Drawings: Show plans, elevations, sections, and details indicating coordination with building structure and relationships with other construction. Indicate variations from specified requirements, maximum loads imposed on building structure at points of support, and power requirements. Indicate access and ventilation for moving walk machine space.
3. Samples: For exposed finishes, 3-inch- (75-mm-) square Samples of sheet materials, and 4-inch (100-mm) lengths of running trim members.
4. Manufacturer Certificates: Signed by manufacturer certifying that moving walk layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for moving walks being provided.
5. Operation and Maintenance Data: For moving walks to include in emergency, operation, and maintenance manuals.
6. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted use of moving walks.

F. Quality Assurance

1. Regulatory Requirements: Comply with ASME A17.1.

G. Delivery, Storage, And Handling

1. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's recommendations to prevent damage, deterioration, or soiling.

H. Warranty



1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective moving walk work within one year from date of Final Completion.

I. Maintenance Service

1. Initial Maintenance Service: Beginning at Final Completion, provide one years' full maintenance service by skilled employees of moving walk Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper moving walk operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.2 PRODUCTS

A. General

1. Provide preengineered pallet- or belt-type moving walks complying with requirements.

B. Materials

1. Stainless Steel: ASTM A 240/A 240M, Type 304 **OR** 316 **OR** 304, except use Type 316 for exterior moving walks, **as directed**.
 - a. Satin Finish: No. 4 directional satin.
 - b. Polished Finish: No. 8 mirror polish.
 - c. Gold-Colored Satin Finish: No. 4 directional satin with gold-colored oxide or titanium nitride finish.
 - d. Gold-Colored Mirror Finish: No. 8 mirror polish with gold-colored oxide or titanium nitride finish.
2. Satin Bronze Sheet: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal), fine satin finish, lacquered.
3. Satin Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (architectural bronze), fine satin finish, lacquered.
4. Steel Sheet: Cold-rolled steel sheet, ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
5. Clear Tempered Glass: ASTM C 1048, Condition A (uncoated surfaces), Type 1 (transparent glass, flat), Class 1 (clear), Quality q3 (glazing, select), Kind FT (fully tempered), 10.0 **OR** 12.0, **as directed**, mm thick.
6. Tinted Tempered Glass: ASTM C 1048, Condition A (uncoated surfaces), Type 1 (transparent glass, flat), Class 2 (tinted), Quality q3 (glazing, select), Kind FT (fully tempered), 10.0 **OR** 12.0, **as directed**, mm thick.
 - a. Color: Bronze **OR** Gray **OR** Green, **as directed**.

C. Components

1. General: Unless otherwise indicated, provide standard components as indicated in manufacturers' publications and as required for a complete moving walk.
 - a. Fabricate exposed metalwork, including deck covers, balustrade panels, and trim to provide surface flatness equivalent to stretcher-leveled standard of flatness and sufficient strength for indicated use; increase metal thickness or reinforce with concealed stiffeners, backing materials, or both, as necessary. Support joints with concealed stiffeners as needed to hold exposed faces of adjoining sheets in flush alignment.
2. Opaque Balustrades: Manufacturer's standard profile or arrangement of moving handrails on fully paneled guide rail with interior balustrade panels, deck covers, skirts, trim, and accessories. Prepare for exterior finish below the deck covers, specified in another Section.
3. Transparent Balustrades: Manufacturer's standard profile or arrangement of moving handrails on guide rail that is supported by clear **OR** tinted, **as directed**, tempered glass panels, with deck covers, skirts, trim, and accessories. Prepare for exterior finish below the deck covers, specified in another Section.
4. Handrails: Smooth, jointless, reinforced neoprene.



- a. Color: Black **OR** As selected from manufacturer's full range, **as directed**.
5. Deck Covers and Trim: Satin stainless steel **OR** Polished stainless steel **OR** Gold-colored satin stainless steel **OR** Gold-colored polished stainless steel **OR** Satin bronze, **as directed**.
6. Balustrade Interior Panels: Satin stainless steel **OR** Polished stainless steel **OR** Gold-colored satin stainless steel **OR** Gold-colored polished stainless steel **OR** Satin bronze, **as directed**.
7. Balustrade Exterior Panels: Satin stainless steel **OR** Polished stainless steel **OR** Gold-colored satin stainless steel **OR** Gold-colored polished stainless steel **OR** Satin bronze, **as directed**.
8. Skirt Panels, if Applicable: Polished stainless steel **OR** Satin stainless steel with exposed surface coated with clear PTFE **OR** Steel panels with exposed surface coated with PTFE, **as directed**.
 - a. Clearance between skirt panels or overhanging balustrade panels and treadway shall not exceed 1/16 inch (1.6 mm).
9. Combs: Integrally colored structural plastic **OR** Cast aluminum **OR** Cast aluminum with powder-coated finish, **as directed**.
 - a. Comb Color: Yellow **OR** Black **OR** Gray **OR** Red, **as directed**.
10. Floor Plates: Cast or extruded aluminum **OR** Stainless steel, **as directed**, with grooved or patterned surface and mill finish.
11. Abrasive-Surface Floor Plates: Cast or extruded aluminum **OR** Stainless steel, **as directed**, with grooved or patterned surface and with abrasive material embedded in or metallically bonded to floor-plate surface and having a coefficient of friction of 0.6 or higher when tested according to ASTM C 1028.
12. Operational Control: Provide moving walks designed and equipped to run equally in either direction. Provide key-operated switches for directional control and key-operated starter switches located on exterior deck above newel base at both ends of moving walks.

D. Features

1. Fault Indicator: Provide moving walks with a microprocessor unit that monitors safety devices, motor temperature, and moving walk speed and records in nonvolatile memory date, time, and device identification if a safety device is activated or moving walk malfunctions.
 - a. Provide built-in or plug-in unit to display recorded information.
2. Reduced-Current Starting: Provide moving walk motors with wye-delta or solid-state starting.
3. Energy-Saving Feature: Provide moving walk motors and controls designed for motors to run on partial windings (at reduced power) when not under full load.
4. Brake-Saving Feature: Provide stopping mechanism that allows moving walks to coast to a stop before applying brakes, unless stopping is initiated by a safety device.
5. Equip pallet drive mechanism with automatic pallet drive-chain lubricators.
6. Oil Drip Pan: Provide metal pan under full width and length of moving walks to collect and hold oil and grease drippings from lubricated components. Design and fabricate drip pan to sustain a load of 250 lbf (1.1 kN) on a 1.0-sq. ft. (0.09-sq. m) area at any location without permanent deflection.
7. Direction Indicator Lights: Provide red and green indicator lights at least 2 inches (50 mm) in diameter in right-hand **OR** both, **as directed**, balustrade newels at both landings. Green light indicates entrance end, and red light indicates exit end. When moving walk is stopped, red lights are illuminated at both ends.
8. Combplate Lights: Provide recessed light fixtures with flush lenses mounted in interior balustrade panels at each side of combplates designed to illuminate treadway at combplate.
9. Comb-Step Impact Device: Activated if a horizontal force in direction of travel is applied exceeding 112 lbf (500 N) at either side or exceeding 225 lbf (1000 N) at center of front edge of combplate, or a resultant force in upward direction is applied exceeding 150 lbf (688 N) at center of front edge of combplate.

E. Exterior Moving Walks

1. Fabricate exposed components from stainless steel **OR** bronze, **as directed**, unless otherwise indicated.
2. Hot-dip galvanize moving walk trusses and other structural components to comply with ASTM A 123/A 123M. Use only stainless-steel or zinc-plated fasteners for assembly of moving walk components.



3. Fabricate oil drip pan from galvanized steel sheet. Provide drain and oil/water separator in oil drip pan.
4. Provide drains, weeps, and drips to prevent water accumulation on horizontal surfaces and to direct water away from electrical equipment and moving parts.
5. Provide enclosures complying with NEMA 250, Type 4 for electrical connections, switches, and equipment.
6. Provide totally enclosed fan-cooled motors complying with NEMA MG 1, Insulation Class B.
7. Equip pallet drive mechanism with automatic pallet drive-chain lubricators.
8. Provide electric heaters with integral thermostats in moving walk truss space to maintain temperature above 40 deg F (4.4 deg C).
9. Equip combplates with 400-W electric heaters to prevent ice and snow accumulation.

1.3 EXECUTION

A. Installation

1. Comply with manufacturer's written instructions.
2. Set moving walks true to line and level, or to indicated slope, properly supported, and anchored to building structure. Use established benchmarks, lines, and levels to ensure dimensional coordination of the Work.
3. Adjust installed components for smooth, efficient operation, complying with required tolerances and free of hazardous conditions. Lubricate operating parts, including bearings, tracks, chains, guides, and hardware. Test operating devices, equipment, signals, controls, and safety devices. Install oil drip pans and verify that no oil drips outside of pans.
4. Repair damaged finishes so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

B. Field Quality Control

1. Acceptance Testing: On completion of moving walk installation and before permitting use of moving walks, perform acceptance tests as required and recommended by ASME A17.1 and by authorities having jurisdiction.
2. Advise the Owner, Architect, and authorities having jurisdiction in advance of dates and times tests are to be performed.

C. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to operate, adjust, and maintain moving walks.

END OF SECTION 14 32 00 00

**SECTION 14 42 13 00 - WHEELCHAIR LIFTS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for wheelchair lifts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Vertical and Private-residence, vertical platform lifts.
 - b. Inclined and Private-residence, inclined platform lifts.
 - c. Inclined and Private-residence, inclined stairway chairlifts.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For each lift. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each type of exposed finish required.
4. Manufacturer Certificates: Signed by lift manufacturer certifying that runway, ramp or pit, and dimensions as shown on Drawings and that electrical service as shown and specified are adequate for lift being provided.
5. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted use of lifts.
6. Operation and Maintenance Data: For each type of lift to include in operation and maintenance manuals.
7. Warranty: Sample of special warranty.
8. Continuing maintenance proposal.

D. Quality Assurance

1. Regulatory Requirements: In addition to requirements of authorities having jurisdiction, comply with ASME A18.1, "Safety Standard for Platform Lifts and Stairway Chairlifts."
2. Fire-Rated, Runway-Enclosure Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** IBC Standard **OR** UL 10B, **as directed**.
 - a. Temperature-Rise Limit: Provide doors that have a maximum transmitted temperature end point of not more than 450 deg F (250 deg C) above ambient after 30 minutes of standard fire-test exposure.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lifts that fail in materials or workmanship within two **OR** Four **OR** Five, **as directed**, years from date of Final Completion.

F. Maintenance Service

1. Initial Maintenance Service: Beginning at Final Completion, provide 12 months' full maintenance by skilled employees of lift Installer. Include quarterly preventive maintenance and repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for



proper lift operation at rated speed and capacity. Provide parts and supplies the same as those used in the manufacture and installation of original equipment.

2. Continuing Maintenance Proposal: From Installer to the Owner, in the form of a standard yearly **OR** two-year **OR** five-year, **as directed**, maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.2 PRODUCTS

A. Materials

1. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
2. Steel Tubing: ASTM A 500.
3. Steel Pipe: ASTM A 53/A 53M; standard weight (Schedule 40) unless otherwise indicated or required by structural loads.
4. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel (CS), Type B, exposed, matte finish.
5. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel (CS), Type B, pickled.
6. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating,
7. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:
 - a. ASTM A 123/A 123M, for galvanizing steel and iron products.
 - b. ASTM A 153/A 153M, for galvanizing steel and iron hardware.
8. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required:
 - a. Extruded Aluminum: ASTM B 221 (ASTM B 221M), Alloy 6063-T6.
 - b. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 5005-H15.
9. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304.
10. Stainless-Steel Tubing: ASTM A 554, Grade MT-304.
11. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666, Type 304.
12. Stainless-Steel Floor Plate: ASTM A 793.
13. Wood and Wood Panel Products: Comply with requirements in Division 06 Section "Interior Architectural Woodwork".
14. Wood and Wood Panel Products:
 - a. Wood: Clear, vertical-grain, straight, kiln-dried wood, AWPA C20-02, Interior Type A, fire-retardant treated, **as directed**; of manufacturer's standard species.
 - b. Wood Panels: Provide wood panels consisting of wood veneer and wood panel as follows:
 - 1) Wood Veneer: Laminated to core with moisture-resistant adhesive.
 - 2) Plywood: DOC PS 1.
 - 3) Particleboard: ANSI A208.1, made with binder containing no urea formaldehyde, **as directed**.
 - 4) Medium-Density Fiberboard: ANSI A208.2, made with binder containing no urea formaldehyde, **as directed**.
 - c. Fire-Retardant-Treated Wood Panels: Provide wood panels consisting of wood veneer and AWPA C27-02 fire-retardant-treated wood panels. Panels shall have flame-spread index of 75 **OR** 25, **as directed**, or less and smoke-developed index of 450 or less per ASTM E 84.
 - 1) Wood Veneer: Laminated to core with moisture-resistant adhesive.
 - 2) Plywood: DOC PS 1.
 - 3) Particleboard: ANSI A208.1, made with binder containing no urea formaldehyde, **as directed**.
 - 4) Medium-Density Fiberboard: ANSI A208.2, made with binder containing no urea formaldehyde, **as directed**.



15. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light-stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and manufacturer's standard finish.
 16. Glass:
 - a. Comply with requirements in Division 08 Section "Glazing".
OR
As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**, and complying with ASME A18.1.
 - 1) Safety Glazing Products: Comply with testing requirements in 16 CFR 1201, Category II.
 - 2) Safety Glass Marking: Glass permanently marked with certification label of SGCC or another certification agency or manufacturer acceptable to authorities having jurisdiction.
 17. Acrylic Glazing: ASTM D 4802, Category A-1 (cell-cast) or Category A-2 (continuous cast), Finish 1 (smooth or polished), clear or tinted as indicated.
 18. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing structural members, guide rails, machines, and other lift components where installation of devices is specified in another Section.
 19. Expansion Anchors: Anchor-bolt-and-sleeve assembly of material indicated below with capability to sustain a load equal to 10 times the load imposed as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.
 - a. Material:
 - 1) Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.
OR
Group 1, Alloy 304 or Alloy 316, stainless-steel bolts and nuts complying with ASTM F 593 (ASTM F 738M) and ASTM F 594 (ASTM F 836M).
 20. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.
- B. Vertical Platform Lifts
1. Private-Residence, **as directed**, Vertical Platform Lifts: Manufacturer's standard preengineered lift systems as indicated.
 2. Platform Size: 34 by 54 inches (864 by 1372 mm) **OR** 35 by 48 inches (889 by 1220 mm) **OR** 35 by 51 inches (889 by 1295 mm) **OR** 36 by 56 inches (914 by 1422 mm) **OR** 36 by 60 inches (914 by 1524 mm), **as directed**.
 3. Door Operation and Clear Opening Width: Low-energy, power-operated doors that remain open for 20 seconds minimum; end door with minimum 32-inch (815-mm) and side door with minimum 42-inch (1065-mm) clear opening width.
 4. Rated Speed: 8 fpm (0.04 m/s) **OR** 10 fpm (0.05 m/s) **OR** 12 fpm (0.06 m/s) **OR** 15 fpm (0.08 m/s) **OR** 20 fpm (0.10 m/s) **OR** 22 fpm (0.11 m/s) **OR** 30 fpm (0.15 m/s), **as directed**.
 5. Power Supply: 208 V, 60 Hz, 3 phase **OR** 240 V, 60 Hz, 1 phase **OR** 120 V, 60 Hz, 1 phase, **as directed**.
 6. Emergency Operation: Provide emergency manual operation and emergency battery power system **OR** connection to indicated standby (emergency) power, **as directed**, to raise or lower units in case of malfunction or power loss.
 7. Attendant Operation: Provide attendant operation at location shown.
 8. Self-Supporting Units: Support vertical loads of units only at base, with lateral support only at landing levels.
 9. Partial, **as directed**, Runway Enclosure: Manufacturer's standard weather-resistant, **as directed**, enclosure assembly.
 - a. Runway Enclosure: One of the following, **as directed**.
 - 1) Rectangular steel-tube frame with flush steel-sheet panels.
 - 2) Rectangular hot-dip-galvanized steel-tube frame with flush galvanized-steel-sheet panels.
 - 3) Extruded-aluminum frame with flush galvanized-steel-sheet panels.



- 4) Extruded-aluminum frame with flush aluminum-sheet panels; with hot-dip-galvanized steel-tube frame for structural framing that cannot be aluminum.
 - 5) Rectangular steel-tube frame with wood panels and trim.
 - 6) Rectangular wood frame with wood panels and trim.
 - 7) Rectangular steel-tube frame with fiberglass panels.
 - b. Glazed Runway Enclosure: Rectangular structure of glazed extruded-aluminum framing with a tinted, acrylic dome roof.
 - 1) Glazing:
 - a) Bronze-tinted acrylic glazing, 6.0 mm thick.
OR
Bronze-tinted, float glass **OR** tempered safety **OR** laminated safety, **as directed**, glass, 6.0 mm thick, where indicated.
 - c. Runway-Enclosure Doors: One of the following, **as directed**:
 - 1) Rectangular steel-tube frames with flush steel-sheet panels.
 - 2) Rectangular steel-tube frames glazed with 6.0-mm-thick, clear acrylic glazing and with 12-inch- (300-mm-) high, steel kick panels.
 - 3) Wide-stile aluminum entrance doors glazed with bronze-tinted tempered safety glass, 6.0 mm thick.
 - 4) Enclosure doors matching appearance of adjacent glass-supported railings, complying with Division 05 Section "Decorative Metal Railings".
 - d. Fire-Rated Runway-Enclosure Door: Provide fire-rated runway-enclosure door where shown **OR** at upper landing **OR** at lower landing, **as directed**.
 - 1) Fire-Protection Rating: 1-1/2 hours.
 - 2) Equip door with wired glass vision panel, delay-action door closer, dead latch, dummy trim door handle, and electric strike.
10. Platform: One of the following, **as directed**:
 - a. Galvanized-steel sheet with black rubber flooring.
 - b. Stainless-steel floor plate with checkered texture.
 - c. Aluminum floor plate with nonskid surface texture.
 11. Platform Low-Profile Carriage: Fabricate platform floor assembly to total thickness not exceeding 1-1/2 inches (38 mm).
 12. Platform Enclosure and Door: One of the following, **as directed**:
 - a. Rectangular steel-tube frame with flush steel-sheet panels.
 - b. Rectangular hot-dip-galvanized steel-tube frame with flush galvanized-steel-sheet panels.
 - c. Extruded-aluminum frame with flush galvanized-steel-sheet panels.
 - d. Extruded-aluminum frame with flush aluminum-sheet panels; with hot-dip-galvanized steel-tube frame for structural framing that cannot be aluminum.
 - e. Rectangular steel-tube frame with wood panels and trim.
 - f. Rectangular steel-tube frame with fiberglass panels.
 - g. Enclosure walls and doors matching appearance of adjacent glass-supported railings, complying with Division 05 Section "Decorative Metal Railings".
 13. Platform Top: Provide a non-load-bearing top, matching construction of enclosure walls. Permanently mark top to indicate that it cannot sustain a load.
 14. Fixed Ramp: Provide fixed ramp matching platform to provide transition from floor to lift platform at bottom landing.
 15. Retractable Ramp: Provide ramp matching platform to provide transition from lower floor to lift platform. Ramp lowers to floor automatically when lifts reach lower landing and door opens. Ramp rises automatically when lift control is activated for lift to leave lower landing.
 - a. Ramp Size: End ramps a minimum of 32 inches (815 mm) and side ramps a minimum of 42 inches (1065 mm) wide; length as required for slope.
 - b. Ramp Slope: As indicated **OR** Maximum 1:12, **as directed**.
 - c. Ramp Finish: Finish ramps to match lift platform **OR** Ramp finish is specified elsewhere as indicated, **as directed**.
 16. Accessories: Provide units with the following accessories:
 - a. Fold-down seat with armrests and safety belt.



- b. Forced Ventilation System: Minimum 1 air change per minute, continuously operating **OR** thermostatically controlled to activate at 90 deg F (32.22 deg C) , **as directed**, and with auxiliary power source to operate ventilation for 1 hour in case of power failure.
 - c. Lighting system within lift enclosures as indicated on Drawings **OR** selected from manufacturer's available products, **as directed**.
- C. Inclined Platform Lifts
- 1. Private-Residence, **as directed**, Inclined Platform Lifts: Manufacturer's standard preengineered lift systems as indicated.
 - 2. Platform Size: 29 by 33 inches (737 by 838 mm) **OR** 28 by 35 inches (711 by 889 mm) **OR** 30 by 35 inches (760 by 889 mm) **OR** 30 by 36 inches (760 by 914 mm) **OR** 31 by 39 inches (787 by 991 mm) **OR** 30 by 41 inches (760 by 1041 mm) **OR** 30 by 42 inches (760 by 1067 mm) **OR** 31 by 43 inches (787 by 1092 mm) **OR** 30 by 48 inches (760 by 1220 mm), **as directed**.
 - 3. Door Operation and Clear Opening Width: Low-energy, power-operated doors that remain open for 20 seconds minimum; end door with minimum 32-inch (815-mm) and side door with minimum 42-inch (1065-mm) clear opening width.
 - 4. Rated Speed: 20 fpm (0.10 m/s) **OR** 22 fpm (0.11 m/s) **OR** 25 fpm (0.13 m/s) **OR** 30 fpm (0.15 m/s), **as directed**.
 - 5. Minimum Headroom Clearance during Travel: Minimum of 80 inches (2032 mm) above any point on platform floor.
 - 6. Power Supply: 208 V, 60 Hz, 3 phase **OR** 240 V, 60 Hz, 1 phase **OR** 120 V, 60 Hz, 1 phase, **as directed**.
 - 7. Emergency Operation: Provide emergency manual operation and emergency battery power system **OR** connection to indicated standby (emergency) power, **as directed**, to raise or lower units in case of malfunction or power loss.
 - 8. Attendant Operation: Provide attendant operation at location shown.
 - 9. Platform: One of the following, **as directed**:
 - a. Galvanized-steel sheet with black rubber flooring.
 - b. Stainless-steel floor plate with checkered texture.
 - c. Aluminum floor plate with nonskid surface texture.
 - 10. Automatic Folding Platforms: When not in use, platforms automatically fold up against wall to minimize projection into stairway.
 - 11. Manual Folding Platforms: When not in use, platforms can be folded up against wall to minimize projection into stairway.
 - 12. Platform Guarding: Guard platform with passenger restraining arms **OR** enclosure, **as directed**.
 - a. Passenger Restraining Arms: Steel **OR** Galvanized-steel **OR** Stainless-steel, **as directed**, tubing, manually **OR** power, **as directed**, operated.
 - b. Platform Enclosure (Side Walls and Self-Closing Door): One of the following, **as directed**:
 - 1) Rectangular steel-tube frame with flush steel-sheet panels.
 - 2) Enclosure walls and doors matching appearance of adjacent glass-supported railings, complying with Division 05 Section "Decorative Metal Railings".
 - 13. Platform Guarding: Guard platform with automatically **OR** manually, **as directed**, actuated, retractable metal guard on lower access end of platform.
 - 14. Fixed Ramp: Provide fixed ramp matching platform to provide transition from floor to lift platform at bottom landing.
 - 15. Retractable Ramp: Provide ramp matching platform to provide transition from floor to lift platform. Ramp lowers to floor automatically when lifts reach landing and enclosure door opens. Ramp rises automatically when lift control is activated for lift to leave landing.
 - a. Ramp Size: End ramps a minimum of 32 inches (815 mm) and side ramps a minimum of 42 inches (1065 mm) wide; length as required for slope.
 - b. Ramp Slope: As indicated **OR** Maximum 1:12, **as directed**.
 - c. Ramp Finish: Finish ramps to match lift platform **OR** Ramp finish is specified elsewhere as indicated, **as directed**.
 - 16. Supporting Structure: Provide framing to support vertical loads from floor or stair treads and only lateral loads from walls. Fabricate framing from steel **OR** stainless-steel, **as directed**, rectangular tubing, plates, shapes, and bars.



17. Guide Rails: Fabricate from steel **OR** stainless-steel, **as directed**, tubing.
18. Accessories: Provide units with the following accessories:
 - a. Fold-down seat with armrests and safety belt.
 - b. Caution sign as required by ASME A18.1.

D. Inclined Stairway Chairlifts

1. Private-Residence, **as directed**, Inclined Stairway Chairlifts: Manufacturer's standard preengineered lift systems as indicated.
2. Systems and Machinery: Manufacturer's standard preengineered lift systems as indicated in published product literature and as follows:
 - a. Rated Capacity: Minimum 250 lb (113 kg) **OR** 400 lb (181 kg), **as directed**.
 - b. Rated Speed: 18 fpm (0.09 m/s) **OR** 20 fpm (0.10 m/s) **OR** 22 fpm (0.11 m/s) **OR** 25 fpm (0.13 m/s), **as directed**.
3. Power Supply: 120 V, 60 Hz, 1 phase.
4. Battery Operation: Provide battery-operated drive with automatic charging system.
5. Manual Lowering: Provide means to manually lower units in case of malfunction or power loss.
6. Folding Units: Provide units that can be folded up against wall when not in use, to minimize projection into stairway.
7. Supporting Structure: Provide brackets to support vertical loads from floor or stair treads and to support lateral loads from walls. Fabricate brackets from steel plates, shapes, or bars.
8. Accessories: Provide units with the following accessories:
 - a. Tubular-steel, manually operated safety arms designed to restrain and provide grab bar for occupant.
 - b. Retractable seat belt.
 - c. Seat with back and two handgrips or arms.

E. General Finish Requirements

1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

F. Finishes

1. Steel and Galvanized-Steel Factory Finish:
 - a. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard 2-coat, baked-on finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat.
 - b. Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard, thermosetting polyester or acrylic urethane powder coating with a cured film thickness not less than 1.5 mils (0.04 mm).
 - c. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
2. Stainless-Steel Finishes:
 - a. Floor Plate Finish: Mill **OR** Abrasive blasted, **as directed**.
 - b. Grab Rail Finish: As selected from manufacturer's full range **OR** Directional satin finish No. 4, **as directed**.
3. Aluminum Finishes:
 - a. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
 - b. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
 - 1) Color: As selected from full range of industry colors and color densities.



- c. Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard, thermosetting polyester or acrylic urethane powder coating with a cured film thickness not less than 1.5 mils (0.04 mm).
 - 1) Color and Gloss: As selected from manufacturer's full range.
4. Wood Finish:
 - a. As specified in Division 09 Section "Staining And Transparent Finishing".
OR
As selected from manufacturer's full range, as follows:
 - 1) Type: Transparent finish **OR** Transparent finish over stain, **as directed**, over wood variety indicated.
5. Fiberglass Color and Gloss: As selected from manufacturer's full range.

1.3 EXECUTION

A. Installation

1. Wiring Method: Conceal conductors and cables within housings of units or building construction. Do not install conduit exposed to view in finished spaces. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
2. Coordinate runway doors with platform travel and positioning, for accurate alignment and minimum clearance between platforms, runway doors, sills, and door frames.
3. Position sills accurately and fill space under sills solidly with nonshrink, nonmetallic grout.
4. Coordinate platform doors with platform travel and positioning.
5. Adjust stops for accurate stopping and leveling at each landing, within required tolerances.
 - a. Leveling Tolerance: 1/4 inch (6 mm) up or down, regardless of load and direction of travel.
6. Adjust retractable ramps to meet maximum allowable slope and change-in-elevation requirements, and to lie fully against landing surfaces.
7. Lubricate operating parts of lift, including drive mechanism, guide rails, hinges, safety devices, and hardware.
8. Test safety devices and verify smoothness of required protective enclosures and fascias

B. Field Quality Control

1. Acceptance Testing: On completion of lift installation and before permitting use of lifts, perform acceptance tests as required and recommended by ASME A18.1 and authorities having jurisdiction.
2. Operating Test: In addition to above testing, load lifts to rated capacity and operate continuously for 30 minutes between lowest and highest landings served. Readjust stops, signal equipment, and other devices for accurate stopping and operation of system.
3. Advise the Owner, Architect, and authorities having jurisdiction in advance of dates and times tests are to be performed on lifts.

C. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain lifts. Include a review of emergency systems and emergency procedures to be followed at time of operational failure and other building emergencies.

END OF SECTION 14 42 13 00



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Task	Specification	Specification Description
14 42 16 00	14 42 13 00	Wheelchair Lifts



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**SECTION 14 91 82 00 - CHUTES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for chutes. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes waste and laundry chutes.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
3. Operation and maintenance data.

D. Quality Assurance

1. NFPA Compliance: Provide chutes complying with NFPA 82.
2. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated.
 - a. Test Pressure: Test at atmospheric (neutral) pressure according to NFPA 252 or UL 10B.
 - b. Intake Door: Class B labeled; 1-hour **OR** 1-1/2-hour, **as directed**, fire rated with 30-minute temperature rise of 250 deg F (140 deg C), **as directed**.
 - c. Discharge Door: Class B labeled; 1-hour fire rated with 30-minute temperature rise of 250 deg F (140 deg C), **as directed**.
 - d. Access Door: Class B labeled; 1-hour **OR** 1-1/2-hour, **as directed**, fire rated with 30-minute temperature rise of 250 deg F (140 deg C), **as directed**.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Chutes

1. Chute Metal: Aluminum-coated, cold-rolled, commercial steel sheet; ASTM A 463/A 463M, Type 1 with not less than T1-40 (T1M-120) coating **OR** Type 430 stainless steel, ASTM A 240/A 240M **OR** Type 304 stainless steel, ASTM A 240/A 240M, **as directed**.
 - a. Thickness: 0.060 inch (1.6 mm) **OR** 0.080 inch (2.0 mm), **as directed**.
2. Size: 20-inch (508-mm) diameter **OR** 24-inch (610-mm) diameter **OR** As indicated on Drawings, **as directed**.

B. Doors

1. Intake Door Assemblies: ASTM A 240/A 240M, Type 304 stainless-steel, self-closing units with positive latch and latch handle; as required to provide fire-protection and temperature-rise, **as directed**, ratings indicated; and with frame suitable for enclosing chase construction.
 - a. Door Type: Hopper **OR** Hopper, limited access **OR** Side hinged, limited access, 180-degree swing, square **OR** Type as indicated on Drawings, **as directed**.
 - b. Size: Manufacturer's standard size for door type, chute type, and diameter indicated.
 - c. Finish: Manufacturer's standard satin or No. 3 directional polish.



- d. Locks: Cylinder locks with keys that are removable only when cylinder is locked. For each chute, key locks alike **OR** to master key system, **as directed**. For each door, furnish four, **as directed**, keys.
 - e. Foot Operators: Hopper-type door operators that unlatch and open door when foot pedal is depressed.
 - f. Mechanical Interlocks: Interlock system operated from discharge door to automatically lock intake doors.
 - g. Electrical Interlocks: Interlock system that is energized by opening one intake door; remaining doors automatically lock when system is energized.
2. Discharge-Door Assemblies: Aluminum-coated-steel doors as required to provide fire-protection and temperature-rise, **as directed**, ratings indicated; equipped with fusible links that cause doors to close in the event of fire.
 - a. Direct Vertical Discharge: Provide inclined, horizontally rolling, shutter-type unit.
 - b. Horizontal Discharge: Provide top-hinged, self-closing, hopper door with self-latching hardware; floor-mounted leg brace designed to absorb impact of material dropping against chute; and minimum NPS 2 (DN 50) drain pipe connection.
 3. Heat- **OR** Heat- and Smoke-, **as directed**, Detector System: Interlock system with temperature-rise elements that locks chute doors when temperature in chute reaches a predetermined, adjustable temperature.
 - a. Locate smoke detector outside discharge door with solenoid to close discharge door.
 4. Access Door Assemblies: Manufacturer's standard ASTM A 240/A 240M, Type 302/304 stainless-steel doors; as required to provide fire-protection and temperature-rise, **as directed**, ratings indicated; with frame suitable for enclosing chase construction; and in satin or No. 3 directional polish finish.
 5. Manual Control System: Control system with manual switches that lock doors of chute during shutdown hours and service operations.
- C. Accessories
1. Fire Sprinklers: NPS 1/2 (DN 13) fire sprinklers ready for piping connections.
 2. Flushing Spray Unit: NPS 3/4 (DN 19) spray head unit located in chute above highest intake door, ready for hot-water piping connection, and with access for head and piping maintenance.
 3. Sanitizing Unit: NPS 3/4 (DN 19) disinfecting and sanitizing spray head unit located in chute above highest intake door, including 1-gal. (3.8-L) tank and adjustable proportioning valve with bypass for manual control of sanitizing and flushing operation, ready for hot-water piping connection, and with access for head and piping maintenance.
 4. Intake Door Baffles: Rubber baffles, 1/8 inch (3 mm) thick.
 5. Sound Dampening: Manufacturer's standard exterior mastic coating on chute.
 - a. Sound and vibration isolator pads at floor supporting frames.
- D. Fabrication
1. General: Factory-assemble chutes to greatest extent practical with continuously welded or lock-seamed joints without bolts, rivets, or clips projecting on chute interior. Include intake-door assemblies and metal supporting framing at each floor, and chute expansion joints between each support point.
 2. Roof Vent: Fabricate vent unit to extend 36 inches (910 mm) **OR** 48 inches (1200 mm), **as directed**, above roof with full-diameter, screened vent and metal safety cap or glass explosion-release cap. Fabricate with roof-deck flange, counterflashing, and clamping ring of nonferrous metal compatible with chute metal.
 3. Fire Sprinklers: Comply with NFPA 13. Locate fire sprinklers at or above the top service opening of chutes, within the chute at alternate floor levels in buildings more than two stories tall, and at the lowest service level.
 4. Equipment Access: Fabricate chutes with access for maintaining equipment located within the chute, such as flushing and sanitizing units, fire sprinklers, and plumbing and electrical connections.



1.3 EXECUTION

A. Installation

1. General: Comply with NFPA 82 requirements and with chute manufacturer's written instructions. Assemble components with tight, nonleaking joints. Anchor securely to supporting structure to withstand impact and stresses on vent units. Install chute and components to maintain fire-resistant construction of chute and enclosing chase.
2. Install chutes plumb, without offsets or obstructions that might prevent materials from free falling within chutes.
3. Anchor roof flanges of chute vents before installing roofing and flashing. Install chute-vent counterflashing after roofing and roof-penetration flashing are installed.
4. Intake and Discharge Doors: Interface door units with throat sections of chutes for safe, snag-resistant, sanitary depositing of materials in chutes by users.
 - a. Coordinate installation of foot-pedal door operator with installation of door and chase.
 - b. Interconnect sanitizer control with door interlock system.
5. Electrical Interlock System: Comply with applicable NECA 1 recommendations.
6. Test chute components after installation. Operate doors, locks, and interlock systems to demonstrate that hardware is adjusted and electrical wiring is connected correctly. Complete test operations before installing chase enclosures.
7. Test fire sprinklers and heat- and smoke-sensing devices for proper operation.
8. Operate sanitizing unit through one complete cycle of chute use and cleanup, and replenish chemicals or cleaning fluids in unit containers.

B. Cleaning

1. After completing chase enclosure, clean exposed surfaces of chute system's components. Do not remove labels of independent testing and inspecting agencies.

END OF SECTION 14 91 82 00



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**SECTION 21 05 13 00 - COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common motor requirements for fire suppression equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

C. Coordination

1. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - a. Motor controllers.
 - b. Torque, speed, and horsepower requirements of the load.
 - c. Ratings and characteristics of supply circuit and required control sequence.
 - d. Ambient and environmental conditions of installation location.

1.2 PRODUCTS

A. General Motor Requirements

1. Comply with requirements in this Section except when stricter requirements are specified in fire suppression equipment schedules or Sections.
2. Comply with NEMA MG 1 unless otherwise indicated.
3. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics

1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
 - a. For motors with 2:1 speed ratio, consequent pole, single winding.
 - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:

Common Motor Requirements for Fire Suppression Equip-
ment



- a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Polyphase Motors With Additional Requirements

1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors

1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split phase.
 - c. Capacitor start, inductor run.
 - d. Capacitor start, capacitor run.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 HP and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.3 EXECUTION (Not Applicable)

END OF SECTION 21 05 13 00



SECTION 21 05 19 00 - WATER DISTRIBUTION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for water distribution. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes water-distribution piping and related components outside the building for water service **OR** fire-service mains **OR** combined water service and fire-service mains, **as directed**.
2. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

C. Definitions

1. EPDM: Ethylene propylene diene terpolymer rubber.
2. LLDPE: Linear, low-density polyethylene plastic.
3. PA: Polyamide (nylon) plastic.
4. PE: Polyethylene plastic.
5. PP: Polypropylene plastic.
6. PVC: Polyvinyl chloride plastic.
7. RTRF: Reinforced thermosetting resin (fiberglass) fittings.
8. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
 - a. Wiring Diagrams: Power, signal, and control wiring for alarms.
3. Field quality-control test reports.
4. Operation and Maintenance Data.

E. Quality Assurance

1. Regulatory Requirements:
 - a. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
 - b. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
 - c. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
2. Piping materials shall bear label, stamp, or other markings of specified testing agency.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.
5. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.
6. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
7. NSF Compliance:



- a. Comply with NSF 14 for plastic potable-water-service piping. Include marking "NSF-pw" on piping.
- b. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

F. Delivery, Storage, And Handling

1. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
 - a. Ensure that valves are dry and internally protected against rust and corrosion.
 - b. Protect valves against damage to threaded ends and flange faces.
 - c. Set valves in best position for handling. Set valves closed to prevent rattling.
2. During Storage: Use precautions for valves, including fire hydrants, according to the following:
 - a. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
 - b. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.
3. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.
4. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
5. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
6. Protect flanges, fittings, and specialties from moisture and dirt.
7. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

G. Project Conditions

1. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of service.
 - b. Do not proceed with interruption of water-distribution service without the Owner's written permission.

H. Coordination

1. Coordinate connection to water main with utility company.

1.2 PRODUCTS

A. Copper Tube And Fittings

1. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**, water tube, annealed temper.
 - a. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
 - b. Copper, Pressure-Seal Fittings:
 - 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
2. Hard Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**, water tube, drawn temper.
 - a. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
 - b. Copper, Pressure-Seal Fittings:



- 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
 3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
 4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- B. Ductile-Iron Pipe And Fittings
1. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - a. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - b. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
 2. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - a. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - b. Gaskets: AWWA C111, rubber.
 3. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.
 - a. Grooved-End, Ductile-Iron Pipe Appurtenances:
 - 1) Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
 - 2) Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
 4. Flanges: ASME 16.1, Class 125, cast iron.
- C. PE Pipe And Fittings
1. PE, ASTM Pipe: ASTM D 2239, SIDR No. 5.3, 7, or 9; with PE compound number required to give pressure rating not less than 160 psig (1100 kPa) **OE** 200 psig (1380 kPa), **as directed**.
 - a. Insert Fittings for PE Pipe: ASTM D 2609, made of PA, PP, or PVC with serrated male insert ends matching inside of pipe. Include bands or crimp rings.
 - b. Molded PE Fittings: ASTM D 3350, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.
 2. PE, AWWA Pipe: AWWA C906, DR No. 7.3, 9, or 9.3; with PE compound number required to give pressure rating not less than 160 psig (1100 kPa) **OR** 200 psig (1380 kPa), **as directed**.
 - a. PE, AWWA Fittings: AWWA C906, socket- or butt-fusion type, with DR number matching pipe and PE compound number required to give pressure rating not less than 160 psig (1100 kPa) **OR** 200 psig (1380 kPa), **as directed**.
 3. PE, Fire-Service Pipe: ASTM F 714, AWWA C906, or equivalent for PE water pipe; FMG approved, with minimum thickness equivalent to FMG Class 150 and Class 200.
 - a. Molded PE Fittings: ASTM D 3350, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.
- D. PVC Pipe And Fittings
1. PVC, Schedule 40 Pipe: ASTM D 1785.
 - a. PVC, Schedule 40 Socket Fittings: ASTM D 2466.
 2. PVC, Schedule 80 Pipe: ASTM D 1785.
 - a. PVC, Schedule 80 Socket Fittings: ASTM D 2467.
 - b. PVC, Schedule 80 Threaded Fittings: ASTM D 2464.
 3. PVC, AWWA Pipe: AWWA C900, Class 150 **OR** Class 200, **as directed**, with bell end with gasket, and with spigot end.
 - a. Comply with UL 1285 for fire-service mains if indicated.



- b. PVC Fabricated Fittings: AWWA C900, Class 150 **OR** Class 200, **as directed**, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
 - c. PVC Molded Fittings: AWWA C907, Class 150, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
 - d. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 1) Gaskets: AWWA C111, rubber.
 - e. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 1) Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- E. Fiberglass Pipe And Fittings
- 1. AWWA RTRP: AWWA C950, Class 150 **OR** Class 200 **OR** Class 250, **as directed**, Type I **OR** II, **as directed**, Grade 1, epoxy **OR** Grade 2, polyester, **as directed**, with bell-and-spigot ends for bonded **OR** with gasket or seal for gasketed, **as directed**, joints. Liner is optional, unless otherwise indicated.
 - a. RTRF: AWWA C950, similar to pipe in material, pressure class, and joining method.
 - 2. UL RTRP: UL 1713, Class 150 **OR** Class 200 **OR** Class 250, **as directed**, with bell-and-spigot ends with gasket or seal for gasketed joints. Liner is optional, unless otherwise indicated.
 - a. RTRF: Similar to pipe in material, pressure class, and joining method.
- F. Special Pipe Fittings
- 1. Ductile-Iron Rigid Expansion Joints:
 - a. Description: Three-piece, ductile-iron assembly consisting of telescoping sleeve with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - 1) Pressure Rating: 250 psig (1725 kPa) minimum.
 - 2) Expansion Required: As directed by the manufacturer or as directed by the Owner.
 - 2. Ductile-Iron Flexible Expansion Joints:
 - a. Description: Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - 1) Pressure Rating: 250 psig (1725 kPa) minimum.
 - 2) Offset: As directed by the manufacturer or as directed by the Owner.
 - 3) Expansion Required: As directed by the manufacturer or as directed by the Owner.
 - 3. Ductile-Iron Deflection Fittings:
 - a. Description: Compound, ductile-iron coupling fitting with sleeve and 1 or 2 flexing sections for up to 15-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - 1) Pressure Rating: 250 psig (1725 kPa) minimum.
- G. Joining Materials
- 1. Refer to Division 33 Section "Common Work Results For Utilities" for commonly used joining materials.
 - 2. Brazing Filler Metals: AWS A5.8, BCuP Series.
 - 3. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.
 - 4. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- H. Piping Specialties



1. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
 2. Tubular-Sleeve Pipe Couplings:
 - a. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.
 - 1) Standard: AWWA C219.
 - 2) Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
 - 3) Gasket Material: Natural or synthetic rubber.
 - 4) Pressure Rating: 150 psig (1035 kPa) **OR** 200 psig (1380 kPa), **as directed**, minimum.
 - 5) Metal Component Finish: Corrosion-resistant coating or material.
 3. Split-Sleeve Pipe Couplings:
 - a. Description: Metal, bolted, split-sleeve-type, reducing or transition coupling with sealing pad and closure plates, O-ring gaskets, and bolt fasteners.
 - 1) Standard: AWWA C219.
 - 2) Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel, **as directed**.
 - 3) Sleeve Dimensions: Of thickness and width required to provide pressure rating.
 - 4) Gasket Material: O-rings made of EPDM rubber, unless otherwise indicated.
 - 5) Pressure Rating: 150 psig (1035 kPa) **OR** 200 psig (1380 kPa), **as directed**, minimum.
 - 6) Metal Component Finish: Corrosion-resistant coating or material.
 4. Flexible Connectors:
 - a. Nonferrous-Metal Piping: Bronze hose covered with bronze wire braid; with copper-tube, pressure-type, solder-joint ends or bronze flanged ends brazed to hose.
 - b. Ferrous-Metal Piping: Stainless-steel hose covered with stainless-steel wire braid; with ASME B1.20.1, threaded steel pipe nipples or ASME B16.5, steel pipe flanges welded to hose.
 5. Dielectric Fittings: Combination of copper alloy and ferrous; threaded, solder, or plain end types; and matching piping system materials.
 - a. Dielectric Unions: Factory-fabricated union assembly, designed for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C). Include insulating material that isolates dissimilar metals and ends with inside threads according to ASME B1.20.1.
 - b. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure to suit system pressures.
 - c. Dielectric-Flange Insulation Kits: Field-assembled companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1) Provide separate companion flanges and steel bolts and nuts for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure to suit system pressures.
 - d. Dielectric Couplings: Galvanized-steel couplings with inert and noncorrosive thermoplastic lining, with threaded ends and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
 - e. Dielectric Nipples: Electroplated steel nipples with inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved end types, and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
- I. Corrosion-Protection Piping Encasement
1. Encasement for Underground Metal Piping:
 - a. Standards: ASTM A 674 or AWWA C105.
 - b. Form: Sheet **OR** Tube, **as directed**.
 - c. Material: LLDPE film of 0.008-inch (0.20-mm) minimum thickness.
 - d. Material: LLDPE film of 0.008-inch (0.20-mm) minimum thickness, or high-density, crosslaminated PE film of 0.004-inch (0.10-mm) minimum thickness.



- e. Material: High-density, crosslaminated PE film of 0.004-inch (0.10-mm) minimum thickness.
- f. Color: Black **OR** Natural, **as directed**.

J. Gate Valves

1. AWWA, Cast-Iron Gate Valves:

- a. Nonrising-Stem, Metal-Seated Gate Valves:
 - 1) Description: Gray- or ductile-iron body and bonnet; with cast-iron or bronze double-disc gate, bronze gate rings, bronze stem, and stem nut.
 - a) Standard: AWWA C500.
 - b) Minimum Pressure Rating: 200 psig (1380 kPa).
 - c) End Connections: Mechanical joint.
 - d) Interior Coating: Complying with AWWA C550.
- b. Nonrising-Stem, Resilient-Seated Gate Valves:
 - 1) Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.
 - a) Standard: AWWA C509.
 - b) Minimum Pressure Rating: 200 psig (1380 kPa).
 - c) End Connections: Mechanical joint.
 - d) Interior Coating: Complying with AWWA C550.
- c. Nonrising-Stem, High-Pressure, Resilient-Seated Gate Valves:
 - 1) Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.
 - a) Standard: AWWA C509.
 - b) Minimum Pressure Rating: 250 psig (1725 kPa).
 - c) End Connections: Push on or mechanical joint.
 - d) Interior Coating: Complying with AWWA C550.
- d. OS&Y, Rising-Stem, Metal-Seated Gate Valves:
 - 1) Description: Cast- or ductile-iron body and bonnet, with cast-iron double disc, bronze disc and seat rings, and bronze stem.
 - a) Standard: AWWA C500.
 - b) Minimum Pressure Rating: 200 psig (1380 kPa).
 - c) End Connections: Flanged.
- e. OS&Y, Rising-Stem, Resilient-Seated Gate Valves:
 - 1) Description: Cast- or ductile-iron body and bonnet, with bronze or gray- or ductile-iron gate, resilient seats, and bronze stem.
 - a) Standard: AWWA C509.
 - b) Minimum Pressure Rating: 200 psig (1380 kPa).
 - c) End Connections: Flanged.

2. UL/FMG, Cast-Iron Gate Valves:

- a. UL/FMG, Nonrising-Stem Gate Valves:
 - 1) Description: Iron body and bonnet with flange for indicator post, bronze seating material, and inside screw.
 - a) Standards: UL 262 and FMG approved.
 - b) Minimum Pressure Rating: 175 psig (1207 kPa).
 - c) End Connections: Flanged.
- b. OS&Y, Rising-Stem Gate Valves:
 - 1) Description: Iron body and bonnet and bronze seating material.
 - a) Standards: UL 262 and FMG approved.
 - b) Minimum Pressure Rating: 175 psig (1207 kPa).
 - c) End Connections: Flanged.

3. Bronze Gate Valves:

- a. OS&Y, Rising-Stem Gate Valves:
 - 1) Description: Bronze body and bonnet and bronze stem.
 - a) Standards: UL 262 and FMG approved.



- b) Minimum Pressure Rating: 175 psig (1207 kPa).
 - c) End Connections: Threaded.
 - b. Nonrising-Stem Gate Valves:
 - 1) Description: Class 125, Type 1, bronze with solid wedge, threaded ends, and malleable-iron handwheel.
 - a) Standard: MSS SP-80.
- K. Gate Valve Accessories And Specialties
 - 1. Tapping-Sleeve Assemblies:
 - a. Description: Sleeve and valve compatible with drilling machine.
 - 1) Standard: MSS SP-60.
 - 2) Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
 - 3) Valve: AWWA, cast-iron, nonrising-stem, metal **OR** resilient, **as directed**, -seated gate valve with one raised face flange mating tapping-sleeve flange.
 - 2. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 inches (125 mm) in diameter.
 - a. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.
 - 3. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.
- L. Check Valves
 - 1. AWWA Check Valves:
 - a. Description: Swing-check type with resilient seat. Include interior coating according to AWWA C550 and ends to match piping.
 - 1) Standard: AWWA C508.
 - 2) Pressure Rating: 175 psig (1207 kPa).
 - 2. UL/FMG, Check Valves:
 - a. Description: Swing-check type with pressure rating; rubber-face checks, unless otherwise indicated; and ends matching piping.
 - 1) Standards: UL 312 and FMG approved.
 - 2) Pressure Rating: 175 psig (1207 kPa) **OR** 250 psig (1725 kPa), **as directed**.
- M. Detector Check Valves
 - 1. Detector Check Valves:
 - a. Description (with water meter): Galvanized cast-iron body, bolted cover with air-bleed device for access to internal parts, and flanged ends. Include one-piece bronze disc with bronze bushings, pivot, and replaceable seat. Include threaded bypass taps in inlet and outlet for bypass meter connection. Set valve to allow minimal water flow through bypass meter when major water flow is required.
 - 1) Standards: UL 312 and FMG approved.
 - 2) Pressure Rating: 175 psig (1207 kPa).
 - 3) Water Meter: AWWA C700, disc type, at least one-fourth size of detector check valve. Include meter, bypass piping, gate valves, check valve, and connections to detector check valve.
 - b. Description (without water meter): Iron body, corrosion-resistant clapper ring and seat ring material, flanged ends, with connections for bypass and installation of water meter.
 - 1) Standards: UL 312 and FMG approved.
 - 2) Pressure Rating: 175 psig (1207 kPa).
- N. Butterfly Valves
 - 1. AWWA Butterfly Valves:



- a. Description: Rubber seated.
 - 1) Standard: AWWA C504.
 - 2) Body: Cast or ductile iron.
 - 3) Body Type: Wafer **OR** Flanged, **as directed**.
 - 4) Pressure Rating: 150 psig (1035 kPa).
 2. UL Butterfly Valves:
 - a. Description: Metal on resilient material seating.
 - 1) Standards: UL 1091 and FMG approved.
 - 2) Body: Cast or ductile iron.
 - 3) Body Type: Wafer **OR** Flanged, **as directed**.
 - 4) Pressure Rating: 175 psig (1207 kPa).
- O. Plug Valves
1. Plug Valves:
 - a. Description: Resilient-seated eccentric.
 - 1) Standard: MSS SP-108.
 - 2) Body: Cast iron.
 - 3) Pressure Rating: 175-psig (1207-kPa) minimum CWP.
 - 4) Seat Material: Suitable for potable-water service.
- P. Corporation Valves And Curb Valves
1. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.
 - a. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
 - b. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.
 - c. Manifold (if utility company requires multiple connections): Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.
 2. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.
 3. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches (75 mm) in diameter.
 - a. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.
- Q. Water Meters
1. Water meters will be furnished by utility company.
NOTE: If water meters are specified in this Section, delete paragraph above and retain and edit paragraphs and subparagraphs below.
 2. Displacement-Type Water Meters:
 - a. Description: With bronze main case.
 - 1) Standard: AWWA C700.
 - 2) Registration: Flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.
 3. Turbine-Type Water Meters:
 - a. Description:
 - 1) Standard: AWWA C701.
 - 2) Registration: Flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.
 4. Compound-Type Water Meters:
 - a. Description:
 - 1) Standard: AWWA C702.
 - 2) Registration: Flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.



5. Remote Registration System:
 - a. Description: Utility company standard; direct-reading type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - 1) Standard: AWWA C706.
 - 2) Registration: Flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.
 6. Remote Registration System:
 - a. Description: Utility company standard; encoder type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - 1) Standard: AWWA C707.
 - 2) Registration: Flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.
 - 3) Data-Acquisition Units: Comply with utility company requirements for type and quantity.
OR
Visible Display Units: Comply with utility company requirements for type and quantity.
- R. Detector-Type Water Meters
1. Detector-Type Water Meters
 2. Description: Main line, proportional meter with second meter on bypass. Register flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.
 - a. Standards: AWWA C703, UL listed, and FMG approved.
 - b. Pressure Rating: 150 psig (1035 kPa).
 - c. Bypass Meter: AWWA C701, turbine **OR** AWWA C702, compound, **as directed**, -type, bronze case.
 - 1) Size: At least one-half nominal size of main-line meter.
 3. Description: Main-line turbine meter with strainer and second meter on bypass. Register flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.
 - a. Standards: AWWA C703, UL listed, and FMG approved.
 - b. Pressure Rating: 175 psig (1207 kPa).
 - c. Bypass Meter: AWWA C701, turbine-type, bronze case.
 - 1) Size: At least NPS 2 (DN 50).
 4. Remote Registration System:
 - a. Description: Utility company standard; direct-reading type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - 1) Standard: AWWA C706.
 - 2) Registration: Flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.
 5. Remote Registration System:
 - a. Description: Utility company standard; encoder type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - 1) Standard: AWWA C707.
 - 2) Registration: Flow in gallons (liters) **OR** cubic feet (cubic meters), **as directed**.
 - 3) Data-Acquisition Units: Comply with utility company requirements for type and quantity.
OR
Visible Display Units: Comply with utility company requirements for type and quantity.
- S. Pressure-Reducing Valves
1. Water Regulators:
 - a. Standard: ASSE 1003.
 - b. Pressure Rating: Initial pressure of 150 psig (1035 kPa).
 - c. Size: As directed by the manufacturer or as directed by the Owner.
 - d. Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - e. Design Inlet Pressure: As directed by the manufacturer or as directed by the Owner.
 - f. Design Outlet Pressure Setting: As directed by the manufacturer or as directed by the Owner.



- g. Body: Bronze with chrome-plated finish, **as directed**, for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved, **as directed**, for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
 - h. Valves for Booster Heater Water Supply: Include integral bypass.
 - i. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
2. Water Control Valves:
- a. Description: Pilot-operation, diaphragm-type, single-seated main water control valve with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.
 - 1) Pressure Rating: Initial pressure of 150 psig (1035 kPa) minimum.
 - 2) Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
 - a) Size: As directed by the manufacturer or as directed by the Owner.
 - b) Pattern: Angle **OR** Globe, **as directed**, -valve design.
 - c) Trim: Stainless steel.
 - 3) Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - 4) Design Inlet Pressure: As directed by the manufacturer or as directed by the Owner.
 - 5) Design Outlet Pressure Setting: As directed by the manufacturer or as directed by the Owner.
 - 6) End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged, **as directed**, for NPS 2-1/2 (DN 65) and larger.

T. Relief Valves

- 1. Air-Release Valves:
 - a. Description: Hydromechanical device to automatically release accumulated air.
 - 1) Standard: AWWA C512.
 - 2) Pressure Rating: 300 psig (2070 kPa), **as directed**.
 - 3) Body Material: Cast iron, **as directed**.
 - 4) Trim Material: Stainless steel, brass, or bronze, **as directed**.
 - 5) Water Inlet Size: As directed by the manufacturer or as directed by the Owner.
 - 6) Air Outlet Size: As directed by the manufacturer or as directed by the Owner.
 - 7) Orifice Size: As directed by the manufacturer or as directed by the Owner.
 - 8) Design Air-Release Capacity: As directed by the manufacturer or as directed by the Owner.
- 2. Air/Vacuum Valves:
 - a. Description: Direct-acting, float-operated, hydromechanical device with large orifice to automatically release accumulated air or to admit air during filling of piping.
 - 1) Standard: AWWA C512.
 - 2) Pressure Rating: 300 psig (2070 kPa), **as directed**.
 - 3) Body Material: Cast iron, **as directed**.
 - 4) Trim Material: Stainless steel, brass, or bronze, **as directed**.
 - 5) Inlet and Outlet Size: As directed by the manufacturer or as directed by the Owner.
 - 6) Orifice Size: As directed by the manufacturer or as directed by the Owner.
 - 7) Design Air Capacity: As directed by the manufacturer or as directed by the Owner.
- 3. Combination Air Valves:
 - a. Description: Float-operated, hydromechanical device to automatically release accumulated air or to admit air.
 - 1) Standard: AWWA C512.
 - 2) Pressure Rating: 300 psig (2070 kPa), **as directed**.
 - 3) Body Material: Cast iron, **as directed**.
 - 4) Trim Material: Stainless steel, brass, or bronze, **as directed**.
 - 5) Inlet and Outlet Size: As directed by the manufacturer or as directed by the Owner.
 - 6) Orifice Size: As directed by the manufacturer or as directed by the Owner.
 - 7) Design Air Capacity: As directed by the manufacturer or as directed by the Owner.



U. Vacuum Breakers

1. Pressure Vacuum Breaker Assembly:
 - a. Standard: ASSE 1020.
 - b. Operation: Continuous-pressure applications.
 - c. Pressure Loss: 5 psig (35 kPa), **as directed**, maximum, through middle 1/3 of flow range.
 - d. Size: As directed by the manufacturer or as directed by the Owner.
 - e. Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - f. Selected Unit Flow Range Limits: As directed by the manufacturer or as directed by the Owner.
 - g. Pressure Loss at Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - h. Accessories: Ball valves on inlet and outlet.

V. Backflow Preventers

1. Reduced-Pressure-Principle Backflow Preventers:
 - a. Standard: ASSE 1013 **OR** AWWA C511, **as directed**.
 - b. Operation: Continuous-pressure applications.
 - c. Pressure Loss: 12 psig (83 kPa), **as directed**, maximum, through middle 1/3 of flow range.
 - d. Size: As directed by the manufacturer or as directed by the Owner.
 - e. Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - f. Selected Unit Flow Range Limits: As directed by the manufacturer or as directed by the Owner.
 - g. Pressure Loss at Design Flow Rate: As directed by the manufacturer or as directed by the Owner.for NPS 2 (DN 50) and smaller; As directed by the manufacturer or as directed by the Owner.for NPS 2-1/2 (DN 65) and larger.
 - h. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved **OR** steel with interior lining complying with AWWA C550 or that is FDA approved **OR** stainless steel, **as directed**, for NPS 2-1/2 (DN 65) and larger.
 - i. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged, **as directed**, for NPS 2-1/2 (DN 65) and larger.
 - j. Configuration: Designed for horizontal, straight through **OR** vertical inlet, horizontal center section, and vertical outlet **OR** vertical, **as directed**, flow.
 - k. Accessories:
 - 1) Valves: Ball type with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate type with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.
 - 2) Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.
2. Double-Check, Backflow-Prevention Assemblies:
 - a. Standard: ASSE 1015 **OR** AWWA C510, **as directed**.
 - b. Operation: Continuous-pressure applications, unless otherwise indicated.
 - c. Pressure Loss: 5 psig (35 kPa), **as directed**, maximum, through middle 1/3 of flow range.
 - d. Size: As directed by the manufacturer or as directed by the Owner.
 - e. Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - f. Selected Unit Flow Range Limits: As directed by the manufacturer or as directed by the Owner.
 - g. Pressure Loss at Design Flow Rate: As directed by the manufacturer or as directed by the Owner.for NPS 2 (DN 50) and smaller; As directed by the manufacturer or as directed by the Owner.for NPS 2-1/2 (DN 65) and larger.
 - h. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved **OR** steel with interior lining complying with AWWA C550 or that is FDA approved **OR** stainless steel, **as directed**, for NPS 2-1/2 (DN 65) and larger.
 - i. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged, **as directed**, for NPS 2-1/2 (DN 65) and larger.



- j. Configuration: Designed for horizontal, straight through, **as directed**, flow.
 - k. Accessories: Ball valves with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate valves with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.
3. Reduced-Pressure-Detector, Fire-Protection Backflow Preventer Assemblies:
- a. Standards: ASSE 1047 and UL listed or FMG approved.
 - b. Operation: Continuous-pressure applications.
 - c. Pressure Loss: 12 psig (83 kPa), **as directed**, maximum, through middle 1/3 of flow range.
 - d. Size: As directed by the manufacturer or as directed by the Owner. Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - e. Selected Unit Flow Range Limits: As directed by the manufacturer or as directed by the Owner.
 - f. Pressure Loss at Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - g. Body: Cast iron with interior lining complying with AWWA C550 or that is FDA approved **OR** Steel with interior lining complying with AWWA C550 or that is FDA approved **OR** Stainless steel, **as directed**.
 - h. End Connections: Flanged.
 - i. Configuration: Designed for horizontal, straight through **OR** vertical inlet, horizontal center section, and vertical outlet **OR** vertical, **as directed**, flow.
 - j. Accessories:
 - 1) Valves: UL 262, FMG-approved, OS&Y gate type with flanged ends on inlet and outlet.
 - 2) Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.
 - 3) Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.
4. Double-Check, Detector-Assembly Backflow Preventers:
- a. Standards: ASSE 1048 and UL listed or FMG approved.
 - b. Operation: Continuous-pressure applications.
 - c. Pressure Loss: 5 psig (35 kPa), **as directed**, maximum, through middle 1/3 of flow range.
 - d. Size: As directed by the manufacturer or as directed by the Owner.
 - e. Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - f. Selected Unit Flow Range Limits: As directed by the manufacturer or as directed by the Owner.
 - g. Pressure Loss at Design Flow Rate: As directed by the manufacturer or as directed by the Owner.
 - h. Body: Cast iron with interior lining complying with AWWA C550 or that is FDA approved **OR** Steel with interior lining complying with AWWA C550 or that is FDA approved **OR** Stainless steel, **as directed**.
 - i. End Connections: Flanged.
 - j. Configuration: Designed for horizontal, straight through **OR** vertical inlet, horizontal center section, and vertical outlet **OR** vertical, **as directed**, flow.
 - k. Accessories:
 - 1) Valves: UL 262, FMG-approved, OS&Y gate type with flanged ends on inlet and outlet.
 - 2) Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.
5. Backflow Preventer Test Kits:
- a. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.
- W. Water Meter Boxes
- 1. Description: Cast-iron body and cover for disc-type water meter, with lettering "WATER METER" in cover; and with slotted, open-bottom base section of length to fit over service piping.



- a. Option: Base section may be cast-iron, PVC, clay, or other pipe.
2. Description: Cast-iron body and double cover for disc-type water meter, with lettering "WATER METER" in top cover; and with separate inner cover; air space between covers; and slotted, open-bottom base section of length to fit over service piping.
3. Description: Polymer-concrete body and cover for disc-type water meter, with lettering "WATER" in cover; and with slotted, open-bottom base section of length to fit over service piping. Include vertical and lateral design loadings of 15,000 lb minimum over 10 by 10 inches (6800 kg minimum over 254 by 254 mm) square.
 - a. Use of this meter box is permitted in walks or unpaved areas away from traffic; do not use in roadways.

X. Concrete Vaults

1. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857 and made according to ASTM C 858.
 - a. Ladder: ASTM A 36/A 36M, steel or polyethylene-encased steel steps.
 - b. Manhole: ASTM A 48/A 48M Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.
 - 1) Dimension: 24-inch (610-mm) minimum diameter, unless otherwise indicated.
 - c. Manhole: ASTM A 536, Grade 60-40-18, ductile-iron traffic frame and cover.
 - 1) Dimension: 24-inch- (610-mm-) minimum diameter, unless otherwise indicated.
 - d. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

Y. Protective Enclosures

1. Freeze-Protection Enclosures:
 - a. Description: Insulated enclosure designed to protect aboveground water piping, equipment, or specialties from freezing and damage, with heat source to maintain minimum internal temperature of 40 deg F (4 deg C) when external temperatures reach as low as minus 34 deg F (minus 36 deg C).
 - 1) Standard: ASSE 1060.
 - 2) Class I: For equipment or devices other than pressure or atmospheric vacuum breakers.
 - 3) Class I-V: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.
 - a) Housing: Reinforced-aluminum **OR** -fiberglass, **as directed**, construction.
 - i. Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
 - ii. Drain opening for units with drain connection.
 - iii. Access doors with locking devices.
 - iv. Insulation inside housing.
 - v. Anchoring devices for attaching housing to concrete base.
 - b) Electric heating cable or heater with self-limiting temperature control.
2. Weather-Resistant Enclosures:
 - a. Description: Uninsulated enclosure designed to protect aboveground water piping, equipment, or specialties from weather and damage.
 - 1) Standard: ASSE 1060.
 - 2) Class III: For equipment or devices other than pressure or atmospheric vacuum breakers.
 - 3) Class III-V: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.
 - i. Housing: Reinforced-aluminum **OR** -fiberglass, **as directed**, construction.
 - ii. Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
 - iii. Drain opening for units with drain connection.



- iv. Access doors with locking devices.
 - v. Anchoring devices for attaching housing to concrete base.
3. Expanded-Metal Enclosures:
- a. Description: Enclosure designed to protect aboveground water piping, equipment, or specialties from damage.
 - 1) Material: ASTM F 1267, expanded metal side and top panels, of weight and with reinforcement of same metal at edges as required for rigidity.
 - 2) Type: Type I, expanded **OR** II, expanded and flattened, **as directed**.
 - 3) Class: Class 1, uncoated carbon steel **OR** 2, hot-dip, zinc-coated carbon steel **OR** 3, corrosion-resisting steel, **as directed**.
 - 4) Finish: Manufacturer's enamel paint.
 - 5) Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
 - 6) Locking device.
 - 7) Lugs or devices for securing enclosure to base.
4. Enclosure Bases:
- a. Description: 4-inch- (100-mm-) **OR** 6-inch- (150-mm-), **as directed**, minimum thickness precast concrete, of dimensions required to extend at least 6 inches (150 mm) beyond edges of enclosure housings. Include openings for piping.

Z. Fire Hydrants

1. Dry-Barrel Fire Hydrants:
- a. Description (for AWWA dry-barrel fire hydrants): Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, 5-1/4-inch (133-mm) main valve, drain valve, and NPS 6 (DN 150) mechanical-joint inlet. Include interior coating according to AWWA C550. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.
 - 1) Standard: AWWA C502.
 - 2) Pressure Rating: 150 psig (1035 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
 - 3) Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
 - 4) Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.
 - 5) Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.
 - 6) Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.
 - b. Description (for UL/FMG, dry-barrel fire hydrants): Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, 5-1/4-inch (133-mm) main valve, drain valve, and NPS 6 (DN 150) mechanical-joint inlet. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.
 - 1) Standards: UL 246, FMG approved.
 - 2) Pressure Rating: 150 psig (1035 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
 - 3) Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
 - 4) Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.
 - 5) Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.
 - 6) Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.
2. Wet-Barrel Fire Hydrants:
- a. Description (for AWWA wet-barrel fire hydrants): Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, NPS 6 (DN 150) threaded or flanged inlet, and base section with NPS 6 (DN 150) mechanical-joint inlet. Include interior coating according to AWWA C550.
 - 1) Standard: AWWA C503.



- 2) Pressure Rating: 150 psig (1035 kPa) minimum.
 - 3) Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
 - 4) Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.
 - 5) Direction of Opening: Open hydrant valves by turning operating nut to left or counterclockwise.
 - 6) Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.
- b. Description (for UL/FMG, wet-barrel fire hydrants): Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, NPS 6 (DN 150) threaded or flanged inlet, and base section with NPS 6 (DN 150) mechanical-joint inlet.
- 1) Standards: UL 246 and FMG approved.
 - 2) Pressure Rating: 150 psig (1035 kPa) minimum.
 - 3) Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
 - 4) Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.
 - 5) Direction of Opening: Open hydrant valves by turning operating nut to left or counterclockwise.
 - 6) Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.
- AA. Flushing Hydrants
1. Post-Type Flushing Hydrants:
 - a. Description: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.
 - 1) Pressure Rating: 150 psig (1035 kPa) minimum.
 - 2) Outlet: One, with horizontal discharge.
 - 3) Hose Thread: NPS 2-1/2 (DN 65), with NFPA 1963 external hose thread for use by local fire department, and with cast-iron cap with brass chain.
 - 4) Barrel: Cast-iron or steel pipe with breakaway feature.
 - 5) Valve: Bronze body with bronze-ball or plunger closure, and automatic draining.
 - 6) Security: Locking device for padlock.
 - 7) Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.
 - 8) Inlet: NPS 2 (DN 50) minimum.
 - 9) Operating Wrench: One for each unit.
 2. Ground-Type Flushing Hydrants:
 - a. Description: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.
 - 1) Pressure Rating: 150 psig (1035 kPa) minimum.
 - 2) Outlet: One, with vertical **OR** angle, **as directed**, discharge.
 - 3) Hose Thread: NPS 2-1/2 (DN 65), with NFPA 1963 external hose thread for use by local fire department, and with cast-iron cap with brass chain.
 - 4) Barrel: Cast-iron or steel pipe.
 - 5) Valve: Bronze body with bronze-ball or plunger closure, and automatic draining.
 - 6) Inlet: NPS 2 (DN 50) minimum.
 - 7) Hydrant Box: Cast iron with cover, for ground mounting.
 - 8) Operating Wrench: One for each unit.
 3. Post-Type Sampling Station:
 - a. Description: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.
 - 1) Pressure Rating: 100 psig (690 kPa) minimum.
 - 2) Sampling Outlet: One unthreaded nozzle with handle.
 - 3) Valve: Bronze body with bronze-ball or plunger closure. Include operating handle.
 - 4) Drain: Tubing with separate manual vacuum pump.
 - 5) Inlet: NPS 3/4 (DN 20) minimum.
 - 6) Housing: Weatherproof material with locking device. Include anchor device.
 - 7) Operating Wrench: One for each unit.



BB. Fire Department Connections

1. Fire Department Connections:
 - a. Description: Freestanding, with cast-bronze body, thread inlets according to NFPA 1963 and matching local fire department hose threads, and threaded bottom outlet. Include lugged caps, gaskets, and chains; lugged swivel connection and drop clapper for each hose-connection inlet; 18-inch- (460-mm-) high brass sleeve; and round escutcheon plate.
 - 1) Standard: UL 405.
 - 2) Connections: Two NPS 2-1/2 (DN 65) inlets and one NPS 4 (DN 100) **OR** NPS 6 (DN 150), **as directed**, outlet.
 - 3) Connections: Three **OR** Four, **as directed**, NPS 2-1/2 (DN 65) inlets and one NPS 6 (DN 150) outlet.
 - 4) Connections: Six NPS 2-1/2 (DN 65) inlets and one NPS 6 (DN 150) **OR** NPS 8 (DN 200), **as directed**, outlet.
 - 5) Inlet Alignment: Inline, horizontal **OR** Square, **as directed**.
 - 6) Finish Including Sleeve: Polished chrome-plated **OR** Rough chrome-plated **OR** Polished bronze, **as directed**.
 - 7) Escutcheon Plate Marking: "AUTO SPKR" **OR** "STANDPIPE" **OR** "AUTO SPKR & STANDPIPE."

CC. Alarm Devices

1. Alarm Devices, General: UL 753 and FMG approved, of types and sizes to mate and match piping and equipment.
2. Water-Flow Indicators (can be used with wet-barrel fire hydrants): Vane-type water-flow detector, rated for 250-psig (1725-kPa) working pressure; designed for horizontal or vertical installation; with 2 single-pole, double-throw circuit switches to provide isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal when cover is removed.
3. Supervisory Switches: Single pole, double throw; designed to signal valve in other than fully open position. Mount on stem of OS&Y gate valves and on indicator posts.
4. Pressure Switches: Single pole, double throw; designed to signal increase in pressure. Mount on barrel of dry-barrel fire hydrants.

1.3 EXECUTION

A. Earthwork

1. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Piping Applications

1. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.
2. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.
3. Do not use flanges or unions for underground piping.
4. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
5. Underground water-service piping NPS 3/4 to NPS 3 (DN 20 to DN 80), **as directed**, shall be selected from the following, **as directed**:
 - a. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; wrought-copper, solder-joint fittings; and brazed **OR** copper, pressure-seal fittings; and pressure-sealed, **as directed**, joints.
 - b. PE, ASTM pipe; insert fittings for PE pipe; and clamped **OR** molded PE fittings; and heat-fusion, **as directed**, joints.
 - c. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.



- d. NPS 1 to NPS 3 (DN 25 to DN 80) fiberglass, AWWA RTRP, Class 150 **OR** 200 **OR** 250, **as directed**; RTRF; and bonded joints.
- e. Fiberglass, AWWA RTRP, Class 150 **OR** 200 **OR** 250, **as directed**; RTRF; and bonded joints.
6. Underground water-service piping NPS 4 to NPS 8 (DN 100 to DN 200), **as directed**, shall be selected from the following, **as directed**:
 - a. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; wrought-copper, solder-joint fittings; and brazed joints.
 - b. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed **OR** mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical **OR** grooved-end pipe; ductile-iron-pipe appurtenances; and grooved, **as directed**, joints.
 - c. PE, AWWA pipe; PE, AWWA fittings; and heat-fusion joints.
 - d. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
 - e. NPS 4 and NPS 6 (DN 100 and DN 150): NPS 6 (DN 150) PVC, AWWA Class 150 pipe; PVC, AWWA Class 150 fabricated **OR** molded, **as directed**, fittings; and gasketed joints.
 - f. NPS 8 (DN 200): PVC, AWWA Class 200 pipe; PVC, AWWA Class 200 fabricated **OR** push-on-joint, ductile-iron **OR** mechanical-joint, ductile-iron, **as directed**, fittings; and gasketed joints.
 - g. Fiberglass, AWWA RTRP, Class 150 **OR** 200 **OR** 250, **as directed**; RTRF; and bonded joints.
7. Water Meter Box Water-Service Piping NPS 3/4 to NPS 2 (DN 20 to DN 50), **as directed**, shall be same as underground water-service piping.
8. Aboveground and Vault, **as directed**, Water-Service Piping NPS 3/4 to NPS 3 (DN 20 to DN 80), **as directed**, shall be selected from the following:

NOTE: Water-service piping materials listed in subparagraphs below are for potable-water service. They may not be suitable for fire-service mains.

- a. Hard copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; wrought-copper, solder-joint fittings; and brazed **OR** copper, pressure-seal fittings; and pressure-sealed, **as directed**, joints.
- b. PVC, Schedule 80 pipe; PVC, Schedule 80 socket fittings; and solvent-cemented **OR** threaded fittings; and threaded, **as directed**, joints.
- c. NPS 1 to NPS 2 (DN 25 to DN 50) fiberglass, AWWA RTRP, Class 150 **OR** 200 **OR** 250, **as directed**; RTRF; and bonded joints.
9. Aboveground and vault, **as directed**, water-service piping NPS 4 to NPS 8 (DN 100 to DN 200), **as directed**, shall be selected from the following:
 - a. Hard copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; wrought-copper, solder-joint fittings; and brazed joints.
 - b. Ductile-iron, grooved-end pipe; ductile-iron, grooved-end appurtenances; and grooved joints.
 - c. PVC, Schedule 80 pipe; PVC, Schedule 80 socket fittings; and solvent-cemented **OR** threaded fittings; and threaded, **as directed**, joints.
 - d. Fiberglass, AWWA RTRP, Class 150 **OR** 200 **OR** 250, **as directed**; RTRF; and bonded joints.
10. Underground Fire-Service-Main Piping NPS 4 to NPS 12 (DN 100 to DN 300), **as directed**, shall be selected from the following:

NOTE: Fire-service-main piping materials listed in subparagraphs below are for fire-protection water service. They may not be suitable for potable-water service.

- a. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed **OR** mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical **OR** grooved-end pipe; ductile-iron-pipe appurtenances; and grooved, **as directed**, joints.
- b. PE, Class 150 **OR** 200, **as directed**, fire-service pipe; molded PE fittings; and heat-fusion joints.



- c. PVC, AWWA Class 150 pipe listed for fire-protection service; PVC Class 150 fabricated or molded fittings; and gasketed joints.
 - d. PVC, AWWA Class 200 pipe listed for fire-protection service; PVC Class 200 fabricated fittings; and gasketed joints.
 - e. Fiberglass, AWWA, FMG-approved RTRP, Class 150 **OR** 200, **as directed**; RTRF; and gasketed joints.
 - f. Fiberglass, UL RTRP, Class 150 **OR** 200 **OR** 250, **as directed**; RTRF; and gasketed joints.
11. Aboveground and Vault, **as directed**, Fire-Service-Main Piping NPS 4 to NPS 12 (DN 100 to DN 300), **as directed**, shall be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.
12. Underground Combined Water-Service and Fire-Service-Main Piping NPS 6 to NPS 12 (DN 150 to DN 300), **as directed**, shall be selected from the following:
- a. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed **OR** mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical **OR** grooved-end pipe; ductile-iron-pipe appurtenances; and grooved, **as directed**, joints.
 - b. PVC, AWWA Class 150 **OR** 200, **as directed**, pipe listed for fire-protection service; PVC fabricated or molded fittings of same class as pipe; and gasketed joints.
 - c. Fiberglass, AWWA, FMG-approved RTRP, Class 150 **OR** 200, **as directed**; RTRF; and gasketed joints.
13. Aboveground and Vault, **as directed**, Combined Water Service and Fire-Service-Main Piping NPS 6 to NPS 12 (DN 150 to DN 300), **as directed**, shall be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

C. Valve Applications

- 1. General Application: Use mechanical-joint-end valves for NPS 3 (DN 80) and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 (DN 50) and smaller installation.
- 2. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - a. Underground Valves, NPS 3 (DN 80) and Larger: AWWA, cast-iron, nonrising-stem, metal **OR** resilient **OR** high-pressure, resilient, **as directed**, -seated gate valves with valve box.
 - b. Underground Valves, NPS 4 (DN 100) and Larger, for Indicator Posts: UL/FMG, cast-iron, nonrising-stem gate valves with indicator post.
 - c. Use the following for valves in vaults and aboveground:
 - 1) Gate Valves, NPS 2 (DN 50) and Smaller: Bronze, nonrising **OR** rising, **as directed**, stem.
 - 2) Gate Valves, NPS 3 (DN 80) and Larger: AWWA, cast iron, OS&Y rising stem, metal seated **OR** AWWA, cast iron, OS&Y rising stem, resilient seated **OR** UL/FMG, cast iron, OS&Y rising stem, **as directed**.
 - 3) Check Valves: AWWA C508 **OR** UL/FMG, **as directed**, swing type.
 - d. Pressure-Reducing Valves: Use for water-service piping in vaults and aboveground to control water pressure.
 - e. Relief Valves: Use for water-service piping in vaults and aboveground.
 - 1) Air-Release Valves: To release accumulated air.
 - 2) Air/Vacuum Valves: To release or admit large volume of air during filling of piping.
 - 3) Combination Air Valves: To release or admit air.
 - f. Detector Check Valves: Use for water-service piping in vaults and aboveground to detect unauthorized use of water.

D. Piping Systems - Common Requirements

- 1. See Division 22 Section "Common Work Results For Plumbing" for piping-system common requirements.



E. Piping Installation

1. Water-Main Connection (if tap is made by utility company): Arrange with utility company for tap of size and in location indicated in water main.
2. Water-Main Connection (if tap is made by Contractor): Tap water main according to requirements of water utility company and of size and in location indicated.
3. Make connections larger than NPS 2 (DN 50) with tapping machine according to the following:
 - a. Install tapping sleeve and tapping valve according to MSS SP-60.
 - b. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
 - c. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
 - d. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
4. Make connections NPS 2 (DN 50) and smaller with drilling machine according to the following:
 - a. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
 - b. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
 - c. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
 - d. Install corporation valves into service-saddle assemblies.
 - e. Install manifold for multiple taps in water main.
 - f. Install curb valve in water-service piping with head pointing up and with service box.
5. Comply with NFPA 24 for fire-service-main piping materials and installation.
 - a. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.
 - b. Install copper tube and fittings according to CDA's "Copper Tube Handbook."
6. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
 - a. If required, install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.
7. Install PE pipe according to ASTM D 2774 and ASTM F 645.
8. Install PVC, AWWA pipe according to ASTM F 645 and AWWA M23.
9. Install fiberglass AWWA pipe according to AWWA M45.
10. Bury piping with depth of cover over top at least 30 inches (750 mm), **as directed**, with top at least 12 inches (300 mm), **as directed**, below level of maximum frost penetration, and according to the following:
 - a. Under Driveways: With at least 36 inches (910 mm), **as directed**, cover over top.
 - b. Under Railroad Tracks: With at least 48 inches (1220 mm), **as directed**, cover over top.
 - c. In Loose Gravelly Soil and Rock: With at least 12 inches (300 mm), **as directed**, additional cover.
11. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
12. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
 - a. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.
13. Sleeves are specified in Division 22 Section "Common Work Results For Plumbing".
14. Mechanical sleeve seals are specified in Division 22 Section "Common Work Results For Plumbing".
15. For piping with gasketed joints: Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.
16. See Division 21 Section "Common Work Results For Fire Suppression" for fire-suppression-water piping inside the building.
17. See Division 22 Section "Common Work Results For Plumbing" for potable-water piping inside the building.



F. Joint Construction

1. See Division 22 Section "Common Work Results For Plumbing" for basic piping joint construction.
2. Make pipe joints according to the following:
 - a. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.
 - b. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
 - c. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
 - d. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
 - e. PE Piping Insert-Fitting Joints: Use plastic insert fittings and fasteners according to fitting manufacturer's written instructions.
 - f. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.
 - g. Fiberglass Piping Bonded Joints: Use adhesive and procedure recommended by piping manufacturer.
 - h. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure. Refer to Division 22 Section "Common Work Results For Plumbing" for joining piping of dissimilar metals.

G. Anchorage Installation

1. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
 - a. Concrete thrust blocks.
 - b. Locking mechanical joints.
 - c. Set-screw mechanical retainer glands.
 - d. Bolted flanged joints.
 - e. Heat-fused joints.
 - f. Pipe clamps and tie rods.
2. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:
 - a. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
 - b. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
 - c. Bonded-Joint Fiberglass, Water-Service Piping: According to AWWA M45.
 - d. Fire-Service-Main Piping: According to NFPA 24.
3. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

H. Valve Installation

1. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
2. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.
3. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.
4. UL/FMG, Valves Other Than Gate Valves: Comply with NFPA 24.
5. MSS Valves: Install as component of connected piping system.
6. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.
7. Pressure-Reducing Valves: Install in vault or aboveground between shutoff valves. Install full-size valved bypass, **as directed**.
8. Relief Valves: Comply with AWWA C512. Install aboveground with shutoff valve on inlet.

I. Detector-Check Valve Installation



1. Install in vault or aboveground.
 2. Install for proper direction of flow. Install bypass with water meter, gate valves on each side of meter, and check valve downstream from meter.
 3. Support detector check valves, meters, shutoff valves, and piping on brick or concrete piers.
- J. Water Meter Installation
1. If water meters are provided by the Contractor: Install water meters, piping, and specialties according to utility company's written instructions.
 2. Water Meters: Install displacement **OR** turbine, **as directed**, -type water meters, NPS 2 (DN 50) and smaller, in meter boxes with shutoff valves on water meter inlets. Include valves on water meter outlets and valved bypass around meters unless prohibited by authorities having jurisdiction.
 3. Water Meters: Install compound **OR** turbine, **as directed**, -type water meters, NPS 3 (DN 80) and larger, in meter vaults. Include shutoff valves on water meter inlets and outlets and valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.
 4. Water Meters: Install detector-type water meters in meter vault according to AWWA M6. Include shutoff valves on water meter inlets and outlets and full-size valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.
- K. Roughing-In For Water Meters
1. If Contractor is to rough-in for water meters to be installed by utility company: Rough-in piping and specialties for water meter installation according to utility company's written instructions.
- L. Vacuum Breaker Assembly Installation
1. Install pressure vacuum breaker assemblies of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
 2. Do not install pressure vacuum breaker assemblies in vault or other space subject to flooding.
- M. Backflow Preventer Installation
1. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
 2. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.
 3. Do not install bypass piping around backflow preventers.
 4. Support NPS 2-1/2 (DN 65) and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.
- N. Water Meter Box Installation
1. Install water meter boxes in paved areas flush with surface.
 2. Install water meter boxes in grass or earth areas with top 2 inches (50 mm), **as directed**, above surface.
- O. Concrete Vault Installation
1. Install precast concrete vaults according to ASTM C 891.
- P. Protective Enclosure Installation
1. Install concrete base level and with top approximately 2 inches (50 mm), **as directed**, above grade.
 2. Install protective enclosure over valves and equipment.
 3. Anchor protective enclosure to concrete base.
- Q. Fire Hydrant Installation
1. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position.



2. Wet-Barrel Fire Hydrants: Install with valve below frost line. Provide for drainage.
3. AWWA Fire Hydrants: Comply with AWWA M17.
4. UL/FMG Fire Hydrants: Comply with NFPA 24.

R. Flushing Hydrant Installation

1. Install post-type flushing hydrants with valve below frost line and provide for drainage. Support in upright position. Include separate gate valve or curb valve and restrained joints in supply piping.
2. Install ground-type flushing hydrants with valve below frost line and provide for drainage. Install hydrant box flush with grade. Include separate gate valve or curb valve and restrained joints in supply piping.
3. Install sampling stations with valve below frost line and provide for drainage. Attach weather-resistant housing and support in upright position. Include separate curb valve in supply piping.

S. Fire Department Connection Installation

1. Install ball drip valves at each check valve for fire department connection to mains.
2. Install protective pipe bollards on two sides of **OR** on three sides of, **as directed**, each fire department connection. Pipe bollards are specified in Division 05 Section "Metal Fabrications".

T. Alarm Device Installation

1. General: Comply with NFPA 24 for devices and methods of valve supervision. Underground valves with valve box do not require supervision.
2. Supervisory Switches: Supervise valves in open position.
 - a. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.
 - b. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.
3. Locking and Sealing: Secure unsupervised valves as follows:
 - a. Valves: Install chain and padlock on open OS&Y gate valve.
 - b. Post Indicators: Install padlock on wrench on indicator post.
4. Pressure Switches: Drill and thread hole in exposed barrel of fire hydrant. Install switch.
5. Water-Flow Indicators: Install in water-service piping in vault. Select indicator with saddle and vane matching pipe size. Drill hole in pipe, insert vane, and bolt saddle to pipe.
6. Connect alarm devices to building fire alarm system. Wiring and fire-alarm devices are specified in Division 28.

U. Connections

1. Piping installation requirements are specified in other Division 22. Drawings indicate general arrangement of piping, fittings, and specialties.
2. See Division 22 Section "Common Work Results For Plumbing" for piping connections to valves and equipment.
3. Connect water-distribution piping to utility water main **OR** existing water main, **as directed**. Use tapping sleeve and tapping valve **OR** service clamp and corporation valve, **as directed**.
4. Connect water-distribution piping to interior domestic water **OR** fire-suppression, **as directed**, piping.
5. Connect waste piping from concrete vault drains to sanitary sewerage system. See Division 22 for connection to sanitary-sewer **OR** storm-drainage system. See Division 23 for connection to storm-sewer, **as directed**, piping.
6. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
7. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

V. Field Quality Control



1. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
2. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.
 - a. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig (0 kPa). Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
3. Prepare reports of testing activities.

W. Identification

1. Install continuous underground detectable, **as directed**, warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Division 31 Section "Earth Moving".
2. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Division 22 Section "Common Work Results For Plumbing" for identifying devices.

NOTE: Delete paragraph above if metallic water-service piping without electrically insulated fittings will be used.

X. Cleaning

1. Clean and disinfect water-distribution piping as follows:
 - a. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
 - b. If fire-protection-water piping is not connected to potable-water supply, use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
 - c. If fire-protection-water piping is connected to potable-water supply, use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
 - 1) Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours **OR** Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours, **as directed**.
 - 2) After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - 3) Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
2. Prepare reports of purging and disinfecting activities.

END OF SECTION 21 05 19 00



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SECTION 21 05 19 00a - METERS AND GAGES FOR PLUMBING PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for meters and gages for plumbing piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Bimetallic-actuated thermometers.
 - b. Filled-system thermometers.
 - c. Liquid-in-glass thermometers.
 - d. Light-activated thermometers.
 - e. Thermowells.
 - f. Dial-type pressure gages.
 - g. Gage attachments.
 - h. Test plugs.
 - i. Test-plug kits.
 - j. Sight flow indicators.

C. Submittals

1. Product Data: For each type of product indicated.
2. Product Certificates: For each type of meter and gage, from manufacturer.
3. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

1.2 PRODUCTS

A. Bimetallic-Actuated Thermometers

1. Standard: ASME B40.200.
2. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch (76-mm) **OR** 5-inch (127-mm), **as directed**, nominal diameter.
3. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F (deg C) **OR** deg F and deg C, **as directed**.
4. Connector Type(s): Union joint, adjustable angle **OR** rigid, back **OR** rigid, bottom, **as directed**, with unified-inch screw threads.
5. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.
6. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.
7. Window: Plain glass or plastic.
8. Ring: Stainless steel.
9. Element: Bimetal coil.
10. Pointer: Dark-colored metal.
11. Accuracy: Plus or minus 1 **OR** 1.5, **as directed**, percent of scale range.

B. Filled-System Thermometers

1. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 5-inch (127-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
 - c. Element: Bourdon tube or other type of pressure element.



- d. Movement: Mechanical, dampening type, **as directed**, with link to pressure element and connection to pointer.
- e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
- f. Pointer: Dark-colored metal.
- g. Window: Glass or plastic.
- h. Ring: Metal **OR** Stainless steel, **as directed**.
- i. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device **OR** rigid, back **OR** rigid, bottom, **as directed**; with ASME B1.1 screw threads.
- j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
- k. Accuracy: Plus or minus 1 percent of scale range.
- 2. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Sealed type, plastic; 4-1/2-inch (114-mm) **OR** 5-inch (127-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
 - c. Element: Bourdon tube or other type of pressure element.
 - d. Movement: Mechanical, with link to pressure element and connection to pointer.
 - e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Pointer: Dark-colored metal.
 - g. Window: Glass or plastic.
 - h. Ring: Metal or plastic.
 - i. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device **OR** rigid, back **OR** rigid, bottom, **as directed**; with ASME B1.1 screw threads.
 - j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
 - k. Accuracy: Plus or minus 1 percent of scale range.
- 3. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
 - c. Element: Bourdon tube or other type of pressure element.
 - d. Movement: Mechanical, with link to pressure element and connection to pointer.
 - e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Pointer: Dark-colored metal.
 - g. Window: Glass or plastic.
 - h. Ring: Metal **OR** Stainless steel, **as directed**.
 - i. Connector Type(s): Union joint, back **OR** bottom, **as directed**; with ASME B1.1 screw threads.
 - j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
 - k. Accuracy: Plus or minus 1 percent of scale range.
- 4. Remote-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Sealed type, plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
 - c. Element: Bourdon tube or other type of pressure element.



- d. Movement: Mechanical, with link to pressure element and connection to pointer.
- e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
- f. Pointer: Dark-colored metal.
- g. Window: Glass or plastic.
- h. Ring: Metal or plastic.
- i. Connector Type(s): Union joint, threaded, back **OR** bottom, **as directed**; with ASME B1.1 screw threads.
- j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
- k. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

C. Liquid-In-Glass Thermometers

- 1. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Cast aluminum; 6-inch (152-mm) nominal size.
 - c. Case Form: Back angle **OR** Straight, **as directed**, unless otherwise indicated.
 - d. Tube: Glass with magnifying lens and blue or red organic liquid.
 - e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Window: Glass or plastic.
 - g. Stem: Aluminum or brass and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
 - h. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
 - i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- 2. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Plastic; 6-inch (152-mm) nominal size.
 - c. Case Form: Back angle **OR** Straight, **as directed**, unless otherwise indicated.
 - d. Tube: Glass with magnifying lens and blue or red organic liquid.
 - e. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Window: Glass or plastic.
 - g. Stem: Aluminum or brass and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
 - h. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
 - i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- 3. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Cast aluminum; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
 - c. Case Form: Adjustable angle **OR** Back angle **OR** Straight, **as directed**, unless otherwise indicated.
 - d. Tube: Glass with magnifying lens and blue or red organic liquid.
 - e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Window: Glass or plastic.
 - g. Stem: Aluminum and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
 - h. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
 - i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.



4. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Plastic; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
 - c. Case Form: Adjustable angle **OR** Back angle **OR** Straight, **as directed**, unless otherwise indicated.
 - d. Tube: Glass with magnifying lens and blue or red organic liquid.
 - e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Window: Glass or plastic.
 - g. Stem: Aluminum **OR** Brass **OR** Stainless steel **OR** Aluminum, brass, or stainless steel, **as directed**, and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
 - h. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
 - i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

- D. Light-Activated Thermometers
 1. Direct-Mounted, Light-Activated Thermometers:
 - a. Case: Plastic **OR** Metal, **as directed**; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
 - b. Scale(s): Deg F (Deg C) **OR** Deg F and deg C, **as directed**.
 - c. Case Form: Adjustable angle.
 - d. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
 - e. Stem: Aluminum and of length to suit installation.
 - 1) Design for Thermowell Installation: Bare stem.
 - f. Display: Digital.
 - g. Accuracy: Plus or minus 2 deg F (1 deg C).
 2. Remote-Mounted, Light-Activated Thermometers:
 - a. Case: Plastic, for wall mounting.
 - b. Scale(s): Deg F (Deg C) **OR** Deg F and deg C, **as directed**.
 - c. Sensor: Bulb and thermister wire.
 - 1) Design for Thermowell Installation: Bare stem.
 - d. Display: Digital.
 - e. Accuracy: Plus or minus 2 deg F (1 deg C).

- E. Thermowells
 1. Thermowells:
 - a. Standard: ASME B40.200.
 - b. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
 - c. Material for Use with Copper Tubing: CNR or CUNI.
 - d. Material for Use with Steel Piping: CRES **OR** CSA, **as directed**.
 - e. Type: Stepped shank unless straight or tapered shank is indicated.
 - f. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
 - g. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
 - h. Bore: Diameter required to match thermometer bulb or stem.
 - i. Insertion Length: Length required to match thermometer bulb or stem.
 - j. Lagging Extension: Include on thermowells for insulated piping and tubing.
 - k. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
 2. Heat-Transfer Medium: Mixture of graphite and glycerin.

- F. Pressure Gages



1. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
 - a. Standard: ASME B40.100.
 - b. Case: Liquid-filled **OR** Sealed **OR** Open-front, pressure relief **OR** Solid-front, pressure relief, **as directed**, type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
 - c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - e. Movement: Mechanical, with link to pressure element and connection to pointer.
 - f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
 - g. Pointer: Dark-colored metal.
 - h. Window: Glass or plastic.
 - i. Ring: Metal **OR** Brass **OR** Stainless steel, **as directed**.
 - j. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
2. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
 - a. Standard: ASME B40.100.
 - b. Case: Sealed type; plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
 - c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - e. Movement: Mechanical, with link to pressure element and connection to pointer.
 - f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
 - g. Pointer: Dark-colored metal.
 - h. Window: Glass or plastic.
 - i. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
3. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
 - a. Standard: ASME B40.100.
 - b. Case: Liquid-filled **OR** Sealed, **as directed**, type; cast aluminum or drawn steel **OR** metal, **as directed**; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
 - c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - e. Movement: Mechanical, with link to pressure element and connection to pointer.
 - f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
 - g. Pointer: Dark-colored metal.
 - h. Window: Glass or plastic.
 - i. Ring: Metal **OR** Stainless steel, **as directed**.
 - j. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
4. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:
 - a. Standard: ASME B40.100.
 - b. Case: Sealed type; plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.



- c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
- d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
- e. Movement: Mechanical, with link to pressure element and connection to pointer.
- f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
- g. Pointer: Dark-colored metal.
- h. Window: Glass or plastic.
- i. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.

G. Gage Attachments

- 1. Snubbers: ASME B40.100, brass; with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and piston **OR** porous-metal, **as directed**, -type surge-dampening device. Include extension for use on insulated piping.
- 2. Valves: Brass ball **OR** Brass or stainless-steel needle, **as directed**, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads.

H. Test Plugs

- 1. Description: Test-station fitting made for insertion into piping tee fitting.
- 2. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- 3. Thread Size: NPS 1/4 (DN 8) or NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.
- 4. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
- 5. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

I. Test-Plug Kits

- 1. Furnish one test-plug kit(s) containing one **OR** two, **as directed**, thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
- 2. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).
- 3. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).
- 4. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).
- 5. Carrying Case: Metal or plastic, with formed instrument padding.

J. Sight Flow Indicators

- 1. Description: Piping inline-installation device for visual verification of flow.
- 2. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.
- 3. Minimum Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1034 kPa), **as directed**.
- 4. Minimum Temperature Rating: 200 deg F (93 deg C).
- 5. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
- 6. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.



1.3 EXECUTION

A. Installation

1. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid **OR** one-third of pipe diameter **OR** to center of pipe, **as directed**, and in vertical position in piping tees.
2. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
3. Install thermowells with extension on insulated piping.
4. Fill thermowells with heat-transfer medium.
5. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
6. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
7. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
8. Install remote-mounted pressure gages on panel.
9. Install valve and snubber in piping for each pressure gage for fluids.
10. Install test plugs in piping tees.
11. Install thermometers in the following locations:
 - a. Inlet and outlet of each water heater.
 - b. Inlets and outlets of each domestic water heat exchanger.
 - c. Inlet and outlet of each domestic hot-water storage tank.
 - d. Inlet and outlet of each remote domestic water chiller.
12. Install pressure gages in the following locations:
 - a. Building water service entrance into building.
 - b. Inlet and outlet of each pressure-reducing valve.
 - c. Suction and discharge of each domestic water pump.

B. Connections

1. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

C. Adjusting

1. Adjust faces of meters and gages to proper angle for best visibility.

D. Thermometer Schedule

1. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct **OR** Remote, **as directed**, -mounted, metal **OR** plastic, **as directed**, -case, vapor-actuated type.
 - c. Compact **OR** Industrial, **as directed**, -style, liquid-in-glass type.
 - d. Direct **OR** Remote, **as directed**, -mounted, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
2. Thermometers at inlets and outlets of each domestic water heat exchanger shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct **OR** Remote, **as directed**, -mounted, metal **OR** plastic, **as directed**, -case, vapor-actuated type.
 - c. Compact **OR** Industrial, **as directed**, -style, liquid-in-glass type.
 - d. Direct **OR** Remote, **as directed**, -mounted, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
3. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.



- b. Direct **OR** Remote, **as directed**, -mounted, metal **OR** plastic, **as directed**, -case, vapor-actuated type.
 - c. Compact **OR** Industrial, **as directed**, -style, liquid-in-glass type.
 - d. Direct **OR** Remote, **as directed**, -mounted, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
4. Thermometers at inlet and outlet of each remote domestic water chiller shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct **OR** Remote, **as directed**, -mounted, metal **OR** plastic, **as directed**, -case, vapor-actuated type.
 - c. Compact **OR** Industrial, **as directed**, -style, liquid-in-glass type.
 - d. Direct **OR** Remote, **as directed**, -mounted, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
 5. Thermometer stems shall be of length to match thermowell insertion length.
- E. Thermometer Scale-Range Schedule
1. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
 2. Scale Range for Domestic Cold-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
 3. Scale Range for Domestic Cold-Water Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
 4. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
 5. Scale Range for Domestic Hot-Water Piping: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
 6. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
 7. Scale Range for Domestic Cooled-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
 8. Scale Range for Domestic Cooled-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
- F. Pressure-Gage Schedule
1. Pressure gages at discharge of each water service into building shall be one of the following:
 - a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct **OR** remote, **as directed**, -mounted, metal case.
 - b. Sealed, direct **OR** remote, **as directed**, -mounted, plastic case.
 - c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
 2. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be one of the following:
 - a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct **OR** remote, **as directed**, -mounted, metal case.
 - b. Sealed, direct **OR** remote, **as directed**, -mounted, plastic case.
 - c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
 3. Pressure gages at suction and discharge of each domestic water pump shall be one of the following:
 - a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct **OR** remote, **as directed**, -mounted, metal case.
 - b. Sealed, direct **OR** remote, **as directed**, -mounted, plastic case.



- c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.

G. Pressure-Gage Scale-Range Schedule

1. Scale Range for Water Service Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
2. Scale Range for Water Service Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
3. Scale Range for Water Service Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
4. Scale Range for Domestic Water Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
5. Scale Range for Domestic Water Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
6. Scale Range for Domestic Water Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
7. Scale Range for Domestic Water Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.

END OF SECTION 21 05 19 00a



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SECTION 21 05 19 00b - METERS AND GAGES FOR HVAC PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for meters and gages for HVAC piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Bimetallic-actuated thermometers.
 - b. Filled-system thermometers.
 - c. Liquid-in-glass thermometers.
 - d. Light-activated thermometers.
 - e. Thermowells.
 - f. Dial-type pressure gages.
 - g. Gage attachments.
 - h. Test plugs.
 - i. Test-plug kits.
 - j. Sight flow indicators.
 - k. Orifice flowmeters.
 - l. Pitot-tube flowmeters.
 - m. Turbine flowmeters.
 - n. Venturi flowmeters.
 - o. Vortex-shedding flowmeters.
 - p. Impeller-turbine, thermal-energy meters.
 - q. Ultrasonic, thermal-energy meters.

C. Submittals

1. Product Data: For each type of product indicated.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Product Certificates: For each type of meter and gage, from manufacturer.
4. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

1.2 PRODUCTS

A. Bimetallic-Actuated Thermometers

1. Standard: ASME B40.200.
2. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch (76-mm) **OR** 5-inch (127-mm), **as directed**, nominal diameter.
3. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F (deg C) **OR** deg F and deg C, **as directed**.
4. Connector Type(s): Union joint, adjustable angle **OR** rigid, back **OR** rigid, bottom, **as directed**, with unified-inch screw threads.
5. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.
6. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.
7. Window: Plain glass or plastic.
8. Ring: Stainless steel.
9. Element: Bimetal coil.
10. Pointer: Dark-colored metal.



11. Accuracy: Plus or minus 1 **OR** 1.5, **as directed**, percent of scale range.

B. Filled-System Thermometers

1. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 5-inch (127-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
 - c. Element: Bourdon tube or other type of pressure element.
 - d. Movement: Mechanical, dampening type, **as directed**, with link to pressure element and connection to pointer.
 - e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Pointer: Dark-colored metal.
 - g. Window: Glass or plastic.
 - h. Ring: Metal **OR** Stainless steel.
 - i. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device **OR** rigid, back **OR** rigid, bottom, **as directed**; with ASME B1.1 screw threads.
 - j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - k. Accuracy: Plus or minus 1 percent of scale range.
2. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Sealed type, plastic; 4-1/2-inch (114-mm) **OR** 5-inch (127-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
 - c. Element: Bourdon tube or other type of pressure element.
 - d. Movement: Mechanical, with link to pressure element and connection to pointer.
 - e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Pointer: Dark-colored metal.
 - g. Window: Glass or plastic.
 - h. Ring: Metal or plastic.
 - i. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device **OR** rigid, back **OR** rigid, bottom, **as directed**; with ASME B1.1 screw threads.
 - j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - k. Accuracy: Plus or minus 1 percent of scale range.
3. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
 - c. Element: Bourdon tube or other type of pressure element.
 - d. Movement: Mechanical, with link to pressure element and connection to pointer.
 - e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Pointer: Dark-colored metal.
 - g. Window: Glass or plastic.
 - h. Ring: Metal **OR** Stainless steel, **as directed**.



- i. Connector Type(s): Union joint, back **OR** bottom, **as directed**; with ASME B1.1 screw threads.
 - j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - k. Accuracy: Plus or minus 1 percent of scale range.
4. Remote-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
- a. Standard: ASME B40.200.
 - b. Case: Sealed type, plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
 - c. Element: Bourdon tube or other type of pressure element.
 - d. Movement: Mechanical, with link to pressure element and connection to pointer.
 - e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Pointer: Dark-colored metal.
 - g. Window: Glass or plastic.
 - h. Ring: Metal or plastic.
 - i. Connector Type(s): Union joint, threaded, back **OR** bottom, **as directed**; with ASME B1.1 screw threads.
 - j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - k. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- C. Liquid-In-Glass Thermometers
- 1. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Cast aluminum; 6-inch (152-mm) nominal size.
 - c. Case Form: Back angle **OR** Straight, **as directed**, unless otherwise indicated.
 - d. Tube: Glass with magnifying lens and blue or red, **as directed**, organic liquid.
 - e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Window: Glass or plastic.
 - g. Stem: Aluminum or brass and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - h. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
 - i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
 - 2. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Plastic; 6-inch (152-mm) nominal size.
 - c. Case Form: Back angle **OR** Straight, **as directed**, unless otherwise indicated.
 - d. Tube: Glass with magnifying lens and blue or red, **as directed**, organic liquid.
 - e. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Window: Glass or plastic.
 - g. Stem: Aluminum or brass and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - h. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
 - i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.



3. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Cast aluminum; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
 - c. Case Form: Adjustable angle **OR** Back angle **OR** Straight, **as directed**, unless otherwise indicated.
 - d. Tube: Glass with magnifying lens and blue or red, **as directed**, organic liquid.
 - e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Window: Glass or plastic.
 - g. Stem: Aluminum and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - h. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
 - i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
 4. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - a. Standard: ASME B40.200.
 - b. Case: Plastic; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
 - c. Case Form: Adjustable angle **OR** Back angle **OR** Straight, **as directed**, unless otherwise indicated.
 - d. Tube: Glass with magnifying lens and blue or red, **as directed**, organic liquid.
 - e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
 - f. Window: Glass or plastic.
 - g. Stem: Aluminum **OR** Brass **OR** Stainless steel, **as directed**, and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - h. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
 - i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- D. Light-Activated Thermometers
1. Direct-Mounted, Light-Activated Thermometers:
 - a. Case: Plastic **OR** Metal, **as directed**; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
 - b. Scale(s): Deg F (Deg C) **OR** Deg F and deg C, **as directed**.
 - c. Case Form: Adjustable angle.
 - d. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
 - e. Stem: Aluminum and of length to suit installation.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - f. Display: Digital.
 - g. Accuracy: Plus or minus 2 deg F (1 deg C).
 2. Remote-Mounted, Light-Activated Thermometers:
 - a. Case: Plastic, for wall mounting.
 - b. Scale(s): Deg F (Deg C) **OR** Deg F and deg C, **as directed**.
 - c. Sensor: Bulb and thermister wire.
 - 1) Design for Air-Duct Installation: With ventilated shroud.
 - 2) Design for Thermowell Installation: Bare stem.
 - d. Display: Digital.
 - e. Accuracy: Plus or minus 2 deg F (1 deg C).



- E. Duct-Thermometer Mounting Brackets
1. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.
- F. Thermowells
1. Thermowells:
 - a. Standard: ASME B40.200.
 - b. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
 - c. Material for Use with Copper Tubing: CNR **OR** CUNI, **as directed**.
 - d. Material for Use with Steel Piping: CRES **OR** CSA, **as directed**.
 - e. Type: Stepped shank unless straight or tapered shank is indicated.
 - f. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
 - g. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
 - h. Bore: Diameter required to match thermometer bulb or stem.
 - i. Insertion Length: Length required to match thermometer bulb or stem.
 - j. Lagging Extension: Include on thermowells for insulated piping and tubing.
 - k. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
 2. Heat-Transfer Medium: Mixture of graphite and glycerin.
- G. Pressure Gages
1. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
 - 1) Standard: ASME B40.100.
 - 2) Case: Liquid-filled **OR** Sealed **OR** Open-front, pressure relief **OR** Solid-front, pressure relief, **as directed**, type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
 - 3) Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 4) Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 5) Movement: Mechanical, with link to pressure element and connection to pointer.
 - 6) Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
 - 7) Pointer: Dark-colored metal.
 - 8) Window: Glass or plastic.
 - 9) Ring: Metal **OR** Brass **OR** Stainless steel, **as directed**.
 - 10) Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
 2. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
 - a. Standard: ASME B40.100.
 - b. Case: Sealed type; plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
 - c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - e. Movement: Mechanical, with link to pressure element and connection to pointer.
 - f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
 - g. Pointer: Dark-colored metal.
 - h. Window: Glass or plastic.
 - i. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.



3. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
 - a. Standard: ASME B40.100.
 - b. Case: Liquid-filled **OR** Sealed, **as directed**, type; cast aluminum or drawn steel **OR** metal, **as directed**; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
 - c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - e. Movement: Mechanical, with link to pressure element and connection to pointer.
 - f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
 - g. Pointer: Dark-colored metal.
 - h. Window: Glass or plastic.
 - i. Ring: Metal **OR** Stainless steel, **as directed**.
 - j. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
 4. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:
 - a. Standard: ASME B40.100.
 - b. Case: Sealed type; plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
 - c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - e. Movement: Mechanical, with link to pressure element and connection to pointer.
 - f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
 - g. Pointer: Dark-colored metal.
 - h. Window: Glass or plastic.
 - i. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
- H. Gage Attachments
1. Snubbers: ASME B40.100, brass; with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and piston-type **OR** porous-metal-type, **as directed**, surge-dampening device. Include extension for use on insulated piping.
 2. Siphons: Loop-shaped section of brass **OR** stainless-steel **OR** steel, **as directed**, pipe with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, pipe threads.
 3. Valves: Brass ball **OR** Brass or stainless-steel needle, **as directed**, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads.
- I. Test Plugs
1. Description: Test-station fitting made for insertion into piping tee fitting.
 2. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
 3. Thread Size: NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe thread.
 4. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
 5. Core Inserts: Chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber.
- J. Test-Plug Kits
1. Furnish one test-plug kit(s) containing one **OR** two, **as directed**, thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.



2. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).
 3. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).
 4. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).
 5. Carrying Case: Metal or plastic, with formed instrument padding.
- K. Sight Flow Indicators
1. Description: Piping inline-installation device for visual verification of flow.
 2. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.
 3. Minimum Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1034 kPa), **as directed**.
 4. Minimum Temperature Rating: 200 deg F (93 deg C).
 5. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 6. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.
- L. Flowmeters
1. Orifice Flowmeters:
 - a. Description: Flowmeter with sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.
 - b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
 - c. Sensor: Wafer-orifice-type, calibrated, flow-measuring element; for installation between pipe flanges.
 - 1) Design: Differential-pressure-type measurement for gas **OR** oil **OR** steam **OR** water, **as directed**.
 - 2) Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
 - 3) Minimum Pressure Rating: 300 psig (2070 kPa).
 - 4) Minimum Temperature Rating: 250 deg F (121 deg C).
 - d. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected sensor and having 6-inch- (152-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to sensor.
 - 1) Scale: Gallons per minute (Liters per second).
 - 2) Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.
 - e. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected sensor and having two 12-foot (3.7-m) hoses, with carrying case.
 - 1) Scale: Gallons per minute (Liters per second).
 - 2) Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.
 - f. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
 - g. Conversion Chart: Flow rate data compatible with sensor and indicator.
 - h. Operating Instructions: Include complete instructions with each flowmeter.
 2. Pitot-Tube Flowmeters:
 - a. Description: Flowmeter with sensor and indicator.
 - b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
 - c. Sensor: Insertion type; for inserting probe into piping and measuring flow directly in gallons per minute (liters per second).
 - 1) Design: Differential-pressure-type measurement for oil **OR** water, **as directed**.
 - 2) Construction: Stainless-steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
 - 3) Minimum Pressure Rating: 150 psig (1035 kPa).
 - 4) Minimum Temperature Rating: 250 deg F (121 deg C).



- d. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
 - e. Integral Transformer: For low-voltage power connection.
 - f. Accuracy: Plus or minus 3 percent.
 - g. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
 - h. Operating Instructions: Include complete instructions with each flowmeter.
3. Turbine Flowmeters:
- a. Description: Flowmeter with sensor and indicator.
 - b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
 - c. Sensor: Impeller turbine; for inserting into pipe fitting or for installing in piping and measuring flow directly in gallons per minute (liters per second).
 - 1) Design: Device or pipe fitting with inline turbine and integral direct-reading scale for gas **OR** oil **OR** steam **OR** water, **as directed**.
 - 2) Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
 - 3) Minimum Pressure Rating: 150 psig (1035 kPa).
 - 4) Minimum Temperature Rating: 180 deg F (82 deg C).
 - d. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
 - e. Accuracy: Plus or minus 1-1/2 percent.
 - f. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
 - g. Operating Instructions: Include complete instructions with each flowmeter.
4. Venturi Flowmeters:
- a. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
 - b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
 - c. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.
 - 1) Design: Differential-pressure-type measurement for gas **OR** oil **OR** steam **OR** water, **as directed**.
 - 2) Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
 - 3) Minimum Pressure Rating: 250 psig (1725 kPa).
 - 4) Minimum Temperature Rating: 250 deg F (121 deg C).
 - 5) End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 - 6) End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged or welded.
 - 7) Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.
 - d. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (152-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
 - 1) Scale: Gallons per minute (Liters per second).
 - 2) Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.
 - e. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two 12-foot (3.7-m) hoses, with carrying case.
 - 1) Scale: Gallons per minute (Liters per second).
 - 2) Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.
 - f. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
 - g. Conversion Chart: Flow rate data compatible with sensor.
 - h. Operating Instructions: Include complete instructions with each flowmeter.
5. Vortex-Shedding Flowmeters:
- a. Description: Flowmeter with sensor and indicator.
 - b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
 - c. Sensor: Inline type; for installing between pipe flanges and measuring flow directly in gallons per minute (liters per second).



- 1) Design: Flow obstruction device, vortex-measurement type for gas **OR** steam **OR** liquids, **as directed**.
- 2) Construction: Stainless-steel body, with integral transmitter and direct-reading scale.
- 3) Minimum Pressure Rating: 1000 psig (6900 kPa).
- 4) Minimum Temperature Rating: 500 deg F (260 deg C).
- 5) Integral Transformer: For low-voltage power operation.
- d. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
- e. Accuracy: Plus or minus 0.25 percent for liquids and 0.75 percent for gases.
- f. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
- g. Operating Instructions: Include complete instructions with each flowmeter.

M. Thermal-Energy Meters

1. Impeller-Turbine, Thermal-Energy Meters:
 - a. Description: System with strainer, **as directed**, flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
 - b. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.
 - 1) Design: Total thermal-energy measurement.
 - 2) Minimum Pressure Rating: 150 psig (1035 kPa).
 - 3) Minimum Temperature Range: 40 to 250 deg F (5 to 121 deg C).
 - c. Temperature Sensors: Insertion-type transducer.
 - d. Indicator: Solid-state, integrating-type meter with integral battery pack, **as directed**; for wall mounting.
 - 1) Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units (joules).
 - 2) Battery Pack: Five-year lithium battery.
 - e. Accuracy: Plus or minus 1 percent.
 - f. Display: Visually indicates total fluid volume in gallons (liters) and thermal-energy flow in kilowatts per hour or British thermal units (joules).
 - g. Strainer: Full size of main line piping.
 - h. Operating Instructions: Include complete instructions with each thermal-energy meter system.
2. Ultrasonic, Thermal-Energy Meters:
 - a. Description: Meter with flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
 - b. Flow Sensor: Transit-time ultrasonic type with transmitter.
 - c. Temperature Sensors: Insertion-type or strap-on transducer.
 - d. Indicator: Solid-state, integrating-type meter with integral battery pack, **as directed**.
 - 1) Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units (joules).
 - 2) Battery Pack: Five-year lithium battery.
 - e. Accuracy: Plus or minus 1 percent.
 - f. Display: Visually indicates total fluid volume in gallons (liters) and thermal-energy flow in kilowatts per hour or British thermal units (joules).
 - g. Operating Instructions: Include complete instructions with each thermal-energy meter system.

1.3 EXECUTION

A. Installation

1. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid **OR** one-third of pipe diameter **OR** to center of pipe, **as directed**, and in vertical position in piping tees.
2. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.



3. Install thermowells with extension on insulated piping.
 4. Fill thermowells with heat-transfer medium.
 5. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
 6. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
 7. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
 8. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
 9. Install remote-mounted pressure gages on panel.
 10. Install valve and snubber in piping for each pressure gage for fluids (except steam).
 11. Install valve and syphon fitting in piping for each pressure gage for steam.
 12. Install test plugs in piping tees.
 13. Install flow indicators in piping systems in accessible positions for easy viewing.
 14. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
 15. Install flowmeter elements in accessible positions in piping systems.
 16. Install wafer-orifice flowmeter elements between pipe flanges.
 17. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
 18. Install permanent indicators on walls or brackets in accessible and readable positions.
 19. Install connection fittings in accessible locations for attachment to portable indicators.
 20. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
 21. Install thermometers in the following locations:
 - a. Inlet and outlet of each hydronic zone.
 - b. Inlet and outlet of each hydronic boiler.
 - c. Two inlets and two outlets of each chiller.
 - d. Inlet and outlet of each hydronic coil in air-handling units.
 - e. Two inlets and two outlets of each hydronic heat exchanger.
 - f. Inlet and outlet of each thermal-storage tank.
 - g. Outside-, return-, supply-, and mixed-air ducts.
 22. Install pressure gages in the following locations:
 - a. Discharge of each pressure-reducing valve.
 - b. Inlet and outlet of each chiller chilled-water and condenser-water connection.
 - c. Suction and discharge of each pump.
- B. Connections
1. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.
 2. Connect flowmeter-system elements to meters.
 3. Connect flowmeter transmitters to meters.
 4. Connect thermal-energy meter transmitters to meters.
- C. Adjusting
1. After installation, calibrate meters according to manufacturer's written instructions.
 2. Adjust faces of meters and gages to proper angle for best visibility.
- D. Thermometer Schedule
1. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
 - c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
 - d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.



2. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
 - c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
 - d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
3. Thermometers at inlets and outlets of each chiller shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
 - c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
 - d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
4. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
 - c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
 - d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
5. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
 - c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
 - d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
6. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
 - c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
 - d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
7. Thermometers at inlet and outlet of each thermal-storage tank shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
 - c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
 - d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
 - e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
8. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:
 - a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
 - b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
 - c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
 - d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
9. Thermometer stems shall be of length to match thermowell insertion length.



E. Thermometer Scale-Range Schedule

1. Scale Range for Chilled-Water Piping: Minus 40 to plus 160 deg F (Minus 40 to plus 100 deg C) **OR** Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C, **as directed**.
2. Scale Range for Chilled-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
3. Scale Range for Chilled-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
4. Scale Range for Chilled-Water Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
5. Scale Range for Condenser-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
6. Scale Range for Condenser-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
7. Scale Range for Condenser-Water Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
8. Scale Range for Condenser-Water Piping: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
9. Scale Range for Condenser-Water Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
10. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
11. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
12. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
13. Scale Range for Heating, Hot-Water Piping: 50 to 400 deg F (0 to 200 deg C) **OR** 50 to 400 deg F and 0 to 200 deg C, **as directed**.
14. Scale Range for Heating, Hot-Water Piping: 50 to 550 deg F (10 to 300 deg C) **OR** 50 to 550 deg F and 10 to 300 deg C, **as directed**.
15. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
16. Scale Range for Steam and Steam-Condensate Piping: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
17. Scale Range for Steam and Steam-Condensate Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
18. Scale Range for Steam and Steam-Condensate Piping: 50 to 400 deg F (0 to 200 deg C) **OR** 50 to 400 deg F and 0 to 200 deg C, **as directed**.
19. Scale Range for Air Ducts: Minus 40 to plus 110 deg F (Minus 40 to plus 45 deg C) **OR** Minus 40 to plus 110 deg F and minus 40 to plus 45 deg C, **as directed**.
20. Scale Range for Air Ducts: Minus 40 to plus 160 deg F (Minus 40 to plus 100 deg C) **OR** Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C, **as directed**.
21. Scale Range for Air Ducts: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
22. Scale Range for Air Ducts: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
23. Scale Range for Air Ducts: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
24. Scale Range for Air Ducts: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
25. Scale Range for Air Ducts: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
26. Scale Range for Air Ducts: 50 to 400 deg F (0 to 200 deg C) **OR** 50 to 400 deg F and 0 to 200 deg C, **as directed**.

F. Pressure-Gage Schedule



1. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:
 - a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct-mounted **OR** remote-mounted, **as directed**, metal case.
 - b. Sealed, direct-mounted **OR** remote-mounted, **as directed**, plastic case.
 - c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
 2. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:
 - a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct-mounted **OR** remote-mounted, **as directed**, metal case.
 - b. Sealed, direct-mounted **OR** remote-mounted, **as directed**, plastic case.
 - c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
 3. Pressure gages at suction and discharge of each pump shall be one of the following:
 - a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct-mounted **OR** remote-mounted, **as directed**, metal case.
 - b. Sealed, direct-mounted **OR** remote-mounted, **as directed**, plastic case.
 - c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
- G. Pressure-Gage Scale-Range Schedule
1. Scale Range for Chilled-Water Piping: 30 in. Hg to 15 psi (minus 100 to 0 kPa) **OR** 30 in. Hg to 15 psi and minus 100 to 0 kPa, **as directed**.
 2. Scale Range for Chilled-Water Piping: 0 to 30 psi (0 to 240 kPa) **OR** 0 to 30 psi and 0 to 240 kPa, **as directed**.
 3. Scale Range for Chilled-Water Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
 4. Scale Range for Chilled-Water Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
 5. Scale Range for Chilled-Water Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
 6. Scale Range for Chilled-Water Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.
 7. Scale Range for Chilled-Water Piping: 0 to 600 psi (0 to 4000 kPa) **OR** 0 to 600 psi and 0 to 4000 kPa, **as directed**.
 8. Scale Range for Condenser-Water Piping: 30 in. Hg to 15 psi (minus 100 to 0 kPa) **OR** 30 in. Hg to 15 psi and minus 100 to 0 kPa, **as directed**.
 9. Scale Range for Condenser-Water Piping: 0 to 30 psi (0 to 240 kPa) **OR** 0 to 30 psi and 0 to 240 kPa, **as directed**.
 10. Scale Range for Condenser-Water Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
 11. Scale Range for Condenser-Water Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
 12. Scale Range for Condenser-Water Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
 13. Scale Range for Condenser-Water Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.
 14. Scale Range for Condenser-Water Piping: 0 to 600 psi (0 to 4000 kPa) **OR** 0 to 600 psi and 0 to 4000 kPa, **as directed**.
 15. Scale Range for Heating, Hot-Water Piping: 30 in. Hg to 15 psi (minus 100 to 0 kPa) **OR** 30 in. Hg to 15 psi and minus 100 to 0 kPa, **as directed**.
 16. Scale Range for Heating, Hot-Water Piping: 0 to 30 psi (0 to 240 kPa) **OR** 0 to 30 psi and 0 to 240 kPa, **as directed**.
 17. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.



18. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
19. Scale Range for Heating, Hot-Water Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
20. Scale Range for Heating, Hot-Water Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.
21. Scale Range for Heating, Hot-Water Piping: 0 to 600 psi (0 to 4000 kPa) **OR** 0 to 600 psi and 0 to 4000 kPa, **as directed**.
22. Scale Range for Steam Piping: 30 in. Hg to 15 psi (minus 100 to 0 kPa) **OR** 30 in. Hg to 15 psi and minus 100 to 0 kPa, **as directed**.
23. Scale Range for Steam Piping: 0 to 30 psi (0 to 240 kPa) **OR** 0 to 30 psi and 0 to 240 kPa, **as directed**.
24. Scale Range for Steam Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
25. Scale Range for Steam Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
26. Scale Range for Steam Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
27. Scale Range for Steam Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.
28. Scale Range for Steam Piping: 0 to 600 psi (0 to 4000 kPa) **OR** 0 to 600 psi and 0 to 4000 kPa, **as directed**.

H. Flowmeter Schedule

1. Flowmeters for Chilled-Water Piping: Orifice **OR** Pitot-tube **OR** Turbine **OR** Venturi **OR** Vortex-shedding, **as directed**, type.
2. Flowmeters for Condenser-Water Piping: Orifice **OR** Pitot-tube **OR** Turbine **OR** Venturi **OR** Vortex-shedding, **as directed**, type.
3. Flowmeters for Heating, Hot-Water Piping: Orifice **OR** Pitot-tube **OR** Turbine **OR** Venturi **OR** Vortex-shedding, **as directed**, type.
4. Flowmeters for Steam and Steam-Condensate Piping: Orifice **OR** Turbine **OR** Venturi **OR** Vortex-shedding, **as directed**, type.

I. Thermal-Energy Meter Schedule

1. Thermal-Energy Meters for Chilled-Water Piping: Impeller-turbine **OR** Ultrasonic, **as directed**, type.
2. Thermal-Energy Meters for Condenser-Water Piping: Impeller-turbine **OR** Ultrasonic, **as directed**, type.
3. Thermal-Energy Meters for Heating, Hot-Water Piping: Impeller-turbine **OR** Ultrasonic, **as directed**, type.
4. Thermal-Energy Meters for Steam and Steam-Condensate Piping: Impeller-turbine **OR** Ultrasonic, **as directed**, type.

END OF SECTION 21 05 19 00b



Task	Specification	Specification Description
21 05 19 00	01 22 16 00	No Specification Required
21 05 29 00	07 72 56 00a	Heat Tracing for Fire-Suppression Piping



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SECTION 21 05 48 13 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of vibration and seismic controls for fire-suppression piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Isolation pads.
 - b. Isolation mounts.
 - c. Restrained elastomeric isolation mounts.
 - d. Restraining braces.

C. Definitions

1. IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. Performance Requirements

1. Seismic-Restraint Loading:
 - a. Site Class as Defined in the IBC: **A OR B OR C OR D OR E OR F, as directed.**
 - b. Assigned Seismic Use Group or Building Category as Defined in the IBC: **I OR II OR III, as directed.**
 - 1) Component Importance Factor: **1.0 OR 1.5, as directed.**
 - 2) Component Response Modification Factor: **1.5 OR 2.5 OR 3.5 OR 5.0, as directed.**
 - 3) Component Amplification Factor: **1.0 OR 2.5, as directed.**
 - c. Design Spectral Response Acceleration at Short Periods (0.2 Second): As required to meet Project requirements.
 - d. Design Spectral Response Acceleration at 1-Second Period: As required to meet Project requirements.

E. Submittals

1. Product Data: For each product indicated.
2. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Qualification Data: For professional engineer.

F. Quality Assurance

1. Comply with seismic-restraint requirements in the IBC and NFPA 13 unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on

Vibration And Seismic Controls For Fire-Suppression Piping And Equipment



calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.2 PRODUCTS

A. Vibration Isolators

1. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
 - a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
3. Restrained Mounts: All-directional mountings with seismic restraint.
 - a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

B. Seismic-Restraint Devices

1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
3. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
4. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
5. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.
6. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
7. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.



8. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

C. Factory Finishes

1. Finish

- a. Manufacturer's standard prime-coat finish ready for field painting.

OR

Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

- 1) Powder coating on springs and housings.
- 2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
- 3) Baked enamel or powder coat for metal components on isolators for interior use.
- 4) Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

1.3 EXECUTION

A. Applications

1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Vibration-Control And Seismic-Restraint Device Installation

1. Equipment Restraints:

- a. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
- b. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.

2. Piping Restraints:

- a. Comply with requirements in MSS SP-127 and NFPA 13.
- b. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
- c. Brace a change of direction longer than 12 feet (3.7 m).

3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
5. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
6. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
7. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
8. Drilled-in Anchors:



- a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
- b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
- c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
- d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
- e. Set anchors to manufacturer's recommended torque, using a torque wrench.
- f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

C. Accommodation Of Differential Seismic Motion

1. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 21 Section "Wet-pipe Sprinkler Systems" for piping flexible connections.

END OF SECTION 21 05 48 13

**SECTION 21 07 00 00 - FIRE-SUPPRESSION SYSTEMS INSULATION**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fire-suppression systems insulation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Insulation Materials:
 - 1) Calcium silicate.
 - 2) Cellular glass.
 - 3) Flexible elastomeric.
 - 4) Mineral fiber.
 - 5) Phenolic.
 - 6) Polyisocyanurate.
 - 7) Polyolefin.
 - 8) Polystyrene.
 - b. Insulating cements.
 - c. Adhesives.
 - d. Mastics.
 - e. Lagging adhesives.
 - f. Sealants.
 - g. Factory-applied jackets.
 - h. Field-applied fabric-reinforcing mesh.
 - i. Field-applied cloths.
 - j. Field-applied jackets.
 - k. Tapes.
 - l. Securements.
 - m. Corner angles.

C. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:
 - a. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - b. Detail attachment and covering of heat tracing inside insulation.
 - c. Detail insulation application at pipe expansion joints for each type of insulation.
 - d. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - e. Detail removable insulation at piping specialties and equipment connections.
 - f. Detail application of field-applied jackets.
 - g. Detail application at linkages of control devices.
 - h. Detail field application for fire-suppression water storage tanks.
4. Field quality-control reports.

D. Quality Assurance



1. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - a. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - b. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

E. Delivery, Storage, And Handling

1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.2 PRODUCTS

A. Insulation Materials

1. Comply with requirements in Part 1.3 schedule articles for where insulating materials shall be applied.
2. Products shall not contain asbestos, lead, mercury, or mercury compounds.
3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
6. Calcium Silicate:
 - a. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - b. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
7. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - a. Block Insulation: ASTM C 552, Type I.
 - b. Special-Shaped Insulation: ASTM C 552, Type III.
 - c. Board Insulation: ASTM C 552, Type IV.
 - d. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 - e. Preformed Pipe Insulation with Factory-Applied ASJ **OR** ASJ-SSL, **as directed**: Comply with ASTM C 552, Type II, Class 2.
 - f. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
8. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
9. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
10. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
11. Mineral-Fiber, Preformed Pipe Insulation:
 - a. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied



- jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- b. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
12. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ **OR** FSK jacket, **as directed**, complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 13. Phenolic:
 - a. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 - b. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 - c. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 - d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - 1) Preformed Pipe Insulation: None **OR** ASJ, **as directed**.
 - 2) Board for Equipment Applications: None **OR** ASJ, **as directed**.
 14. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
 - a. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
 - b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E 84.
 - c. Fabricate shapes according to ASTM C 450 and ASTM C 585.
 - d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - 1) Pipe Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
 - 2) Equipment Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
 15. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
 16. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.
- B. Insulating Cements
1. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
 2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
 3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- C. Adhesives
1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
 2. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).
 - a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).



3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
7. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. PVC Jacket Adhesive: Compatible with PVC jacket.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mastics

1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - a. For indoor applications, use mastics that have a VOC content of <Insert value> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - a. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - b. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - d. Color: White.
3. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
 - a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
 - b. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 - c. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - d. Color: White.
4. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - a. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 - b. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
 - c. Solids Content: 63 percent by volume and 73 percent by weight.
 - d. Color: White.

E. Lagging Adhesives

1. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
 - a. For indoor applications, use lagging adhesives that have a VOC content of <Insert value> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
 - c. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
 - d. Color: White.



F. Sealants

1. Joint Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Permanently flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 - d. Color: White or gray.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. FSK and Metal Jacket Flashing Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Fire- and water-resistant, flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - d. Color: Aluminum.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Fire- and water-resistant, flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - d. Color: White.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Factory-Applied Jackets

1. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 - b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 - c. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 - d. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
 - e. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
 - f. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

H. Field-Applied Fabric-Reinforcing Mesh

1. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
2. Woven Glass-Fiber Fabric for Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.
3. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave.

I. Field-Applied Cloths

1. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).



J. Field-Applied Jackets

1. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
2. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - a. Adhesive: As recommended by jacket material manufacturer.
 - b. Color: White **OR** Color-code jackets based on system. Color as selected by the Owner, **as directed**.
 - c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - 1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 - d. Factory-fabricated tank heads and tank side panels.
3. Metal Jacket:
 - a. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - 1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
 - 2) Finish and thickness are indicated in field-applied jacket schedules.
 - 3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 5) Factory-Fabricated Fitting Covers:
 - a) Same material, finish, and thickness as jacket.
 - b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c) Tee covers.
 - d) Flange and union covers.
 - e) End caps.
 - f) Beveled collars.
 - g) Valve covers.
 - h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
 - b. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - 1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
 - 2) Material, finish, and thickness are indicated in field-applied jacket schedules.
 - 3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 5) Factory-Fabricated Fitting Covers:
 - a) Same material, finish, and thickness as jacket.
 - b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c) Tee covers.
 - d) Flange and union covers.
 - e) End caps.
 - f) Beveled collars.
 - g) Valve covers.
 - h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

K. Tapes



1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - a. Width: 3 inches (75 mm).
 - b. Thickness: 11.5 mils (0.29 mm).
 - c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - d. Elongation: 2 percent.
 - e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - f. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - a. Width: 3 inches (75 mm).
 - b. Thickness: 6.5 mils (0.16 mm).
 - c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - d. Elongation: 2 percent.
 - e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - f. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
3. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - a. Width: 2 inches (50 mm).
 - b. Thickness: 6 mils (0.15 mm).
 - c. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 - d. Elongation: 500 percent.
 - e. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
4. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - a. Width: 2 inches (50 mm).
 - b. Thickness: 3.7 mils (0.093 mm).
 - c. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 - d. Elongation: 5 percent.
 - e. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
5. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - a. Width: 3 inches (75 mm).
 - b. Film Thickness: 4 mils (0.10 mm).
 - c. Adhesive Thickness: 1.5 mils (0.04 mm).
 - d. Elongation at Break: 145 percent.
 - e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.
6. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - a. Width: 3 inches (75 mm).
 - b. Film Thickness: 6 mils (0.15 mm).
 - c. Adhesive Thickness: 1.5 mils (0.04 mm).
 - d. Elongation at Break: 145 percent.
 - e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

L. Securements

1. Bands:
 - a. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
 - b. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
 - c. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
2. Insulation Pins and Hangers:
 - a. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in



- position indicated when self-locking washer is in place. Comply with the following requirements:
- 1) Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - 2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - 3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- b. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
- 1) Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - 2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - 3) Adhesive-backed base with a peel-off protective cover.
- c. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- 1) Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
3. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
 4. Wire: 0.080-inch (2.0-mm) nickel-copper alloy **OR** 0.062-inch (1.6-mm) soft-annealed, stainless steel **OR** 0.062-inch (1.6-mm) soft-annealed, galvanized steel, **as directed**.

1.3 EXECUTION

A. Preparation

1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
OR
Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - b. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
3. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

B. General Installation Requirements

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.



2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
4. Install insulation with longitudinal seams at top and bottom of horizontal runs.
5. Install multiple layers of insulation with longitudinal and end seams staggered.
6. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
7. Keep insulation materials dry during application and finishing.
8. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
9. Install insulation with least number of joints practical.
10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - a. Install insulation continuously through hangers and around anchor attachments.
 - b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
11. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
12. Install insulation with factory-applied jackets as follows:
 - a. Draw jacket tight and smooth.
 - b. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - c. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, o.c.
 - 1) For below ambient services, apply vapor-barrier mastic over staples.
 - d. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - e. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
16. For above ambient services, do not install insulation to the following:
 - a. Vibration-control devices.
 - b. Testing agency labels and stamps.
 - c. Nameplates and data plates.
 - d. Manholes.
 - e. Handholes.
 - f. Cleanouts.

C. Penetrations



1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - a. Seal penetrations with flashing sealant.
 - b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - d. Seal jacket to roof flashing with flashing sealant.
 2. Insulation Installation at Below-Grade Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
 3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - a. Seal penetrations with flashing sealant.
 - b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - c. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 - d. Seal jacket to wall flashing with flashing sealant.
 4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
 5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - a. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
 6. Insulation Installation at Floor Penetrations:
 - a. Pipe: Install insulation continuously through floor penetrations.
 - b. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping".
- D. Equipment, Tank, And Vessel Insulation Installation
1. Secure insulation with adhesive and anchor pins and speed washers.
 - a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of tank and vessel surfaces.
 - b. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 - c. Protect exposed corners with secured corner angles.
 - d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - 1) Do not weld anchor pins to ASME-labeled pressure vessels.
 - 2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - 3) On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
 - 4) Do not overcompress insulation during installation.
 - 5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - 6) Impale insulation over anchor pins and attach speed washers.
 - 7) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.



- e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 - f. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
 - g. Stagger joints between insulation layers at least 3 inches (75 mm).
 - h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 - i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 - j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
 - a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 - b. Seal longitudinal seams and end joints.

E. General Pipe Insulation Installation

1. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
2. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - a. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 - b. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - c. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - d. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 - e. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 - f. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 - g. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for



above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

- h. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 - i. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
3. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
 4. Install removable insulation covers at locations indicated. Installation shall conform to the following:
 - a. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 - b. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 - c. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 - d. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 - e. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

F. Calcium Silicate Insulation Installation

1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
 - b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
 - c. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.
2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
 - d. Finish flange insulation same as pipe insulation.
3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available.



- b. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
 - c. Finish fittings insulation same as pipe insulation.
 - 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - b. Install insulation to flanges as specified for flange insulation application.
 - c. Finish valve and specialty insulation same as pipe insulation.
- G. Cellular-Glass Insulation Installation
- 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and applicable insulation joint sealant.
 - c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
 - 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
 - d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
 - 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available.
 - b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
 - 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed sections of cellular-glass insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
- H. Flexible Elastomeric Insulation Installation
- 1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 - 2. Insulation Installation on Pipe Flanges:
 - a. Install pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 - 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install mitered sections of pipe insulation.
 - b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.



4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - b. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
 - d. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

- I. Mineral-Fiber Insulation Installation
 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and applicable insulation joint sealant.
 - c. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
 - d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available.
 - b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available.
 - b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
 - c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - d. Install insulation to flanges as specified for flange insulation application.

- J. Phenolic Insulation Installation
 1. General Installation Requirements:
 - a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
 - b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
 2. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.



- b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and applicable insulation joint sealant.
 - c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
3. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
 4. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed insulation sections of same material as straight segments of pipe insulation.
 5. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed insulation sections of same material as straight segments of pipe insulation.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
- K. Polyisocyanurate Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
 - b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
 - c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.
 3. Insulation Installation on Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation.
 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed sections of polyisocyanurate insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
- L. Polyolefin Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
 - a. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 2. Insulation Installation on Pipe Flanges:
 - a. Install pipe insulation to outer diameter of pipe flange.



- b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
 - d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install mitered sections of polyolefin pipe insulation.
 - b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install cut sections of polyolefin pipe and sheet insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
 - d. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

M. Polystyrene Insulation Installation

1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
 - b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
 - c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.
3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed insulation sections of same material as straight segments of pipe insulation.
4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed section of polystyrene insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.

N. Field-Applied Jacket Installation

1. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - a. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 - b. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
 - c. Completely encapsulate insulation with coating, leaving no exposed insulation.
2. Where FSK jackets are indicated, install as follows:
 - a. Draw jacket material smooth and tight.
 - b. Install lap or joint strips with same material as jacket.



- c. Secure jacket to insulation with manufacturer's recommended adhesive.
 - d. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
3. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
 - a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
 4. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.
 5. Where PVDC jackets are indicated, install as follows:
 - a. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
 - b. Wrap factory-presizes jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
 - c. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
 - d. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
 - e. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.
- O. Finishes
1. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 07.
 - a. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - 1) Finish Coat Material: Interior, flat, latex-emulsion size.
 2. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
 3. Color: Final color as selected by the Owner. Vary first and second coats to allow visual inspection of the completed Work.
 4. Do not field paint aluminum or stainless-steel jackets.
- P. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Inspect field-insulated equipment, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
 - b. Inspect pipe, fittings, strainers, and valves, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of



inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

3. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

Q. Equipment Insulation Schedule

1. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
2. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
3. Fire-suppression water storage tank insulation shall be one of the following:
 - a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.

R. Piping Insulation Schedule, General

1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - a. Indoor fire-suppression piping.
 - b. Underground piping.

S. Indoor Piping Insulation Schedule

1. Indoor Engine Coolant Piping for Remote Radiator of Engine-Driven Fire Pump:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 2 inches (50 mm) thick.
 - 2) Cellular Glass: 2 inches (50 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches (50 mm) thick.
2. Indoor Engine Exhaust Piping and Silencer, All Pipe Sizes: Calcium silicate, 4 inches (100 mm) thick.

T. Outdoor, Aboveground Piping Insulation Schedule

1. Outdoor Engine Coolant Piping for Remote Radiator of Engine-Driven Fire Pump:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 2 inches (50 mm) thick.
 - 2) Cellular Glass: 2 inches (50 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches (50 mm) thick.
2. Outdoor Engine Exhaust Piping and Silencer, All Pipe Sizes: Calcium silicate, 4 inches (100 mm) thick.
3. Outdoor Fire-Suppression Piping Filled with Water:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Flexible Elastomeric: 2 inches (50 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 4) Phenolic: 2 inches (50 mm) thick.
 - 5) Polyisocyanurate: 2 inches (50 mm) thick.
 - 6) Polyolefin: 2 inches (50 mm) thick.
 - 7) Polystyrene: 2 inches (50 mm) thick.



U. Indoor, Field-Applied Jacket Schedule

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Piping, Concealed:
 - a. None.
 - b. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - c. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - d. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Piping, Exposed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

V. Outdoor, Field-Applied Jacket Schedule

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Equipment, Concealed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 - a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.



5. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 - a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Outdoor Exposed Piping:
 - a. PVC: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm) **OR** 40 mils (1.0 mm), **as directed**, thick.
 - b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed** with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

END OF SECTION 21 07 00 00



SECTION 21 11 19 00 - FIRE-SUPPRESSION STANDPIPES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fire-suppression standpipes. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pipes, fittings, and specialties.
 - b. Fire-protection valves.
 - c. Hose connections.
 - d. Hose stations.
 - e. Monitors.
 - f. Fire-department connections.
 - g. Alarm devices.
 - h. Manual control stations.
 - i. Control panels.
 - j. Pressure gages.

C. Definitions

1. High-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure higher than standard 175 psig (1200 kPa), but not higher than 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**.
2. Standard-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure 175 psig (1200 kPa) maximum.

D. System Descriptions

1. Automatic Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.
2. Automatic Wet-Type, Class II Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations. Has open water-supply valve with pressure maintained and is capable of supplying water demand.
3. Automatic Wet-Type, Class III Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations and NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.
4. Automatic Dry-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve and dry-pipe valve with standpipes containing compressed air. Opening fire-hose valve releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into standpipes.
5. Automatic Dry-Type, Class II Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations. Has open water-supply valve and dry-pipe valve with standpipes containing compressed air. Opening fire-hose valve releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into standpipes.
6. Automatic Dry-Type, Class III Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations and NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve and dry-pipe valve with standpipes containing compressed air. Opening fire-hose valve releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into standpipes.
7. Semiautomatic Dry-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve and deluge valve with standpipes containing air.



Actuation of detection device permits water pressure to open deluge valve. Water then flows into standpipes.

8. Semiautomatic Dry-Type, Class II Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations. Has open water-supply valve and deluge valve with standpipes containing air. Actuation of detection device permits water pressure to open deluge valve. Water then flows into standpipes.
9. Semiautomatic Dry-Type, Class III Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations and NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve and deluge valve with standpipes containing air. Actuation of detection device permits water pressure to open deluge valve. Water then flows into standpipes.
10. Manual Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has small water supply to maintain water in standpipes. Piping is wet, but water must be pumped into standpipes to satisfy demand.
11. Manual Dry-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Does not have permanent water supply. Piping is dry. Water must be pumped into standpipes to satisfy demand.

E. Performance Requirements

1. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
2. High-Pressure, Fire-Suppression Standpipe System Component: Listed for 250-psig (1725-kPa) minimum **OR** 300-psig (2070-kPa), **as directed**, working pressure.
3. Delegated Design: Design fire-suppression standpipes, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
4. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.
 - a. Minimum residual pressure at each hose-connection outlet is as follows:
 - 1) NPS 1-1/2 (DN 40) Hose Connections: 65 psig (450 kPa).
 - 2) NPS 2-1/2 (DN 65) Hose Connections: 100 psig (690 kPa).
 - b. Maximum residual pressure at required flow at each hose-connection outlet is as follows unless otherwise indicated:
 - 1) NPS 1-1/2 (DN 40) Hose Connections: 100 psig (690 kPa).
 - 2) NPS 2-1/2 (DN 65) Hose Connections: 175 psig (1200 kPa).
5. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

F. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For fire-suppression standpipes. Include plans, elevations, sections, details, and attachments to other work.
 - a. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For standpipe systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. Qualification Data: For qualified Installer and professional engineer.
5. Approved Standpipe Drawings: Working plans, prepared according to NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
6. Welding certificates.
7. Fire-hydrant flow test report.
8. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."
9. Field quality-control reports.
10. Operation and Maintenance Data: For fire-suppression standpipes specialties to include in emergency, operation, and maintenance manuals.



G. Quality Assurance

1. Installer Qualifications:
 - a. Installer's responsibilities include designing, fabricating, and installing fire-suppression standpipes and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - 1) Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
2. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. NFPA Standards: Fire-suppression standpipe equipment, specialties, accessories, installation, and testing shall comply with NFPA 14, "Installation of Standpipe and Hose Systems."

H. Project Conditions

1. Interruption of Existing Fire-Suppression Standpipe Service: Do not interrupt fire-suppression standpipe service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fire-suppression standpipe service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of fire-suppression standpipe service.
 - b. Do not proceed with interruption of fire-suppression standpipe service without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials

1. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. Steel Pipe And Fittings

1. Standard Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
2. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A 135; ASTM A 795/A 795M, Type E; or ASME B36.10M, wrought steel; with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
3. Thinwall Galvanized- and Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
4. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
5. Nonstandard OD, Thinwall Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, thinwall, with plain ends and wall thickness less than Schedule 10.
6. Hybrid Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5.
7. Standard-Weight, Galvanized- and Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, seamless steel pipe with threaded ends.
8. Galvanized and Uncoated, Steel Couplings: ASTM A 865, threaded.
9. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
10. Malleable- or Ductile-Iron Unions: UL 860.
11. Cast-Iron Flanges: ASME B16.1, Class 125.
12. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
13. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.



14. Grooved-Joint, Steel-Pipe Appurtenances:
 - a. Pressure Rating: 175 psig (1200 kPa) **OR** 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**, minimum.
 - b. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
 - c. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

- C. Copper Tube And Fittings
 1. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) and ASTM B 88, Type M (ASTM B 88M, Type C) water tube, drawn temper.
 2. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
 3. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.
 4. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
 5. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
 6. Grooved-Joint, Copper-Tube Appurtenances:
 - a. Grooved-End, Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze castings.
 - b. Grooved-End-Tube Couplings: To fit copper tube dimensions, with design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gasket suitable for hot and cold water, and bolts and nuts.

- D. Piping Joining Materials
 1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.
 - a. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 - b. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
 2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
 3. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
 4. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

- E. Listed Fire-Protection Valves
 1. General Requirements:
 - a. Valves shall be UL listed or FM approved.
 - b. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).
 - c. Minimum Pressure Rating for High-Pressure Piping: 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**.
 2. Ball Valves:
 - a. Standard: UL 1091 except with ball instead of disc.
 - b. Valves NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
 - c. Valves NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
 - d. Valves NPS 3 (DN 80): Ductile-iron body with grooved ends.
 3. Bronze Butterfly Valves:
 - a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Bronze.
 - d. End Connections: Threaded.



4. Iron Butterfly Valves:
 - a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Cast or ductile iron.
 - d. Style: Lug or wafer.
OR
End Connections: Grooved.
 5. Check Valves:
 - a. Standard: UL 312.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Type: Swing check.
 - d. Body Material: Cast iron.
 - e. End Connections: Flanged or grooved.
 6. Bronze OS&Y Gate Valves:
 - a. Standard: UL 262.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Bronze.
 - d. End Connections: Threaded.
 7. Iron OS&Y Gate Valves:
 - a. Standard: UL 262.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast or ductile iron.
 - d. End Connections: Flanged or grooved.
 8. Indicating-Type Butterfly Valves:
 - a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 - c. Valves NPS 2 (DN 50) and Smaller:
 - 1) Valve Type: Ball or butterfly.
 - 2) Body Material: Bronze.
 - 3) End Connections: Threaded.
 - d. Valves NPS 2-1/2 (DN 65) and Larger:
 - 1) Valve Type: Butterfly.
 - 2) Body Material: Cast or ductile iron.
 - 3) End Connections: Flanged, grooved, or wafer.
 - e. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch **OR** electrical, 115-V ac, prewired, two-circuit, supervisory switch **OR** visual, **as directed**, indicating device.
 9. NRS Gate Valves:
 - a. Standard: UL 262.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast iron with indicator post flange.
 - d. Stem: Nonrising.
 - e. End Connections: Flanged or grooved.
 10. Indicator Posts:
 - a. Standard: UL 789.
 - b. Type: Horizontal for wall mounting.
 - c. Body Material: Cast iron with extension rod and locking device.
 - d. Operation: Wrench **OR** Hand wheel, **as directed**.
- F. Trim And Drain Valves
1. General Requirements:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 2. Angle Valves.
 3. Ball Valves.



4. Globe Valves.
5. Plug Valves.

G. Specialty Valves

1. General Requirements:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating:
 - 1) Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.
 - 2) High-Pressure Piping Specialty Valves: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast or ductile iron.
 - d. Size: Same as connected piping.
 - e. End Connections: Flanged or grooved.
2. Alarm Valves:
 - a. Standard: UL 193.
 - b. Design: For horizontal or vertical installation.
 - c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, **as directed**, and fill-line attachment with strainer.
 - d. Drip Cup Assembly (if retarding chamber is required): Pipe drain without valves and separate from main drain piping.
 - e. Drip Cup Assembly (if retarding chamber is not required): Pipe drain with check valve to main drain piping.
3. Dry-Pipe Valves:
 - a. Standard: UL 260.
 - b. Design: Differential-pressure type.
 - c. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
 - d. Air-Pressure Maintenance Device:
 - 1) Standard: UL 260.
 - 2) Type: Automatic device to maintain minimum air pressure in piping.
 - 3) Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) **OR** 300-psig (2070-kPa), **as directed**, outlet pressure.
 - e. Air Compressor:
 - 1) Standard: UL's "Fire Protection Equipment Directory" listing.
 - 2) Motor Horsepower: Fractional.
 - 3) Power: 120-V ac, 60 Hz, single phase.
4. Deluge Valves:
 - a. Standard: UL 260.
 - b. Design: Hydraulically operated, differential-pressure type.
 - c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection.
 - d. Wet, Pilot-Line Trim Set: Include gage to read push-rod chamber pressure, globe valve for manual operation of deluge valve, and connection for actuation device.
 - e. Dry, Pilot-Line Trim Set: Include dry, pilot-line actuator; air- and water-pressure gages; low-air-pressure warning switch; air relief valve; and actuation device. Dry, pilot-line actuator includes cast-iron, operated, diaphragm-type valve with resilient facing plate, resilient diaphragm, and replaceable bronze seat. Valve includes threaded water and air inlets and water outlet. Loss of air pressure on dry, pilot-line side allows pilot-line actuator to open and causes deluge valve to open immediately.
 - f. Air-Pressure Maintenance Device:



- 1) Standard: UL 260.
- 2) Type: Automatic device to maintain minimum air pressure in piping.
- 3) Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator, or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) **OR** 300-psig (2070-kPa), **as directed**, outlet pressure.
- g. Air Compressor:
 - 1) Standard: UL's "Fire Protection Equipment Directory" listing.
 - 2) Motor Horsepower: Fractional.
 - 3) Power: 120-V ac, 60 Hz, single phase.
5. Pressure-Reducing Valves:
 - a. UL 668 hose valve, with integral UL 1468 reducing device.
 - b. Pressure Rating: 300 psig (2070 kPa) minimum.
 - c. Material: Brass or bronze.
 - d. Inlet: Female pipe threads.
 - e. Outlet: Threaded with or without adapter having male hose threads.
 - f. Pattern: Angle or gate.
 - g. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
6. Automatic (Ball Drip) Drain Valves:
 - a. Standard: UL 1726.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 - c. Type: Automatic draining, ball check.
 - d. Size: NPS 3/4 (DN 20).
 - e. End Connections: Threaded.
- H. Hose Connections
 1. Adjustable-Valve Hose Connections:
 - a. Standard: UL 668 hose valve, with integral UL 1468 reducing or restricting pressure-control device, for connecting fire hose.
 - b. Pressure Rating: 300 psig (2070 kPa) minimum.
 - c. Material: Brass or bronze.
 - d. Size: NPS 1-1/2 or NPS 2-1/2 (DN 40 or DN 65), as indicated.
 - e. Inlet: Female pipe threads.
 - f. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
 - g. Pattern: Angle or gate.
 - h. Pressure-Control Device Type: Pressure reducing **OR** restricting, **as directed**.
 - i. Design Outlet Pressure Setting: as directed by the Owner.
 - j. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 2. Nonadjustable-Valve Hose Connections:
 - a. Standard: UL 668 hose valve for connecting fire hose.
 - b. Pressure Rating: 300 psig (2070 kPa) minimum.
 - c. Material: Brass or bronze.
 - d. Size: NPS 1-1/2 or NPS 2-1/2 (DN 40 or DN 65), as indicated.
 - e. Inlet: Female pipe threads.
 - f. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
 - g. Pattern: Angle or gate.
 - h. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
- I. NPS 1-1/2 (DN 40) Rack-Type Hose Stations
 1. Hose Rack:
 - a. Standard: UL 47.



- b. Material: Brass or bronze with polished chrome-plated **OR** Steel with red-enamel, **as directed**, finish.
 - c. Type: Hose-rack assembly. Include hose valve, hose rack, water-retention device, hose pins, and hose.
 - d. Operation: Semiautomatic.
 - e. Sized to hold fire hose.
2. Hose Valve:
- a. Standard: UL 668 NPS 1-1/2 (DN 40), for connecting fire hose.
 - b. Type: Adjustable **OR** Nonadjustable, **as directed**.
 - c. Pressure-Control Device: Not required **OR** Pressure reducing **OR** Pressure restricting, **as directed**.
 - d. Design Outlet Pressure Setting: Not applicable **OR as directed**.
 - e. Hose Valve and Trim Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - f. Pressure Rating: 300 psig (2070 kPa) minimum.
 - g. Pattern: Angle.
 - h. Material: Brass or bronze.
 - i. Pressure-Control Device: UL 1468 integral or for field installation if indicated.
 - j. Size: NPS 1-1/2 (DN 40).
 - k. Inlet: Female pipe threads.
 - l. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.
3. Hose:
- a. Standards: NFPA 1961 and UL 219 lined fire hose with swivel inlet, coupling, gaskets, and nozzle.
 - b. Size: NPS 1-1/2 (DN 40).
 - c. Length: 50 feet (15 m) **OR** 75 feet (23 m) **OR** 100 feet (30 m), **as directed**.
 - d. Jacket: Combination of natural and synthetic threads **OR** Natural thread **OR** Synthetic thread, **as directed**.
 - e. Lining: Combination of rubber and plastic compounds **OR** Rubber compound **OR** Plastic compound, **as directed**.
 - f. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
 - g. Nozzle: UL 401.
 - 1) Material: Brass **OR** Polished brass **OR** Rough chrome-plated brass **OR** Polished chrome-plated brass **OR** Polycarbonate plastic, **as directed**.
 - 2) Type: Plain, for nonadjustable water stream **OR** Spray, adjustable from shutoff to fog spray or straight stream **OR** Spray, adjustable from shutoff to full fog; for use on electrical fires, **as directed**.
- J. NPS 1-1/2 BY NPS 2-1/2 (DN 40 BY DN 65) Rack-Type Hose Stations
1. Hose Rack:
- a. Standard: UL 47.
 - b. Material: Brass or bronze with polished chrome-plated **OR** Steel with red-enamel, **as directed**, finish.
 - c. Type: Hose-rack assembly. Include hose valve, reducer adapter, hose rack, water-retention device, hose pins, and hose.
 - d. Operation: Semiautomatic.
 - e. Sized to hold fire hose.
2. Hose Valve:
- a. Standard: UL 668, NPS 2-1/2 (DN 65), for connecting fire hose.
 - b. Type: Adjustable **OR** Nonadjustable, **as directed**.
 - c. Pressure-Control Device: Not required **OR** Pressure reducing **OR** Pressure restricting, **as directed**.
 - d. Design Outlet Pressure Setting: Not applicable **OR as directed**.



- e. Hose Valve and Trim Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - f. Pressure Rating: 300 psig (2070 kPa) minimum.
 - g. Pattern: Angle.
 - h. Material: Brass or bronze.
 - i. Pressure-Control Device: UL 1468, integral or for field installation if indicated.
 - j. Size: NPS 2-1/2 (DN 65).
 - k. Inlet: Female pipe threads.
 - l. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.
 - m. Reducer Adapter: NPS 2-1/2 by NPS 1-1/2 (DN 65 by DN 40).
3. Hose:
- a. Standards: NFPA 1961 and UL 219, lined fire hose with swivel inlet, coupling, gaskets, and nozzle.
 - b. Size: NPS 1-1/2 (DN 40).
 - c. Length: 50 feet (15 m) **OR** 75 feet (23 m) **OR** 100 feet (30 m), **as directed**.
 - d. Jacket: Combination of natural and synthetic threads **OR** Natural thread **OR** Synthetic thread, **as directed**.
 - e. Lining: Combination of rubber and plastic compounds **OR** Rubber compound **OR** Plastic compound, **as directed**.
 - f. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
 - g. Nozzle: UL 401 spray nozzle unless plain nozzle is indicated.
 - 1) Material: Brass **OR** Polished brass **OR** Rough chrome-plated brass **OR** Polished chrome-plated brass **OR** Polycarbonate plastic, **as directed**.
 - 2) Type: Plain, for nonadjustable water stream **OR** Spray, adjustable from shutoff to fog spray or straight stream **OR** Spray, adjustable from shutoff to full fog; for use on electrical fires, **as directed**.
- K. NPS 1-1/2 (DN 40) Reel-Type Hose Stations
- 1. Hose Reel:
 - a. Standard: UL 47.
 - b. Hose Reel and Bracket Material: Steel.
 - c. Type: Hose-reel assembly. Include hose valve, wall bracket, hose reel, water-retention device, hose pins, and hose.
 - d. Operation: Semiautomatic.
 - e. Sized to hold fire hose.
 - f. Finish: Red enamel.
 - 2. Hose Valve:
 - a. Standard: UL 668, NPS 1-1/2 (DN 40), for connecting fire hose.
 - b. Type: Adjustable **OR** Nonadjustable, **as directed**.
 - c. Pressure-Control Device: Not required **OR** Pressure reducing **OR** Pressure restricting, **as directed**.
 - d. Design Outlet Pressure Setting: Not applicable **OR as directed**.
 - e. Hose Valve and Trim Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - f. Pressure Rating: 300 psig (2070 kPa) minimum.
 - g. Pattern: Angle.
 - h. Material: Brass or bronze.
 - i. Pressure-Control Device: UL 1468, integral or for field installation if indicated.
 - j. Size: NPS 1-1/2 (DN 40).
 - k. Inlet: Female pipe threads.
 - l. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.
 - 3. Hose:
 - a. Standards: NFPA 1961 and UL 219 lined fire hose with swivel inlet, coupling, gaskets, and nozzle.



- b. Size: NPS 1-1/2 (DN 40).
- c. Length: 50 feet (15 m) **OR** 75 feet (23 m) **OR** 100 feet (30 m), **as directed**.
- d. Jacket: Combination of natural and synthetic threads **OR** Natural thread **OR** Synthetic thread, **as directed**.
- e. Lining: Combination of rubber and plastic compounds **OR** Rubber compound **OR** Plastic compound, **as directed**.
- f. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
- g. Nozzle: UL 401.
 - 1) Material: Brass **OR** Polished brass **OR** Rough chrome-plated brass **OR** Polished chrome-plated brass **OR** Polycarbonate plastic, **as directed**.
 - 2) Type: Spray, adjustable from shutoff to fog spray or straight stream **OR** full fog; for use on electrical fires, **as directed**.

L. Monitors

- 1. Type: Stationary.
- 2. Nozzle: UL 401, NPS 2-1/2 (DN 65), brass, adjustable from fog spray to straight stream to shutoff.
- 3. Horizontal Rotation: 360 degrees with locking device.
- 4. Vertical Rotation: 80-degree elevation and 60-degree depression with locking device.
- 5. Waterway: Double **OR** Single, **as directed**, brass or stainless-steel tube.
- 6. Waterway Size: NPS 2-1/2 (DN 65) minimum.
- 7. Water Stream Flow: 500 gpm (31.5 L/s) **OR** 750 gpm (47.3 L/s) **OR** 1000 gpm (63 L/s), **as directed**.
- 8. Operation: Lever **OR** Wheel, **as directed**.
- 9. Base Inlet Size: NPS 2-1/2 (DN 65) **OR** NPS 3 (DN 80) **OR** NPS 4 (DN 100), **as directed**.
- 10. Finish: Red-painted body with brass trim.

M. Fire-Department Connections

- 1. Exposed-Type, Fire-Department Connection:
 - a. Standard: UL 405.
 - b. Type: Exposed, projecting, for wall mounting.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum.
 - d. Body Material: Corrosion-resistant metal.
 - e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Round, brass, wall type.
 - h. Outlet: Back, with pipe threads.
 - i. Number of Inlets: Two **OR** Three, **as directed**.
 - j. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "STANDPIPE", **as directed**.
 - k. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - l. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.
- 2. Flush-Type, Fire-Department Connection:
 - a. Standard: UL 405.
 - b. Type: Flush, for wall mounting.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum.
 - d. Body Material: Corrosion-resistant metal.
 - e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Rectangular, brass, wall type.



- h. Outlet: With pipe threads.
 - i. Body Style: Horizontal **OR** Square **OR** Vertical, **as directed**.
 - j. Number of Inlets: Two **OR** Three **OR** Four **OR** Six, **as directed**.
 - k. Outlet Location: Back **OR** Bottom **OR** Left side **OR** Right side **OR** Top, **as directed**.
 - l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "STANDPIPE", **as directed**.
 - m. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150) **OR** NPS 8 (DN 200), **as directed**.
3. Yard-Type, Fire-Department Connection:
- a. Standard: UL 405.
 - b. Type: Exposed, freestanding.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - d. Body Material: Corrosion-resistant metal.
 - e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Round, brass, floor type.
 - h. Outlet: Bottom, with pipe threads.
 - i. Number of Inlets: Two **OR** Three **OR** Four, **as directed**.
 - j. Sleeve: Brass **OR** Not required, **as directed**.
 - k. Sleeve Height: 18 inches (460 mm).
 - l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "STANDPIPE", **as directed**.
 - m. Finish, Including Sleeve: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.
- N. Alarm Devices
- 1. Alarm-device types shall match piping and equipment connections.
 - 2. Water-Motor-Operated Alarm:
 - a. Standard: UL 753.
 - b. Type: Mechanically operated, with Pelton wheel.
 - c. Alarm Gong: Cast aluminum with red-enamel factory finish.
 - d. Size: 10-inch (250-mm) diameter.
 - e. Components: Shaft length, bearings, and sleeve to suit wall construction.
 - f. Inlet: NPS 3/4 (DN 20).
 - g. Outlet: NPS 1 (DN 25) drain connection.
 - 3. Electrically Operated Alarm Bell:
 - a. Standard: UL 464.
 - b. Type: Vibrating, metal alarm bell.
 - c. Size: 6-inch (150-mm) minimum **OR** 8-inch (200-mm) minimum **OR** 10-inch (250-mm), **as directed**, diameter.
 - d. Finish: Red-enamel factory finish, suitable for outdoor use.
 - 4. Water-Flow Indicators:
 - a. Standard: UL 346.
 - b. Water-Flow Detector: Electrically supervised.
 - c. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
 - d. Type: Paddle operated.
 - e. Pressure Rating: 250 psig (1725 kPa).
 - f. Design Installation: Horizontal or vertical.



5. Pressure Switches:
 - a. Standard: UL 346.
 - b. Type: Electrically supervised water-flow switch with retard feature.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design Operation: Rising pressure signals water flow.
 6. Valve Supervisory Switches:
 - a. Standard: UL 346.
 - b. Type: Electrically supervised.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design: Signals that controlled valve is in other than fully open position.
 7. Indicator-Post Supervisory Switches:
 - a. Standard: UL 346.
 - b. Type: Electrically supervised.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design: Signals that controlled indicator-post valve is in other than fully open position.
- O. Manual Control Stations
1. Description: UL listed or FM approved, hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
- P. Control Panels
1. Description: Single-area, two-area, or single-area cross-zoned control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire-alarm bell; lamp test facility; single-pole, double-throw auxiliary alarm contacts; and rectifier.
 - a. Panels: UL listed and FM approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
 - b. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

OR

 Manual Control Stations: Hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
- Q. Pressure Gages
1. Standard: UL 393.
 2. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.
 3. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum **OR** 0 to 300 psig (0 to 2070 kPa), **as directed**.
 4. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
 5. Air System Piping Gage: Include retard feature, **as directed**, and "AIR" or "AIR/WATER" label on dial face.
- R. Escutcheons
1. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
 2. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with set-screws.
 3. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.



4. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw or spring clips.
5. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with concealed hinge and set-screw.
6. Split-Plate, Stamped-Steel Escutcheons: Chrome-plated finish with concealed **OR** exposed-rivet, **as directed**, hinge, set-screw or spring clips.
7. One-Piece Floor Plates: Cast-iron flange with holes for fasteners, **as directed**.
8. Split-Casting Floor Plates: Cast brass with concealed hinge.

S. Sleeves

1. Cast-Iron Wall-Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
4. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
5. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
6. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.
7. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set-screws.

T. Sleeve Seals

1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

U. Grout

1. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink, and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Preparation

1. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
2. Report test results promptly and in writing.

B. Service-Entrance Piping

1. Connect fire-suppression standpipe piping to water-service piping at service entrance into building. Comply with requirements for exterior piping in Division 21 Section "Facility Fire-suppression Water-service Piping".
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories at connection to fire-suppression water-service piping. Comply with requirements for backflow preventers in Division 21 Section "Facility Fire-suppression Water-service Piping", **as directed**.
3. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.



C. Water-Supply Connections

1. Connect fire-suppression standpipe piping to building's interior water-distribution piping. Comply with requirements for interior piping in Division 22 Section "Domestic Water Piping".
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories at connection to water-distribution piping. Comply with requirements for backflow preventers in Division 22 Section "Domestic Water Piping Specialties", **as directed**.
OR
Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

D. Piping Installation

1. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - a. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with the Owner before deviating from approved working plans.
2. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.
3. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.
4. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
5. Install drain valves on standpipes. Extend drain piping to outside of building.
6. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or outside building.
7. Install alarm devices in piping systems.
8. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.
9. Install pressure gages on riser or feed main and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
10. Drain dry-type standpipe system piping.
11. Pressurize and check dry-type standpipe system piping and air-pressure maintenance devices **OR** air compressors, **as directed**.
12. Fill wet-type standpipe system piping with water.
13. Install electric heating cables and pipe insulation on wet-type, fire-suppression standpipe piping in areas subject to freezing. Comply with requirements for heating cables in Division 21 Section "Heat Tracing For Fire-suppression Piping" and for piping insulation in Division 21 Section "Fire-suppression Systems Insulation".
14. Connect compressed-air supply to dry-pipe sprinkler piping.
OR
Connect air compressor to the following piping and wiring:
 - a. Pressure gages and controls.
 - b. Electrical power system.
 - c. Fire-alarm devices, including low-pressure alarm.

E. Joint Construction

1. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
2. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
3. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
4. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.



5. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
 6. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
 7. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
 8. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
 9. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
 10. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
 - a. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
 11. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
 12. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
 13. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.
- F. Valve And Specialties Installation
1. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14 and authorities having jurisdiction.
 2. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
 3. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
 4. Specialty Valves:
 - a. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
 - b. Alarm Valves: Install bypass check valve and retarding chamber drain-line connection.
 - c. Dry-Pipe and Deluge Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
 - 1) Install air compressor and compressed-air supply piping.
OR
Air-Pressure Maintenance Device: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range; and 175-psig (1200-kPa) maximum inlet pressure.
 - 2) Install compressed-air supply piping from building's compressed-air piping system.
- G. Hose-Connection Installation
1. Install hose connections adjacent to standpipes.
 2. Install freestanding hose connections for access and minimum passage restriction.
 3. Install NPS 1-1/2 (DN 40) hose-connection valves with flow-restricting device.



4. Install NPS 2-1/2 (DN 65) hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 (DN 65 by DN 40) reducer adapter and flow-restricting device.
 5. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Division 10 Section "Fire Extinguisher Cabinets".
- H. Hose-Station Installation
1. Install freestanding hose stations for access and minimum passage restriction.
 2. Install NPS 1-1/2 (DN 40) hose-station valves with flow-restricting device unless otherwise indicated.
 3. Install NPS 2-1/2 (DN 65) hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 (DN 65 by DN 40) reducer adapter and flow-restricting device unless otherwise indicated.
 4. Install freestanding hose stations with support or bracket attached to standpipe.
 5. Install wall-mounted, rack hose stations in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Division 10 Section "Fire Extinguisher Cabinets".
 6. Install hose-reel hose stations on wall with bracket.
- I. Monitor Installation
1. Install monitors on standpipe piping.
- J. Fire-Department Connection Installation
1. Install wall-type, fire-department connections.
 2. Install yard-type, fire-department connections in concrete slab support. Comply with requirements for concrete in Division 03 Section "Cast-in-place Concrete".
 - a. Install two **OR** three, **as directed**, protective pipe bollards around **OR** on sides of, **as directed**, each fire-department connection. Comply with requirements for bollards in Division 05 Section "Metal Fabrications".
 3. Install automatic (ball drip) drain valve at each check valve for fire-department connection.
- K. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors.
 2. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set-screw **OR** stamped steel with set-screw or spring clips **OR** stamped steel with spring clips, **as directed**.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set-screw **OR** One piece or split plate, stamped steel with set-screw **OR** Split plate, stamped steel with set-screw, **as directed**.
 - d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
 - e. Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
 - f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
 3. Escutcheons for Existing Piping:
 - a. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.



- b. Insulated Piping: Split plate, stamped steel with concealed or exposed-rivet hinge and spring clips.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set-screw, **as directed**.
 - e. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set-screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set-screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set-screw or spring clips, **as directed**.
 - f. Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set-screw or spring clips, **as directed**.
 - g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.
- L. Sleeve Installation
- 1. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
 - 2. Sleeves are not required for core-drilled holes.
 - 3. Permanent sleeves are not required for holes formed by removable PE sleeves.
 - 4. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
 - 5. Install sleeves in new partitions, slabs, and walls as they are built.
 - 6. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
 - 7. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
 - 8. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals.
 - 9. Seal space outside of sleeves in concrete slabs and walls with grout.
 - 10. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
 - 11. Install sleeve materials according to the following applications:
 - a. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
 - b. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized-steel pipe **OR** Stack sleeve fittings, **as directed**.
 - 1) Extend sleeves 2 inches (50 mm) above finished floor level.
 - 2) For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements for flashing in Division 07 Section "Sheet Metal Flashing And Trim".
 - c. Sleeves for Piping Passing through Gypsum-Board Partitions:
 - 1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
 - 3) Exception: Sleeves are not required for water-supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
 - d. Sleeves for Piping Passing through Concrete Roof Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
 - e. Sleeves for Piping Passing through Exterior Concrete Walls:
 - 1) Galvanized-steel-pipe sleeves for pipes smaller than NPS 6 (DN 150).



- 2) Cast-iron wall pipe sleeves for pipes NPS 6 (DN 150) and larger.
 - 3) Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
 - f. Sleeves for Piping Passing through Interior Concrete Walls:
 - 1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
 12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestop materials and installations in Division 07 Section "Penetration Firestopping".
- M. Sleeve Seal Installation
1. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
 2. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- N. Identification
1. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 14.
 2. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
- O. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - c. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
 - d. Energize circuits to electrical equipment and devices.
 - e. Start and run air compressors.
 - f. Coordinate with fire-alarm tests. Operate as required.
 - g. Coordinate with fire-pump tests. Operate as required.
 - h. Verify that equipment hose threads are same as local fire-department equipment.
 3. Fire-suppression standpipe system will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.
- P. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain specialty valves.
- Q. Piping Schedule
1. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded **OR** grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved, **as directed**, joints.
 2. Standard-pressure, wet-type, fire-suppression standpipe piping, NPS 4 (DN 100) and smaller, shall be one of the following:
 - a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight **OR** Schedule 30 or thinwall, **as directed**, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.



- c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - f. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - g. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with plain ends; welding fittings; and welded joints.
 - h. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
 - i. Type L (Type B) **OR** Type M (Type B), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
3. Standard-pressure, wet-type, fire-suppression standpipe piping, NPS 5 to NPS 8 (DN 125 to DN 200), shall be one of the following:
- a. Standard-weight **OR** Schedule 30, **as directed**, or thinwall, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - f. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - g. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
 - h. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
 - i. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
4. Standard-pressure, wet-type, fire-suppression standpipe piping, NPS 10 and NPS 12 (DN 250 and DN 300), shall be one of the following:
- a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - f. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with plain ends; welding fittings; and welded joints.



5. High-pressure, wet-type, fire-suppression standpipe piping, NPS 4 (DN 100) and smaller, shall be one of the following:
 - a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - c. Standard-weight or Schedule 30, black-steel pipe with cut-grooved **OR** roll-grooved, **as directed**, ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - f. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with plain ends; welding fittings; and welded joints.
6. High-pressure, wet-type, fire-suppression standpipe piping, NPS 5 (DN 125) and larger, shall be one of the following:
 - a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - f. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with plain ends; welding fittings; and welded joints.
7. Standard-pressure, dry-type, fire-suppression standpipe piping, NPS 4 (DN 100) and smaller, shall be one of the following:
 - a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - c. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
 - d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
8. Standard-pressure, dry-type, fire-suppression standpipe piping, NPS 5 and NPS 6 (DN 125 and DN 150), shall be one of the following:
 - a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - c. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
 - d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.



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Task	Specification	Specification Description
21 12 13 00	21 11 19 00	Fire-Suppression Standpipes
21 12 23 00	21 11 19 00	Fire-Suppression Standpipes
21 12 29 00	01 22 16 00	No Specification Required
21 12 29 00	21 11 19 00	Fire-Suppression Standpipes



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**SECTION 21 13 13 00 - WET-PIPE FIRE-SUPPRESSION SPRINKLERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for wet-pipe fire-suppression sprinklers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pipes, fittings, and specialties.
 - b. Fire-protection valves.
 - c. Fire-department connections.
 - d. Sprinklers.
 - e. Excess-pressure pumps.
 - f. Alarm devices.
 - g. Manual control stations.
 - h. Control panels.
 - i. Pressure gages.

C. Definitions

1. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig (1200 kPa), but not higher than 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**.
2. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig (1200 kPa) maximum.

D. System Descriptions

1. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.
2. Deluge Sprinkler System: Open sprinklers are attached to piping connected to water supply through deluge valve. Fire-detection system, in same area as sprinklers, opens valve. Water flows into piping system and discharges from attached sprinklers when valve opens.

E. Performance Requirements

1. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
2. High-Pressure Piping System Component: Listed for 250-psig (1725-kPa) minimum **OR** 300-psig (2070-kPa), **as directed**, working pressure.
3. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
4. Sprinkler system design shall be approved by authorities having jurisdiction.
 - a. Margin of Safety for Available Water Flow and Pressure: 10 **OR** 20, **as directed**, percent, including losses through water-service piping, valves, and backflow preventers.
 - b. Sprinkler Occupancy Hazard Classifications:
 - 1) Automobile Parking Areas: Ordinary Hazard, Group 1.
 - 2) Building Service Areas: Ordinary Hazard, Group 1.
 - 3) Churches: Light Hazard.
 - 4) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
 - 5) Dry Cleaners: Ordinary Hazard, Group 2.



- 6) General Storage Areas: Ordinary Hazard, Group 1.
 - 7) Laundries: Ordinary Hazard, Group 1.
 - 8) Libraries except Stack Areas: Light Hazard.
 - 9) Library Stack Areas: Ordinary Hazard, Group 2.
 - 10) Machine Shops: Ordinary Hazard, Group 2.
 - 11) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
 - 12) Office and Public Areas: Light Hazard.
 - 13) Plastics Processing Areas: Extra Hazard, Group 2.
 - 14) Printing Plants: Extra Hazard, Group 1.
 - 15) Repair Garages: Ordinary Hazard, Group 2.
 - 16) Residential Living Areas: Light Hazard.
 - 17) Restaurant Service Areas: Ordinary Hazard, Group 1.
 - 18) Solvent Cleaning Areas: Extra Hazard, Group 2.
 - 19) Upholstering Plants: Extra Hazard, Group 1.
 - c. Minimum Density for Automatic-Sprinkler Piping Design:
 - 1) Residential (Dwelling) Occupancy: 0.05 gpm over 400-sq. ft. (2.04 mm/min. over 37.2-sq. m) area.
 - 2) Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
 - 3) Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
 - 4) Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. (8.1 mm/min. over 139-sq. m) area.
 - 5) Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. (12.2 mm/min. over 232-sq. m) area.
 - 6) Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. (16.3 mm/min. over 232-sq. m) area.
 - 7) Special Occupancy Hazard: As determined by authorities having jurisdiction.
 - d. Minimum Density for Deluge-Sprinkler Piping Design:
 - 1) Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm (6.1 mm/min.) over entire area.
 - 2) Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm (8.1 mm/min.) over entire area.
 - 3) Extra-Hazard, Group 1 Occupancy: 0.30 gpm (12.2 mm/min.) over entire area.
 - 4) Extra-Hazard, Group 2 Occupancy: 0.40 gpm (16.3 mm/min.) over entire area.
 - 5) Special Occupancy Hazard: As determined by authorities having jurisdiction.
 - e. Maximum Protection Area per Sprinkler: Per UL listing.
OR
 Maximum Protection Area per Sprinkler:
 - 1) Residential Areas: 400 sq. ft. (37 sq. m).
 - 2) Office Spaces: 120 sq. ft. (11.1 sq. m) **OR** 225 sq. ft. (20.9 sq. m), **as directed**.
 - 3) Storage Areas: 130 sq. ft. (12.1 sq. m).
 - 4) Mechanical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
 - 5) Electrical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
 - 6) Other Areas: According to NFPA 13 recommendations unless otherwise indicated.
 - f. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
 - 1) Light-Hazard Occupancies: 100 gpm (6.3 L/s) for 30 minutes.
 - 2) Ordinary-Hazard Occupancies: 250 gpm (15.75 L/s) for 60 to 90 minutes.
 - 3) Extra-Hazard Occupancies: 500 gpm (31.5 L/s) for 90 to 120 minutes.
5. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

F. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:



- a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content and chemical components.
 3. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.
 - a. Wiring Diagrams: For power, signal, and control wiring.
 4. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 5. Qualification Data: For qualified Installer and professional engineer, **as directed**.
 6. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
 7. Welding certificates.
 8. Fire-hydrant flow test report.
 9. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
 10. Field quality-control reports.
 11. Operation and maintenance data.
- G. Quality Assurance
1. Installer Qualifications:
 - a. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - 1) Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
 2. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
 3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 4. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - a. NFPA 13, "Installation of Sprinkler Systems."
 - b. NFPA 13R, "Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height."
 - c. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."
- H. Project Conditions
1. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of sprinkler service.
 - b. Do not proceed with interruption of sprinkler service without the Owner's written permission.
- 1.2 PRODUCTS
- A. Piping Materials
1. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
- B. Steel Pipe And Fittings
1. Standard Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.



2. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A 135; ASTM A 795/A 795M, Type E; or ASME B36.10M, wrought steel; with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
 3. Thinwall Galvanized- and Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
 4. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
 5. Nonstandard OD, Thinwall Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, thinwall, with plain ends and wall thickness less than Schedule 10.
 6. Hybrid Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5.
 7. Schedule 5 Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, lightwall, with plain ends.
 8. Galvanized- and Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
 9. Galvanized and Uncoated, Steel Couplings: ASTM A 865, threaded.
 10. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
 11. Malleable- or Ductile-Iron Unions: UL 860.
 12. Cast-Iron Flanges: ASME 16.1, Class 125.
 13. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
 14. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
 15. Grooved-Joint, Steel-Pipe Appurtenances:
 - a. Pressure Rating: 175 psig (1200 kPa) **OR** 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**, minimum.
 - b. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
 - c. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
 16. Steel Pressure-Seal Fittings: UL 213, FM-approved, 175-psig (1200-kPa) pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.
- C. Copper Tube And Fittings
1. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) and ASTM B 88, Type M (ASTM B 88M, Type C) water tube, drawn temper.
 2. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
 3. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.
 4. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
 5. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
 6. Copper Pressure-Seal Fittings:
 - a. Standard: UL 213.
 - b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
 - c. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze fitting with EPDM-rubber O-ring seal in each end.
 7. Grooved-Joint, Copper-Tube Appurtenances:
 - a. Grooved-End, Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze castings.



- b. Grooved-End-Tube Couplings: To fit copper-tube dimensions, with design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gasket suitable for hot and cold water, and bolts and nuts.
8. Copper-Tube, Extruded-Tee Connections:
 - a. Description: Tee formed in copper tube according to ASTM F 2014.
- D. CPVC Pipe And Fittings
1. CPVC Pipe: ASTM F 442/F 442M and UL 1821, SDR 13.5, for 175-psig (1200-kPa) rated pressure at 150 deg F (62 deg C), with plain ends. Include "LISTED" and "CPVC SPRINKLER PIPE" markings.
 2. CPVC Fittings: UL listed or FM approved, for 175-psig (1200-kPa) rated pressure at 150 deg F (62 deg C), socket type. Include "LISTED" and "CPVC SPRINKLER FITTING" markings.
 - a. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): ASTM F 438 and UL 1821, Schedule 40, socket type.
 - b. NPS 2 to NPS 3 (DN 50 to DN 80): ASTM F 439 and UL 1821, Schedule 80, socket type.
 - c. CPVC-to-Metal Transition Fittings: CPVC, one piece, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
 - d. CPVC-to-Metal Transition Unions: CPVC, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
 - e. Flanges: CPVC, one or two pieces.
- E. Piping Joining Materials
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.
 - a. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 - b. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
 2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
 3. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
 4. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
 5. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493, solvent cement recommended by pipe and fitting manufacturer, and made for joining CPVC sprinkler pipe and fittings. Include cleaner or primer recommended by pipe and fitting manufacturer.
 - a. Use solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 650 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 6. Plastic, Pipe-Flange Gasket, and Bolts and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- F. Cover System For Sprinkler Piping
1. Description: System of support brackets and covers made to protect sprinkler piping.
 2. Brackets: Glass-reinforced nylon.
 3. Covers: Extruded PVC sections of length, shape, and size required for size and routing of CPVC piping.
- G. Listed Fire-Protection Valves
1. General Requirements:
 - a. Valves shall be UL listed or FM approved.
 - b. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).
 - c. Minimum Pressure Rating for High-Pressure Piping: 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**.
 2. Ball Valves:



- a. Standard: UL 1091 except with ball instead of disc.
 - b. Valves NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
 - c. Valves NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
 - d. Valves NPS 3 (DN 80): Ductile-iron body with grooved ends.
3. Bronze Butterfly Valves:
- a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Bronze.
 - d. End Connections: Threaded.
4. Iron Butterfly Valves:
- a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Cast or ductile iron.
 - d. Style: Lug or wafer.
- OR**
End Connections: Grooved.
5. Check Valves:
- a. Standard: UL 312.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Type: Swing check.
 - d. Body Material: Cast iron.
 - e. End Connections: Flanged or grooved.
6. Bronze OS&Y Gate Valves:
- a. Standard: UL 262.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Bronze.
 - d. End Connections: Threaded.
7. Iron OS&Y Gate Valves:
- a. Standard: UL 262.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast or ductile iron.
 - d. End Connections: Flanged or grooved.
8. Indicating-Type Butterfly Valves:
- a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 - c. Valves NPS 2 (DN 50) and Smaller:
 - 1) Valve Type: Ball or butterfly.
 - 2) Body Material: Bronze.
 - 3) End Connections: Threaded.
 - d. Valves NPS 2-1/2 (DN 65) and Larger:
 - 1) Valve Type: Butterfly.
 - 2) Body Material: Cast or ductile iron.
 - 3) End Connections: Flanged, grooved, or wafer.
 - e. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch **OR** electrical, 115-V ac, prewired, two-circuit, supervisory switch **OR** visual, **as directed**, indicating device.
9. NRS Gate Valves:
- a. Standard: UL 262.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast iron with indicator post flange.
 - d. Stem: Nonrising.
 - e. End Connections: Flanged or grooved.
10. Indicator Posts:
- a. Standard: UL 789.



- b. Type: Horizontal for wall mounting.
 - c. Body Material: Cast iron with extension rod and locking device.
 - d. Operation: Wrench **OR** Hand wheel, **as directed**.
- H. Trim And Drain Valves
- 1. General Requirements:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 - 2. Angle Valves.
 - 3. Ball Valves.
 - 4. Globe Valves.
 - 5. Plug Valves.
- I. Specialty Valves
- 1. General Requirements:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating:
 - 1) Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.
 - 2) High-Pressure Piping Specialty Valves: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast or ductile iron.
 - d. Size: Same as connected piping.
 - e. End Connections: Flanged or grooved.
 - 2. Alarm Valves:
 - a. Standard: UL 193.
 - b. Design: For horizontal or vertical installation.
 - c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, **as directed**, and fill-line attachment with strainer.
 - d. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
OR
Drip Cup Assembly: Pipe drain with check valve to main drain piping.
 - 3. Deluge Valves:
 - a. Standard: UL 260.
 - b. Design: Hydraulically operated, differential-pressure type.
 - c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection.
 - d. Wet, Pilot-Line Trim Set: Include gage to read push-rod chamber pressure, globe valve for manual operation of deluge valve, and connection for actuation device.
 - 4. Automatic (Ball Drip) Drain Valves:
 - a. Standard: UL 1726.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 - c. Type: Automatic draining, ball check.
 - d. Size: NPS 3/4 (DN 20).
 - e. End Connections: Threaded.
- J. Fire-Department Connections
- 1. Exposed-Type, Fire-Department Connection:
 - a. Standard: UL 405.
 - b. Type: Exposed, projecting, for wall mounting.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum.
 - d. Body Material: Corrosion-resistant metal.



- e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Round, brass, wall type.
 - h. Outlet: Back, with pipe threads.
 - i. Number of Inlets: Two **OR** Three, **as directed**.
 - j. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
 - k. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - l. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.
2. Flush-Type, Fire-Department Connection:
- a. Standard: UL 405.
 - b. Type: Flush, for wall mounting.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum.
 - d. Body Material: Corrosion-resistant metal.
 - e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Rectangular, brass, wall type.
 - h. Outlet: With pipe threads.
 - i. Body Style: Horizontal **OR** Square **OR** Vertical, **as directed**.
 - j. Number of Inlets: Two **OR** Three **OR** Four **OR** Six, **as directed**.
 - k. Outlet Location: Back **OR** Bottom **OR** Left side **OR** Right side **OR** Top, **as directed**.
 - l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
 - m. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150) **OR** NPS 8 (DN 200), **as directed**.
3. Yard-Type, Fire-Department Connection:
- a. Standard: UL 405.
 - b. Type: Exposed, freestanding.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - d. Body Material: Corrosion-resistant metal.
 - e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Round, brass, floor type.
 - h. Outlet: Bottom, with pipe threads.
 - i. Number of Inlets: Two **OR** Three **OR** Four, **as directed**.
 - j. Sleeve: Brass **OR** Not required, **as directed**.
 - k. Sleeve Height: 18 inches (460 mm).
 - l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
 - m. Finish, Including Sleeve: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.

K. Sprinkler Specialty Pipe Fittings

- 1. Branch Outlet Fittings:
 - a. Standard: UL 213.



- b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
 - d. Type: Mechanical-T and -cross fittings.
 - e. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
 - f. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
 - g. Branch Outlets: Grooved, plain-end pipe, or threaded.
 2. Flow Detection and Test Assemblies:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
 - d. Size: Same as connected piping.
 - e. Inlet and Outlet: Threaded.
 3. Branch Line Testers:
 - a. Standard: UL 199.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Brass.
 - d. Size: Same as connected piping.
 - e. Inlet: Threaded.
 - f. Drain Outlet: Threaded and capped.
 - g. Branch Outlet: Threaded, for sprinkler.
 4. Sprinkler Inspector's Test Fittings:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast- or ductile-iron housing with sight glass.
 - d. Size: Same as connected piping.
 - e. Inlet and Outlet: Threaded.
 5. Adjustable Drop Nipples:
 - a. Standard: UL 1474.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Steel pipe with EPDM-rubber O-ring seals.
 - d. Size: Same as connected piping.
 - e. Length: Adjustable.
 - f. Inlet and Outlet: Threaded.
 6. Flexible, Sprinkler Hose Fittings:
 - a. Standard: UL 1474.
 - b. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - d. Size: Same as connected piping, for sprinkler.
- L. Sprinklers
1. General Requirements:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating for Residential Sprinklers: 175 psig (1200 kPa) maximum.
 - c. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
 - d. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 2. Automatic Sprinklers with Heat-Responsive Element:
 - a. Early-Suppression, Fast-Response Applications: UL 1767.
 - b. Nonresidential Applications: UL 199.
 - c. Residential Applications: UL 1626.



- d. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
 3. Open Sprinklers with Heat-Responsive Element Removed: UL 199.
 - a. Characteristics:
 - 1) Nominal 1/2-inch (12.7-mm) Orifice: With Discharge Coefficient K between 5.3 and 5.8.
 - 2) Nominal 17/32-inch (13.5-mm) Orifice: With Discharge Coefficient K between 7.4 and 8.2.
 4. Sprinkler Finishes:
 - a. Chrome plated.
 - b. Bronze.
 - c. Painted.
 5. Special Coatings:
 - a. Wax.
 - b. Lead.
 - c. Corrosion-resistant paint.
 6. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 - a. Ceiling Mounting: Chrome-plated steel, one piece, flat **OR** Chrome-plated steel, two piece, with 1-inch (25-mm) vertical adjustment **OR** Plastic, white finish, one piece, flat, **as directed**.
 - b. Sidewall Mounting: Chrome-plated steel **OR** Plastic, white finish, **as directed**, one piece, flat.
 7. Sprinkler Guards:
 - a. Standard: UL 199.
 - b. Type: Wire cage with fastening device for attaching to sprinkler.
- M. Excess-Pressure Pumps
1. Pump: Factory-fabricated, positive-displacement, gear type.
 - a. Pump and Motor: Directly connected.
 - b. Motor: Comply with requirements in Division 21 Section "Common Work Results For Fire Suppression".
 2. Miscellaneous Components: Wet-pipe kit of switches, fittings, valves, mounting brackets, and connections for power, hydraulic piping, and wiring from alarm devices.
 3. Motor Control: Differential-pressure switch.
 4. Lights: To indicate sprinkler system's operating condition.
 - a. White Light: Pressure is normal.
 - b. Red Light: Pressure is low.
 5. Capacity: 2.0 gpm at 75-psig (0.13 L/s at 520-kPa) differential pressure and 1/3 hp **OR** 1.85 gpm at 100-psig (0.12 L/s at 690-kPa) differential pressure and 1/2 hp **OR** 3.5 gpm at 100-psig (0.22 L/s at 690-kPa) differential pressure and 1/2 hp, **as directed**.
- N. Alarm Devices
1. Alarm-device types shall match piping and equipment connections.
 2. Water-Motor-Operated Alarm:
 - a. Standard: UL 753.
 - b. Type: Mechanically operated, with Pelton wheel.
 - c. Alarm Gong: Cast aluminum with red-enamel factory finish.
 - d. Size: 10-inch (250-mm) diameter.
 - e. Components: Shaft length, bearings, and sleeve to suit wall construction.
 - f. Inlet: NPS 3/4 (DN 20).
 - g. Outlet: NPS 1 (DN 25) drain connection.
 3. Electrically Operated Alarm Bell:



- a. Standard: UL 464.
 - b. Type: Vibrating, metal alarm bell.
 - c. Size: 6-inch (150-mm) minimum-diameter **OR** 8-inch (200-mm) minimum-diameter **OR** 10-inch (250-mm) diameter, **as directed**.
 - d. Finish: Red-enamel factory finish, suitable for outdoor use.
4. Water-Flow Indicators:
- a. Standard: UL 346.
 - b. Water-Flow Detector: Electrically supervised.
 - c. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
 - d. Type: Paddle operated.
 - e. Pressure Rating: 250 psig (1725 kPa).
 - f. Design Installation: Horizontal or vertical.
5. Pressure Switches:
- a. Standard: UL 346.
 - b. Type: Electrically supervised water-flow switch with retard feature.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design Operation: Rising pressure signals water flow.
6. Valve Supervisory Switches:
- a. Standard: UL 346.
 - b. Type: Electrically supervised.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design: Signals that controlled valve is in other than fully open position.
7. Indicator-Post Supervisory Switches:
- a. Standard: UL 346.
 - b. Type: Electrically supervised.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design: Signals that controlled indicator-post valve is in other than fully open position.
- O. Manual Control Stations
1. Description: UL listed or FM approved, hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
- P. Control Panels
1. Description: Single-area, two-area, or single-area cross-zoned control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire-alarm bell; lamp test facility; single-pole, double-throw auxiliary alarm contacts; and rectifier.
 - a. Panels: UL listed and FM approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
 - b. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

OR

Manual Control Stations: Hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
- Q. Pressure Gages



1. Standard: UL 393.
2. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.
3. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum **OR** 0 to 300 psig (0 to 2070 kPa), **as directed**.
4. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
5. Air System Piping Gage: Include retard feature, **directed**, and "AIR" or "AIR/WATER" label on dial face.

R. Escutcheons

1. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
2. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated **OR** rough-brass, **as directed**, finish with set-screws.
3. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.
4. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw **OR** spring clips, **as directed**.
5. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated **OR** rough-brass, **as directed**, finish with concealed hinge and set-screw.
6. Split-Plate, Stamped-Steel Escutcheons: Chrome-plated finish with concealed **OR** exposed-rivet, **as directed**, hinge, set-screw **OR** spring clips, **as directed**.
7. One-Piece Floor Plates: Cast-iron flange with holes for fasteners, **as directed**.
8. Split-Casting Floor Plates: Cast brass with concealed hinge.

S. Sleeves

1. Cast-Iron Wall Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
4. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
5. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
6. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.
7. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set-screws.

T. Sleeve Seals

1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

U. Grout

1. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink, and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.



1.3 EXECUTION

A. Preparation

1. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
2. Report test results promptly and in writing.

B. Service-Entrance Piping

1. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Division 21 Section "Facility Fire-suppression Water-service Piping".
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories indicated at connection to water-service piping. Comply with requirements for backflow preventers in Division 21 Section "Facility Fire-suppression Water-service Piping", **as directed**.
OR
Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

C. Water-Supply Connections

1. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Division 22 Section "Domestic Water Piping".
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements for backflow preventers in Division 22 Section "Domestic Water Piping Specialties", **as directed**.
OR
Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

D. Piping Installation

1. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - a. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with the Owner before deviating from approved working plans.
2. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.
3. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.
4. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
5. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
6. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
7. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
8. Install sprinkler piping with drains for complete system drainage.
9. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
10. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
11. Install alarm devices in piping systems.
12. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
13. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.



14. Pressurize and check preaction sprinkler system piping and air-pressure maintenance devices **OR** air compressors, **as directed**.
15. Fill sprinkler system piping with water.
16. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing. Comply with requirements for heating cables in Division 21 Section "Heat Tracing For Fire-suppression Piping" and for piping insulation in Division 21 Section "Fire-suppression Systems Insulation".

E. Joint Construction

1. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
2. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
3. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
4. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
5. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
6. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
7. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
8. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
9. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
10. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
 - a. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
11. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
12. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
13. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
14. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
15. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
16. Copper-Tubing, Pressure-Sealed Joints: Join copper tube and copper pressure-seal fittings with tools recommended by fitting manufacturer.
17. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
18. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.



19. Plastic-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
 - b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
- F. Installation Of Cover System For Sprinkler Piping
 1. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and with NFPA 13 or NFPA 13R for supports.
- G. Valve And Specialties Installation
 1. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
 2. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
 3. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
 4. Specialty Valves:
 - a. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
 - b. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.
 - c. Deluge Valves: Install in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
- H. Excess-Pressure Pump Installation
 1. Assemble components and mount on wood backing. Comply with requirements in Division 06 Section "Rough Carpentry" for wood backing material and installation.
 2. Install excess-pressure pumps, controls, devices, and supports for sprinkler piping application.
 - a. Mounting: Install on wall, where indicated **OR** attached to water-supply pipe, **as directed**.
- I. Sprinkler Installation
 1. Install sprinklers in suspended ceilings in center of narrow dimension of, **as directed**, acoustical ceiling panels.
 2. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
 3. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.
- J. Fire-Department Connection Installation
 1. Install wall-type, fire-department connections.
 2. Install yard-type, fire-department connections in concrete slab support. Comply with requirements for concrete in Division 03 Section "Cast-in-place Concrete".
 - a. Install two **OR** three, **as directed**, protective pipe bollards around **OR** on sides of, **as directed**, each fire-department connection. Comply with requirements for bollards in Division 05 Section "Metal Fabrications".
 3. Install automatic (ball drip) drain valve at each check valve for fire-department connection.
- K. Escutcheon Installation
 1. Install escutcheons for penetrations of walls, ceilings, and floors.
 2. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set-screw **OR** stamped steel with set-screw or spring clips **OR** stamped steel with spring clips, **as directed**.



- c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set-screw **OR** One piece or split plate, stamped steel with set-screw **OR** Split plate, stamped steel with set-screw, **as directed**.
 - d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
 - e. Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
 - f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
3. Escutcheons for Existing Piping:
- a. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
 - b. Insulated Piping: Split plate, stamped steel with concealed or exposed-rivet hinge and spring clips.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set-screw, **as directed**.
 - e. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set-screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set-screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set-screw or spring clips, **as directed**.
 - f. Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set-screw or spring clips, **as directed**.
 - g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.
- L. Sleeve Installation
- 1. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
 - 2. Sleeves are not required for core-drilled holes.
 - 3. Permanent sleeves are not required for holes formed by removable PE sleeves.
 - 4. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
 - 5. Install sleeves in new partitions, slabs, and walls as they are built.
 - 6. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
 - 7. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
 - 8. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals.
 - 9. Seal space outside of sleeves in concrete slabs and walls with grout.
 - 10. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
 - 11. Install sleeve materials according to the following applications:
 - a. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
 - b. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized-steel pipe **OR** Stack sleeve fittings, **as directed**.



- 1) Extend sleeves 2 inches (50 mm) above finished floor level.
 - 2) For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements for flashing in Division 07 Section "Sheet Metal Flashing And Trim".
 - c. Sleeves for Piping Passing through Gypsum-Board Partitions:
 - 1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
 - 3) Exception: Sleeves are not required for water-supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
 - d. Sleeves for Piping Passing through Concrete Roof Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
 - e. Sleeves for Piping Passing through Exterior Concrete Walls:
 - 1) Galvanized-steel-pipe sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Cast-iron wall-pipe sleeves for pipes NPS 6 (DN 150) and larger.
 - 3) Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
 - f. Sleeves for Piping Passing through Interior Concrete Walls:
 - 1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestop materials and installations in Division 07 Section "Penetration Firestopping".
- M. Sleeve Seal Installation
1. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
 2. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- N. Identification
1. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
 2. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
- O. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - c. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - d. Energize circuits to electrical equipment and devices.
 - e. Start and run excess-pressure pumps.
 - f. Coordinate with fire-alarm tests. Operate as required.
 - g. Coordinate with fire-pump tests. Operate as required.
 - h. Verify that equipment hose threads are same as local fire-department equipment.
 3. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.



- P. Cleaning
1. Clean dirt and debris from sprinklers.
 2. Remove and replace sprinklers with paint other than factory finish.
- Q. Piping Schedule
1. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded **OR** grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved, **as directed**, joints.
 2. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
 3. Copper-tube, extruded-tee connections may be used for tee branches in copper tubing instead of specified copper fittings. Branch-connection joints must be brazed.
 4. CPVC pipe; Schedule 40 **OR** Schedule 80, **as directed**, CPVC fittings; and solvent-cemented joints may be used for light-hazard and residential occupancies.
 5. Standard-pressure, wet-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be one of the following:
 - a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - c. Standard-weight or Schedule 30, black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
 - d. Standard-weight or Schedule 30, galvanized-steel pipe with plain ends; galvanized, plain-end-pipe fittings; and twist-locked joints.
 - e. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - f. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - g. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - h. Thinwall **OR** Schedule 10, **as directed**, nonstandard OD, thinwall or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - i. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
 - j. Thinwall **OR** Schedule 10, **as directed**, nonstandard OD, thinwall or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
 - k. Schedule 5 steel pipe; steel pressure-seal fittings; and pressure-sealed joints.
 - l. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
 - m. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; copper pressure-seal fittings; and pressure-sealed joints.
 - n. NPS 2 (DN 50), Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
 6. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
 - a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.



- d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - f. Thinwall **OR** Schedule 10, **as directed**, nonstandard OD, thinwall or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - g. Thinwall **OR** Schedule 10, **as directed**, nonstandard OD, thinwall or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
 - h. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
 - i. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; copper pressure-seal fittings; and pressure-sealed joints.
 - j. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
7. Standard-pressure, wet-pipe sprinkler system, NPS 5 (DN 125) and larger, shall be one of the following:
- a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - f. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - g. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
 - h. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
 - i. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
8. High-pressure, wet-pipe sprinkler system, NPS 4 (DN 100) and smaller, shall be one of the following:
- a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - c. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - d. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
9. High-pressure, wet-pipe sprinkler system, NPS 5 (DN 125) and larger, shall be one of the following:
- a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.



- b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
- c. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
- d. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.

R. Sprinkler Schedule

- 1. Use sprinkler types in subparagraphs below for the following applications:
 - a. Rooms without Ceilings: Upright sprinklers.
 - b. Rooms with Suspended Ceilings: Pendent sprinklers **OR** Recessed sprinklers **OR** Flush sprinklers **OR** Concealed sprinklers, **as directed**.
 - c. Wall Mounting: Sidewall sprinklers.
 - d. Spaces Subject to Freezing: Upright sprinklers **OR** Pendent, dry sprinklers **OR** Sidewall, dry sprinklers, **as directed**.
 - e. Deluge-Sprinkler Systems: Upright and pendent, open sprinklers.
 - f. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers where indicated.
- 2. Provide sprinkler types in subparagraphs below with finishes indicated.
 - a. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
 - b. Flush Sprinklers: Bright chrome, with painted white escutcheon.
 - c. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
 - d. Residential Sprinklers: Dull chrome.
 - e. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 21 13 13 00



SECTION 21 13 16 00 - DRY-PIPE FIRE-SUPPRESSION SPRINKLERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for dry-pipe fire-suppression sprinklers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pipes, fittings, and specialties.
 - b. Fire-protection valves.
 - c. Fire-department connections.
 - d. Sprinkler specialty pipe fittings.
 - e. Sprinklers.
 - f. Alarm devices.
 - g. Manual control stations.
 - h. Control panels.
 - i. Pressure gages.

C. Definitions

1. Standard-Pressure Sprinkler Piping: Dry-pipe sprinkler system piping designed to operate at working pressure 175 psig (1200 kPa) maximum.

D. System Descriptions

1. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from sprinklers that are open.
2. Combined Dry-Pipe and Preaction Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Fire-detection system in same area as sprinklers actuates tripping devices that open dry-pipe valve without loss of air pressure and actuates fire alarm. Water discharges from sprinklers that have opened.
3. Single-Interlock Preaction Sprinkler System: Automatic sprinklers are attached to piping containing low-pressure air. Actuation of fire-detection system in same area as sprinklers opens deluge valve, permitting water to flow into piping and to discharge from sprinklers that have opened.
4. Double-Interlock Preaction Sprinkler System: Automatic sprinklers are attached to piping containing low-pressure air. Actuation of a fire-detection system in the same area as sprinklers opens the deluge valve permitting water to flow into the sprinkler piping; a closed solenoid valve in the sprinkler piping is opened by another fire-detection device; then water will discharge from sprinklers that have opened.

E. Performance Requirements

1. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
2. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Sprinkler system design shall be approved by authorities having jurisdiction.
 - a. Margin of Safety for Available Water Flow and Pressure: 10 **OR** 20, **as directed**, percent, including losses through water-service piping, valves, and backflow preventers.
 - b. Sprinkler Occupancy Hazard Classifications:
 - 1) Automobile Parking Areas: Ordinary Hazard, Group 1.



- 2) Building Service Areas: Ordinary Hazard, Group 1.
- 3) Churches: Light Hazard.
- 4) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
- 5) Dry Cleaners: Ordinary Hazard, Group 2.
- 6) General Storage Areas: Ordinary Hazard, Group 1.
- 7) Laundries: Ordinary Hazard, Group 1.
- 8) Libraries Except Stack Areas: Light Hazard.
- 9) Library Stack Areas: Ordinary Hazard, Group 2.
- 10) Machine Shops: Ordinary Hazard, Group 2.
- 11) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
- 12) Office and Public Areas: Light Hazard.
- 13) Plastics Processing Areas: Extra Hazard, Group 2.
- 14) Printing Plants: Extra Hazard, Group 1.
- 15) Repair Garages: Ordinary Hazard, Group 2.
- 16) Restaurant Service Areas: Ordinary Hazard, Group 1.
- 17) Solvent Cleaning Areas: Extra Hazard, Group 2.
- 18) Upholstering Plants: Extra Hazard, Group 1.
- c. Minimum Density for Automatic-Sprinkler Piping Design:
 - 1) Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
 - 2) Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
 - 3) Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. (8.1 mm/min. over 139-sq. m) area.
 - 4) Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. (12.2 mm/min. over 232-sq. m) area.
 - 5) Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. (16.3 mm/min. over 232-sq. m) area.
 - 6) Special Occupancy Hazard: As determined by authorities having jurisdiction.
- d. Maximum Protection Area per Sprinkler: Per UL listing.
OR
Maximum Protection Area per Sprinkler:
 - 1) Office Spaces: 120 sq. ft. (11.1 sq. m) **OR** 225 sq. ft. (20.9 sq. m), **as directed**.
 - 2) Storage Areas: 130 sq. ft. (12.1 sq. m).
 - 3) Mechanical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
 - 4) Electrical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
 - 5) Other Areas: According to NFPA 13 recommendations unless otherwise indicated.
- e. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
 - 1) Light-Hazard Occupancies: 100 gpm (6.3 L/s) for 30 minutes.
 - 2) Ordinary-Hazard Occupancies: 250 gpm (15.75 L/s) for 60 to 90 minutes.
 - 3) Extra-Hazard Occupancies: 500 gpm (31.5 L/s) for 90 to 120 minutes.
4. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

F. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For dry-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.
 - a. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. Qualification Data: For qualified Installer and professional engineer, **as directed**.



5. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
6. Fire-hydrant flow test report.
7. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
8. Field quality-control reports.
9. Operation and maintenance data.

G. Quality Assurance

1. Installer Qualifications:
 - a. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - 1) Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - a. NFPA 13, "Installation of Sprinkler Systems."
 - b. NFPA 13R, "Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height."
 - c. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

H. Project Conditions

1. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of sprinkler service.
 - b. Do not proceed with interruption of sprinkler service without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials

1. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Steel Pipe And Fittings

1. Standard Weight, Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
2. Schedule 30, Galvanized-Steel Pipe: ASTM A 135; ASTM A 795/A 795M, Type E; or ASME B36.10M, wrought steel; with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
3. Thinwall Galvanized-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
4. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
5. Galvanized, Steel Couplings: ASTM A 865, threaded.
6. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
7. Malleable- or Ductile-Iron Unions: UL 860.
8. Cast-Iron Flanges: ASME B16.1, Class 125.



9. Plain-End-Pipe Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn or screwed retainer pin to secure pipe in fitting.
 10. Grooved-Joint, Steel-Pipe Appurtenances:
 - a. Pressure Rating: 175 psig (1200 kPa) **OR** 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**, minimum.
 - b. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
 - c. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
- C. Copper Tube And Fittings
1. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) and ASTM B 88, Type M (ASTM B 88M, Type C) water tube, drawn temper.
 2. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
 3. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.
 4. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
 5. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
 6. Copper Pressure-Seal Fittings:
 - a. Standard: UL 213.
 - b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
 - c. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze fitting with EPDM-rubber O-ring seal in each end.
 7. Grooved-Joint, Copper-Tube Appurtenances:
 - a. Grooved-End, Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze castings.
 - b. Grooved-End-Tube Couplings: To fit copper tube, with dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gasket suitable for hot and cold water, and bolts and nuts.
 8. Copper-Tube, Extruded-Tee Connections:
 - a. Description: Tee formed in copper tube according to ASTM F 2014.
- D. Piping Joining Materials
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.
 - a. Class 125, Cast-Iron and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 - b. Class 250, Cast-Iron and Class 300, Raised-Face Flanges: Ring-type gaskets.
 2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
 3. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- E. Listed Fire-Protection Valves
1. General Requirements:
 - a. Valves shall be UL listed or FM approved.
 - b. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).
 2. Ball Valves:
 - a. Standard: UL 1091 except with ball instead of disc.
 - b. Valves NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
 - c. Valves NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
 - d. Valves NPS 3 (DN 80): Ductile-iron body with grooved ends.
- F. Bronze Butterfly Valves:



- a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Bronze.
 - d. End Connections: Threaded.
- G. Iron Butterfly Valves:
- a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Cast or ductile iron.
 - d. Style: Lug or wafer.
- OR**
End Connections: Grooved.
- H. Check Valves:
- a. Standard: UL 312
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Type: Swing check.
 - d. Body Material: Cast iron.
 - e. End Connections: Flanged or grooved.
2. Bronze OS&Y Gate Valves:
- a. Standard: UL 262.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Bronze.
 - d. End Connections: Threaded.
3. Iron OS&Y Gate Valves:
- a. Standard: UL 262.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast or ductile iron.
 - d. End Connections: Flanged or grooved.
4. Indicating-Type Butterfly Valves:
- a. Standard: UL 1091.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 - c. Valves NPS 2 (DN 50) and Smaller:
 - 1) Valve Type: Ball or butterfly.
 - 2) Body Material: Bronze.
 - 3) End Connections: Threaded.
 - d. Valves NPS 2-1/2 (DN 65) and Larger:
 - 1) Valve Type: Butterfly.
 - 2) Body Material: Cast or ductile iron.
 - 3) End Connections: Flanged, grooved, or wafer.
 - e. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch **OR** electrical, 115-V ac, prewired, two-circuit, supervisory switch **OR** visual, **as directed**, indicating device.
5. NRS Gate Valves:
- a. Standard: UL 262.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast iron with indicator post flange.
 - d. Stem: Nonrising.
 - e. End Connections: Flanged or grooved.
6. Indicator Posts:
- a. Standard: UL 789.
 - b. Type: Horizontal for wall mounting.
 - c. Body Material: Cast iron with extension rod and locking device.
 - d. Operation: Wrench **OR** Hand wheel, **as directed**.
- I. Trim And Drain Valves



1. General Requirements:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
2. Angle Valves.
3. Ball Valves.
4. Globe Valves.
5. Plug Valves.

J. Specialty Valves

1. General Requirements:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating:
 - 1) Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.
 - 2) High-Pressure Piping Specialty Valves: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast or ductile iron.
 - d. Size: Same as connected piping.
 - e. End Connections: Flanged or grooved.
2. Dry-Pipe Valves:
 - a. Standard: UL 260
 - b. Design: Differential-pressure type.
 - c. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
 - d. Air-Pressure Maintenance Device:
 - 1) Standard: UL 260.
 - 2) Type: Automatic device to maintain minimum air pressure in piping.
 - 3) Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) **OR** 300-psig (2070-kPa), **as directed**, outlet pressure.
 - e. Air Compressor:
 - 1) Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - 2) Motor Horsepower: Fractional.
 - 3) Power: 120-V ac, 60 Hz, single phase.
3. Deluge Valves:
 - a. Standard: UL 260.
 - b. Design: Hydraulically operated, differential-pressure type.
 - c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection.
 - d. Dry, Pilot-Line Trim Set: Include dry, pilot-line actuator; air- and water-pressure gages; low-air-pressure warning switch; air relief valve; and actuation device. Dry, pilot-line actuator includes cast-iron, operated, diaphragm-type valve with resilient facing plate, resilient diaphragm, and replaceable bronze seat. Valve includes threaded water and air inlets and water outlet. Loss of air pressure on dry, pilot-line side allows pilot-line actuator to open and causes deluge valve to open immediately.
 - e. Air-Pressure Maintenance Device:
 - 1) Standard: UL 260.
 - 2) Type: Automatic device to maintain minimum air pressure in piping.
 - 3) Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure,



- strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) **OR** 300-psig (2070-kPa), **as directed**, outlet pressure.
- f. Air Compressor:
 - 1) Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - 2) Motor Horsepower: Fractional.
 - 3) Power: 120-V ac, 60 Hz, single phase.
4. Automatic (Ball Drip) Drain Valves:
 - a. Standard: UL 1726.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 - c. Type: Automatic draining, ball check.
 - d. Size: NPS 3/4 (DN 20).
 - e. End Connections: Threaded.
- K. Fire-Department Connections
1. Exposed-Type, Fire-Department Connection:
 - a. Standard: UL 405.
 - b. Type: Exposed, projecting, for wall mounting.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum.
 - d. Body Material: Corrosion-resistant metal.
 - e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Round, brass, wall type.
 - h. Outlet: Back, with pipe threads.
 - i. Number of Inlets: Two **OR** Three, **as directed**.
 - j. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
 - k. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - l. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.
 2. Flush-Type, Fire-Department Connection:
 - a. Standard: UL 405.
 - b. Type: Flush, for wall mounting.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum.
 - d. Body Material: Corrosion-resistant metal.
 - e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Rectangular, brass, wall type.
 - h. Outlet: With pipe threads.
 - i. Body Style: Horizontal **OR** Square **OR** Vertical, **as directed**.
 - j. Number of Inlets: Two **OR** Three **OR** Four **OR** Six, **as directed**.
 - k. Outlet Location: Back **OR** Bottom **OR** Left side **OR** Right side **OR** Top, **as directed**.
 - l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
 - m. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150) **OR** NPS 8 (DN 200), **as directed**.
 3. Yard-Type, Fire-Department Connection:
 - a. Standard: UL 405.
 - b. Type: Exposed, freestanding.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.



- d. Body Material: Corrosion-resistant metal.
 - e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
 - f. Caps: Brass, lugged type, with gasket and chain.
 - g. Escutcheon Plate: Round, brass, floor type.
 - h. Outlet: Bottom, with pipe threads.
 - i. Number of Inlets: Two **OR** Three **OR** Four, **as directed**.
 - j. Sleeve: Brass **OR** Not required, **as directed**.
 - k. Sleeve Height: 18 inches (460 mm).
 - l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
 - m. Finish, Including Sleeve: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
 - n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.
- L. Sprinkler Specialty Pipe Fittings
1. General Requirements for Dry-Pipe-System Fittings: UL listed for dry-pipe service.
 2. Branch Outlet Fittings:
 - a. Standard: UL 213.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
 - d. Type: Mechanical-T and -cross fittings.
 - e. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
 - f. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
 - g. Branch Outlets: Grooved, plain-end pipe, or threaded.
 3. Flow Detection and Test Assemblies:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
 - d. Size: Same as connected piping.
 - e. Inlet and Outlet: Threaded.
 4. Branch Line Testers:
 - a. Standard: UL 199.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum.
 - c. Body Material: Brass.
 - d. Size: Same as connected piping.
 - e. Inlet: Threaded.
 - f. Drain Outlet: Threaded and capped.
 - g. Branch Outlet: Threaded, for sprinkler.
 5. Sprinkler Inspector's Test Fittings:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Cast- or ductile-iron housing with sight glass.
 - d. Size: Same as connected piping.
 - e. Inlet and Outlet: Threaded.
 6. Adjustable Drop Nipples:
 - a. Standard: UL 1474.
 - b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - c. Body Material: Steel pipe with EPDM O-ring seals.
 - d. Size: Same as connected piping.
 - e. Length: Adjustable.



- f. Inlet and Outlet: Threaded.
- 7. Flexible, Sprinkler Hose Fittings:
 - a. Standard: UL 1474.
 - b. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
 - c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - d. Size: Same as connected piping, for sprinkler.
- M. Sprinklers
 - 1. General Requirements:
 - a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - b. Pressure Rating for Residential Sprinklers: 175 psig (1200 kPa) maximum.
 - c. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
 - d. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - 2. Automatic Sprinklers with Heat-Responsive Element:
 - a. Nonresidential Applications: UL 199.
 - b. Residential Applications: UL 1626.
 - c. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with discharge coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
 - 3. Sprinkler Finishes:
 - a. Chrome plated.
 - b. Bronze.
 - c. Painted.
 - 4. Special Coatings:
 - a. Wax.
 - b. Lead.
 - c. Corrosion-resistant paint.
 - 5. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 - a. Ceiling Mounting: Chrome-plated steel, one piece, flat **OR** Chrome-plated steel, two piece, with 1-inch (25-mm) vertical adjustment **OR** Plastic, white finish, one piece, flat, **as directed**.
 - b. Sidewall Mounting: Chrome-plated steel **OR** Plastic, white finish, **as directed**, one piece, flat.
 - 6. Sprinkler Guards:
 - a. Standard: UL 199.
 - b. Type: Wire cage with fastening device for attaching to sprinkler.
- N. Alarm Devices
 - 1. Alarm-device types shall match piping and equipment connections.
 - 2. Water-Motor-Operated Alarm:
 - a. Standard: UL 753.
 - b. Type: Mechanically operated, with Pelton wheel.
 - c. Alarm Gong: Cast aluminum with red-enamel factory finish.
 - d. Size: 10-inch (250-mm) diameter.
 - e. Components: Shaft length, bearings, and sleeve to suit wall construction.
 - f. Inlet: NPS 3/4 (DN 20).
 - g. Outlet: NPS 1 (DN 25) drain connection.
 - 3. Electrically Operated Alarm Bell:
 - a. Standard: UL 464.
 - b. Type: Vibrating, metal alarm bell.



- c. Size: 6-inch (150-mm) minimum **OR** 8-inch (200-mm) minimum **OR** 10-inch (250-mm), **as directed**, diameter.
 - d. Finish: Red-enamel factory finish, suitable for outdoor use.
 - 4. Pressure Switches:
 - a. Standard: UL 346.
 - b. Type: Electrically supervised water-flow switch with retard feature.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design Operation: Rising pressure signals water flow.
 - 5. Valve Supervisory Switches:
 - a. Standard: UL 346.
 - b. Type: Electrically supervised.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design: Signals that controlled valve is in other than fully open position.
 - 6. Indicator-Post Supervisory Switches:
 - a. Standard: UL 346.
 - b. Type: Electrically supervised.
 - c. Components: Single-pole, double-throw switch with normally closed contacts.
 - d. Design: Signals that controlled indicator-post valve is in other than fully open position.
- O. Manual Control Stations
 - 1. Description: UL listed or FM Global approved, hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
- P. Control Panels
 - 1. Description: Single-area, two-area, or single-area cross-zoned type control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire-alarm bell; lamp test facility; single-pole, double-throw auxiliary alarm contacts; and rectifier.
 - 2. Panels: UL listed and FM Global approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
 - a. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
OR
Manual Control Stations: Hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
- Q. Pressure Gages
 - 1. Standard: UL 393.
 - 2. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.
 - 3. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum **OR** 0 to 300 psig (0 to 2070 kPa), **as directed**.
 - 4. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
 - 5. Air System Piping Gage: Include retard feature, **as directed**, and "AIR" or "AIR/WATER" label on dial face.
- R. Escutcheons
 - 1. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.



2. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with set-screws.
3. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.
4. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw or spring clips.
5. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with concealed hinge and set-screw.
6. Split-Plate, Stamped-Steel Escutcheons: Chrome-plated finish with concealed **OR** exposed-rivet, **as directed**, hinge, set-screw or spring clips.
7. One-Piece Floor Plates: Cast-iron flange with holes for fasteners, **as directed**.
8. Split-Casting Floor Plates: Cast brass with concealed hinge.

S. Sleeves

1. Cast-Iron Wall Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
4. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
5. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
6. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.
7. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set-screws.

T. Sleeve Seals

1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

U. Grout

1. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink, and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Preparation

1. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
2. Report test results promptly and in writing.

B. Service-Entrance Piping

1. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements in Division 21 Section "Facility Fire-suppression Water-service Piping" for exterior piping.



2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories indicated at connection to water-service piping. Comply with requirements in Division 21 Section "Facility Fire-suppression Water-service Piping" for backflow preventers, **as directed**.
3. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

C. Water-Supply Connections

1. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements in Division 22 Section "Domestic Water Piping" for interior piping.
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, **as directed**.
3. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

D. Piping Installation

1. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - a. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with the Owner before deviating from approved working plans.
2. Piping Standard: Comply with requirements in NFPA 13 for installation of sprinkler piping.
3. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.
4. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
5. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
6. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
7. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
8. Install sprinkler piping with drains for complete system drainage.
9. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
10. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or to outside building.
11. Connect compressed-air supply to dry-pipe sprinkler piping.

OR

Connect air compressor to the following piping and wiring:

 - a. Pressure gages and controls.
 - b. Electrical power system.
 - c. Fire-alarm devices, including low-pressure alarm.
12. Install alarm devices in piping systems.
13. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13 for hanger materials.
14. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
15. Drain dry-pipe sprinkler piping.
16. Pressurize and check dry-pipe sprinkler system piping and air-pressure maintenance devices **OR** air compressors, **as directed**.

E. Joint Construction



1. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
 2. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
 3. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
 4. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 5. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
 6. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
 7. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
 8. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
 9. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
 10. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
 11. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
 12. Copper-Tubing, Pressure-Sealed Joints: Join copper tube and copper pressure-seal fittings with tools recommended by fitting manufacturer.
 13. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
 14. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.
- F. Valve And Specialties Installation
1. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
 2. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
 3. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
 4. Specialty Valves:
 - a. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
 - b. Dry-Pipe and Deluge Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
 - 1) Install air compressor and compressed-air supply piping.
 - 2) Air-Pressure Maintenance Device: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range; and 175-psig (1200-kPa) maximum inlet pressure.
 - 3) Install compressed-air supply piping from building's compressed-air piping system.



- G. Sprinkler Installation
1. Install sprinklers in suspended ceilings in center of narrow dimension of, **as directed**, acoustical ceiling panels.
 2. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
 3. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.
- H. Fire-Department Connection Installation
1. Install wall-type, fire-department connections.
 2. Install yard-type, fire-department connections in concrete slab support. Comply with requirements for concrete in Division 03 Section "Cast-in-place Concrete".
 - a. Install two **OR** three, **as directed**, protective pipe bollards around **OR** on sides of, **as directed**, each fire-department connection. Comply with requirements for bollards in Division 05 Section "Metal Fabrications".
 3. Install automatic (ball drip) drain valve at each check valve for fire-department connection.
- I. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors.
 2. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set-screw **OR** stamped steel with set-screw or spring clips **OR** stamped steel with spring clips, **as directed**.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set-screw **OR** One piece or split plate, stamped steel with set-screw **OR** Split plate, stamped steel with set-screw, **as directed**.
 - d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
 - e. Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
 - f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
 3. Escutcheons for Existing Piping:
 - a. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
 - b. Insulated Piping: Split plate, stamped steel with concealed or exposed-rivet hinge and spring clips.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set-screw, **as directed**.
 - e. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set-screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set-screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set-screw or spring clips, **as directed**.
 - f. Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set-screw or spring clips, **as directed**.
 - g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

**J. Sleeve Installation**

1. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
2. Sleeves are not required for core-drilled holes.
3. Permanent sleeves are not required for holes formed by removable PE sleeves.
4. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
5. Install sleeves in new partitions, slabs, and walls as they are built.
6. For interior wall penetrations, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
7. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
8. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals.
9. Seal space outside of sleeves in concrete slabs and walls with grout.
10. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe unless otherwise indicated.
11. Install sleeve materials according to the following applications:
 - a. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
 - b. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized-steel pipe **OR** Stack sleeve fittings, **as directed**.
 - 1) Extend sleeves 2 inches (50 mm) above finished floor level.
 - 2) For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements for flashing in Division 07 Section "Sheet Metal Flashing And Trim".
 - c. Sleeves for Piping Passing through Gypsum-Board Partitions:
 - 1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
 - 3) Exception: Sleeves are not required for water-supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
 - d. Sleeves for Piping Passing through Concrete Roof Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
 - e. Sleeves for Piping Passing through Exterior Concrete Walls:
 - 1) Galvanized-steel-pipe sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Cast-iron wall pipe sleeves for pipes NPS 6 (DN 150) and larger.
 - 3) Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe when sleeve seals are used.
 - f. Sleeves for Piping Passing through Interior Concrete Walls:
 - 1) PVC-pipe **OR** Galvanized-steel pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

K. Sleeve Seal Installation

1. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
2. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe



and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

- L. Identification
1. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
 2. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
- M. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - c. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - d. Energize circuits to electrical equipment and devices.
 - e. Start and run air compressors.
 - f. Coordinate with fire-alarm tests. Operate as required.
 - g. Coordinate with fire-pump tests. Operate as required.
 - h. Verify that equipment hose threads are same as local fire-department equipment.
 3. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.
- N. Cleaning
1. Clean dirt and debris from sprinklers.
 2. Remove and replace sprinklers with paint other than factory finish.
- O. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain specialty valves.
- P. Piping Schedule
1. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded **OR** grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved, **as directed**, joints.
 2. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
 3. Copper-tube, extruded-tee connections may be used for tee branches in copper tubing instead of specified copper fittings. Branch-connection joints must be brazed.
 4. Standard-pressure, dry-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be one of the following:
 - a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight **OR** Schedule 30 **OR** thinwall, **as directed**, galvanized-steel pipe with plain ends; plain-end-pipe fittings; and twist-locked joints.
 - c. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast-or wrought-copper solder-joint fittings; and brazed joints.
 - e. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; copper pressure-seal fittings; and pressure-sealed joints.
 - f. NPS 2 (DN 50), Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.



5. Standard-pressure, dry-pipe sprinkler system, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
 - a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - c. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast-or wrought-copper solder-joint fittings; and brazed joints.
 - d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; copper pressure-seal fittings; and pressure-sealed joints.
 - e. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
6. Standard-pressure, dry-pipe sprinkler system, NPS 5 and NPS 6 (DN 125 and DN 150), shall be one of the following:
 - a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - c. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast-or wrought-copper solder-joint fittings; and brazed joints.
 - d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.

Q. Sprinkler Schedule

1. Use sprinkler types in subparagraphs below for the following applications:
 - a. Rooms without Ceilings: Upright sprinklers.
 - b. Rooms with Suspended Ceilings: Dry pendent sprinklers **OR** Dry recessed sprinklers **OR** Dry flush sprinklers **OR** Dry concealed sprinklers, **as directed**.
 - c. Wall Mounting: Dry sidewall sprinklers.
 - d. Spaces Subject to Freezing: Upright sprinklers **OR** Dry pendent sprinklers **OR** Dry sidewall sprinklers, **as directed**.
 - e. Special Applications: Extended-coverage and quick-response sprinklers where indicated.
2. Provide sprinkler types in subparagraphs below with finishes indicated.
 - a. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
 - b. Flush Sprinklers: Bright chrome, with painted white escutcheon.
 - c. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
 - d. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 21 13 16 00



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SECTION 21 13 39 00 - FOAM FIRE EXTINGUISHING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for foam fire extinguishing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes fixed, low-expansion, AFFF fire-extinguishing systems and the following:
 - a. Concentrate piping and piping specialties.
 - b. Proportioning tanks and proportioning devices.
 - c. Foam concentrate.
 - d. Discharge devices.
 - e. Monitoring and alarm devices.

C. Definitions

1. AFFF: Aqueous film-forming foam.
2. AR-AFFF: Alcohol-resistant aqueous film-forming foam.
3. ATS: Acceptance Testing Specifications.

D. System Description

1. Description: Engineered, fixed, wet-pipe **OR** dry-pipe, **OR** preaction, **OR** deluge, **as directed**, automatically actuated, low-expansion, AFFF **OR** AR-AFFF, **as directed**, fire-extinguishing system for flammable-liquid fires. System includes diaphragm proportioning tanks and devices as described in NFPA 16.

E. Performance Requirements

1. Standard Piping System Component Working Pressure: Listed for at least 175 psig (1200 kPa).
2. Minimum design parameters to be used with the approval of authorities having jurisdiction are as follows:
 - a. Solution: 3 percent foam-water solution.
 - b. Sprinkler Spacing: Maximum of 100 sq. ft. (9.5 sq. m) per sprinkler, and maximum 12-foot (3.7-m) spacing.
 - c. Design Density: Minimum 0.16 gpm/sq. ft. (0.108 L/s per sq. m).
 - d. Foam Supply: Minimum 10-minute discharge time.
 - e. Water Supply: Minimum 60 minutes.
 - f. Remote Area: Minimum 5000-sq. ft. (476-sq. m) design area for closed-sprinkler systems. Open-sprinkler systems shall discharge over the entire system area.
 - g. Sprinkler Temperature Rating: Maximum 250 to 300 deg F (121 to 149 deg C) at a roof or ceiling, and 135 to 170 deg F (57 to 77 deg C) for intermediate sprinklers.
3. Seismic Performance: Fire-suppression piping shall be capable of withstanding the effects of earthquake motions determined according to NFPA 13.

F. Submittals

1. Product Data: For the following:
 - a. Piping and equipment seismic restraints.
 - b. Valves.
 - c. Proportioning tanks and proportioning devices.
 - d. Foam concentrate.
 - e. Discharge devices. Include flow characteristics.
 - f. Monitoring and alarm devices. Include electrical data.



2. Shop Drawings: Signed and sealed by a qualified professional engineer. Include the following for each hazard area, drawn to scale:
 - a. Include plans, elevations, sections, details, and attachments to other work. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: Power, signal, and control wiring.
 - c. Design Calculations: For amount of foam concentrate required for each hazard area.
 - d. Plans: Show the following:
 - 1) Foam-solution proportioning tanks and devices, piping, discharge devices, monitoring and alarm devices, and accessories.
 - 2) Method of attaching hangers to building structure.
 - 3) Fire alarm panel.
 - 4) Equipment and furnishings.
3. Permit-Approved Drawings: Working plans, prepared according to NFPA 16, that have been approved by authorities having jurisdiction. Include design calculations.
4. Welding certificates.
5. Field quality-control test reports.
6. Operation and Maintenance Data: For foam fire extinguishing to include in emergency, operation, and maintenance manuals.

G. Quality Assurance

1. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. FMG Compliance: Provide components that are FMG approved and that are listed in FMG's "Fire Protection Approval Guide."
4. UL Compliance: Provide equipment listed in UL's "Fire Protection Equipment Directory."

1.2 PRODUCTS

A. Pipe And Fittings

1. Steel Pipe: ASTM A 53/A 53M, ASTM A 135, ASTM A 106, or ASTM A 795, Type E or S, Grade A or B, Schedule 40, with factory- or field-formed threaded ends.
 - a. Cast-Iron Threaded Flanges: ASME B16.1.
 - b. Malleable-Iron Threaded Fittings: ASME B16.3.
 - c. Gray-Iron Threaded Fittings: ASME B16.4.
 - d. Butt-Weld Fittings: ASTM A 234/A 234M, Grade WPB, Schedule 40, carbon-steel butt-weld fittings.
 - e. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe. Include ends matching joining method.
 - f. Steel Threaded Couplings: ASTM A 865.
2. Stainless Steel: ASTM A 312/A 312M, Schedule 40, with factory-formed threaded or beveled ends; ASTM A 376/A 376M for seamless pipe; or ASTM A 213/A 213M, ASTM A 249/A 249M, and ASTM A 269 for seamless and welded tubing.
 - a. Class 150 Threaded Fittings: ASME B16.3 and MSS SP 114.
 - b. Butt-Weld Fittings: ASTM A 403/A 403M.
 - c. Flanges, Forged Fittings and Flanges, and Socket-Weld Fittings: ASTM A 182/A 182M.
 - d. Bar Stock and Compression Fittings: ASTM A 276 and ASTM A 479/A 479M.
3. Red Brass Pipe: ASTM B 43, Schedule 40, with factory- or field-formed threaded ends.
 - a. Threaded Flanges and Fittings: ASTM B 584.
4. Refer to Division 21 Section "Common Work Results For Fire Suppression" for basic joining materials.



- B. Valves
1. Ball Valves: Bronze body with threaded or flanged ends. Comply with UL 1091, except with stainless-steel ball instead of disc.
- C. Specialties
1. Concentrate Storage Tank: Buna-N, bladder-type proportioning tank complying with UL 162 and ASME Boiler and Pressure Vessel Code: Section VIII. Include bladder, internal piping, fill and drain, pipe assembly, glass sight gage, piping, and valves. Concentrate to be contained in the bladder.
 - a. Orientation: Horizontal design with saddle **OR** Vertical design with skirt, **as directed**, support.
 2. Proportioning Controller: Venturi type complying with UL 162 and of capacity to match design at minimum and maximum flow.
 3. Concentrate Control Valve: Water-operated ball or deluge valve designed to open with flow through the proportioning controller.
 4. Concentrate Strainers: Bronze body and stainless-steel mesh strainer with minimum 0.125-inch (3.2-mm) perforations to remove solids that would block system components.
 5. Provide devices that comply with NFPA 16, are compatible with the foam concentrate, and are designed to be drained and cleaned.
- D. Foam Concentrate
1. Description: AFFF **OR** AR-AFFF, **as directed**, liquid concentrate, complying with NFPA 11 and UL 162, for making foam-water fire-extinguishing foam solution.
- E. Pressure Gages
1. Description: Comply with UL 393, with 3-1/2-inch- (90-mm-) minimum diameter dial, 0- to 300-psig (0- to 2070-kPa) dial range, and caption "WATER" or "CONCENTRATE" on dial face.
- F. Discharge Devices
1. General: Discharge devices shall be listed and approved by UL and FMG.
 2. Sprinklers: Closed **OR** Open, **as directed**, air-aspirating **OR** non-air-aspirating, **as directed**, type complying with UL 162 and suitable for discharging foam.
 3. Spray Nozzles: Foam-water spray nozzles including foam generator and distributing deflector complying with UL 162 and designed to distribute foam or water in the absence of foam solution in a special pattern peculiar to a particular head.
- G. Monitoring Devices
1. Valve Supervisory Switches: UL 753, electrical, single pole, double throw, with normally closed contacts. Include design that signals controlled valve is in other than fully open position.
- H. Alarm Devices
1. Description: UL listed or FMG approved, low voltage, and surface mounting. Alarm and monitoring devices are specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System".

1.3 EXECUTION

- A. Concentrate Storage Tank Installation
1. Install proportioning tanks on concrete bases. Concrete bases are specified in Division 21 Section "Common Work Results For Fire Suppression".
 2. Install tanks level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 3. Install seismic restraints for tanks. Anchor tanks to substrate.



- B. Piping Applications
1. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
 2. AFFF-Concentrate Piping: Steel pipe, malleable- or cast-iron threaded fittings, and threaded joints.
 3. AFFF-Concentrate Piping: Steel pipe with welded fittings and joints.
 4. AR-AFFF-Concentrate Piping: Brass **OR** Stainless-steel, **as directed**, pipe, threaded fittings, and joints.
 5. AR-AFFF-Concentrate Piping: Stainless-steel pipe with welded fittings and joints.
 6. Foam-solution piping is specified in Division 21 Section "Wet-pipe Sprinkler Systems".
- C. Piping Installation
1. Install piping and other components level and plumb.
 2. Refer to Division 21 Section "Common Work Results For Fire Suppression" for basic pipe installation and joint construction.
 3. Install proportioning tanks anchored to substrate.
 4. Install pipe and fittings, valves, and discharge devices according to requirements listed in NFPA 16, "Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems."
 - a. Support piping using supports and methods according to NFPA 13.
 - b. Install seismic restraints for proportioning tanks and piping systems.
 - c. Install monitoring and alarm devices according to NFPA 16 and NFPA 72.
- D. Connections
1. Piping installation requirements are specified in Division 21 Section "Wet-pipe Sprinkler Systems". Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Provide concentrate control, maintenance service, and drain valves with piping to permit maintenance of the foam concentrate with continuous sprinkler system service.
 3. Install proportioning controller in fire-suppression piping to provide coverage to area indicated on Drawings.
 4. Install piping adjacent to equipment to allow service and maintenance.
 5. Connect electrical devices to building's fire alarm system. Electrical power, wiring, and devices are specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System".
- E. Labeling
1. Install labeling on piping, equipment, and panels according to Division 22 Section "Identification For Plumbing Piping And Equipment".
- F. Charging System
1. Fill proportioning tanks with foam concentrate after field quality-control testing is complete and satisfactory results have been achieved.
- G. Field Quality Control
1. Inspection: Engage the services of a qualified professional engineer to inspect installed fire-extinguishing systems, prepare installation report, and certify that installation complies with the Contract Documents, calculations, and requirements of authorities having jurisdiction.
 2. Comply with operating instructions and procedures in NFPA 16, "Acceptance Tests" Chapter. Include the following tests and inspections to demonstrate compliance with requirements:
 - a. Check mechanical items.
 - b. Inspect equipment and fire-extinguishing foam concentrate, and check mountings for adequate anchoring to substrate.
 - c. Check electrical systems.
 - d. Flush piping.
 - e. Perform acceptance test.
 - f. Perform pressure test.



- g. Perform operating test.
 - h. Perform discharge test.
 - i. Correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment that cannot be satisfactorily corrected or does not perform as specified and indicated, then retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.
 - 1) Report test results promptly and in writing and authorities having jurisdiction.
3. Perform the following field tests and inspections and prepare test reports:
 - a. After installing foam fire-extinguishing piping system and after electrical circuitry has been energized, test for compliance with requirements.
 - b. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, "Inspection and Test Procedures" and "System Function Tests." Certify compliance with test parameters.
 - c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - d. Operational Test: After electrical circuitry has been energized, start systems to confirm proper unit operation.
 - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 4. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 21 13 39 00



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**SECTION 21 22 16 00 - CLEAN-AGENT EXTINGUISHING SYSTEMS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for clean-agent extinguishing systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes clean-agent extinguishing systems and the following:
 - a. Piping and piping specialties.
 - b. Extinguishing-agent containers.
 - c. Extinguishing agent.
 - d. Detection and alarm devices.
 - e. Control and alarm panels.
 - f. Accessories.
 - g. Connection devices for and wiring between system components.
 - h. Connection devices for power and integration into building's fire alarm system.

C. Definitions

1. ATS: Acceptance Testing Specifications.
2. EPO: Emergency Power Off.

D. System Description

1. Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the hazard area including the room cavity below the ceiling and below the raised floor. Provide separate zones above and below the raised floor. If smoke is detected below the raised floor, agent shall be discharged in the underfloor zone only. If smoke is detected above the raised floor, agent shall be discharged in zones above and below the floor.

E. Performance Requirements

1. Design clean-agent extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class A, B, or C fires as appropriate for areas being protected and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.
2. Performance Requirements: Discharge HFC 227ea within 10 seconds and maintain 7.1 percent concentration by volume at 70 deg F (21 deg C) for 10-minute holding time in hazard areas.
 - a. HFC 227ea concentration in hazard areas greater than 9.0 percent immediately after discharge or less than 5.8 percent throughout holding time will not be accepted without written authorization from the Owner and authorities having jurisdiction.
 - b. System Capabilities: Minimum 620-psig (4278-kPa) calculated working pressure and 360-psig (2484-kPa) initial charging pressure.
3. Performance Requirements: Discharge IG-541 within 60 seconds and maintain 38 percent concentration by volume at 70 deg F (21 deg C) for 10-minute holding time in hazard areas.
 - a. IG-541 concentration in hazard areas greater than 40 percent immediately after discharge or less than 32 percent throughout holding time will not be accepted without written authorization from the Owner and authorities having jurisdiction.
 - b. System Capabilities: Minimum 2175-psig (15-MPa) calculated working pressure upstream from orifice union, minimum 1000-psig (6895-kPa) calculated working pressure downstream from orifice union, and 2175-psig (15-MPa) initial charging pressure.



4. Cross-Zoned Detection: Devices located in two separate zones. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating single-detection device in other zone.
OR
Verified Detection: Devices located in single zone. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating second-detection device.
5. System Operating Sequence: As follows:
 - a. Actuating First Detector: Visual indication on annunciator panel, energize audible alarm and visual alarms (slow pulse), shut down air-conditioning and ventilating systems serving protected area, close doors in protected area, and send signal to fire alarm system.
 - b. Actuating Second Detector: Visual indication on annunciator panel, energize audible and visual alarms (fast pulse), shut down power to protected equipment, start time delay for extinguishing-agent discharge for 30 seconds, and discharge extinguishing agent. On agent discharge, release preaction valve to allow water to fill sprinkler system.
 - c. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.
6. System Operating Sequence: System shall be cross-zoned, air-sampling detectors and photoelectric detectors reporting to a fully programmable microprocessor-based control panel programmed to operate as follows:
 - a. If one photoelectric detector and air-sampling detector reaches the third detection level (Fire 1), agent discharge will be initiated as described for the third detection level (Fire 1) below.
 - b. Air-Sampling System:
 - 1) First Detection Level (Alert): Mild audible and visual indication on annunciator panel. Strobe lights flash slowly in the protected area.
 - 2) Second Detection Level (Action): Strong audible and visual indication on annunciator panel. Strobe lights flash rapidly in the protected area.
 - 3) Third Detection Level (Fire 1): Strong audible and visual indication on annunciator panel. Energize horn(s), bell(s), and strobe light(s) in the protected area and outside entry doors. Shut down air-conditioning and ventilating systems serving the protected area, and close doors in the protected area. Send signal to fire alarm system, initiate 30-second time delay for extinguishing-agent discharge, and discharge extinguishing agent. At agent discharge, terminate power to equipment in the protected area, and release preaction valve to allow water flow to sprinkler system.
 - 4) Fourth Detection Level (Fire 2): Same as Fire 1.
7. Manual stations shall immediately discharge extinguishing agent when activated.
8. Operating abort switches will delay extinguishing-agent discharge while being activated, and switches must be reset to prevent agent discharge. Release of hand pressure on the switch will cause agent discharge if the time delay has expired.
9. EPO: Will terminate power to protected equipment immediately on actuation.
10. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure.
11. Power Transfer Switch: Transfer from normal to stand-by power source.
12. Seismic Performance: Fire-suppression piping and containers shall be capable of withstanding the effects of earthquake motions determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

F. Submittals

1. Product Data: For each product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that clean agents comply.
3. Shop Drawings: Signed and sealed by a qualified professional engineer. Include design calculations.



4. Permit Approved Drawings: Working plans, prepared according to NFPA 2001, that have been approved by authorities having jurisdiction. Include design calculations.
5. Field quality-control test reports.
6. Maintenance Data: For components to include in maintenance manuals.

G. Quality Assurance

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of clean-agent extinguishing systems that are similar to those indicated for this Project in material, design, and extent.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Piping Materials

1. Refer to Part 1.3 piping applications Article retained for applications of pipe, tube, fitting, and joining materials.
2. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.

B. Pipe And Fittings

1. Steel Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106, Grade B; Schedule 40, or Schedule 80, seamless steel pipe.
 - a. Threaded Fittings:
 - 1) Malleable-Iron Fittings: ASME B16.3, Class 300.
 - 2) Flanges and Flanged Fittings: ASME B16.5, Class 300, unless Class 600 is indicated.
 - b. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.
 - c. Grooved-End Fittings: FMG approved and NRTL listed, ASTM A 47/A 47M malleable iron or ASTM A 536 ductile iron, with dimensions matching steel pipe and ends factory grooved according to AWWA C606.
Plain-End, Hard Copper Tube: ASTM B 88, Type K **OR** L, **as directed**, (ASTM B 88M, Type A **OR** B, **as directed**), water tube, drawn temper.
 - d. Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper alloy, pressure.
 - e. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 300.
2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, unless thickness or specific material is indicated.
3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
4. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing.
5. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
6. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for clean-agent service, and matching steel-pipe dimensions. Include ASTM A 536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

C. Valves

1. General: Brass; suitable for intended operation.
2. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.



3. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure relief device.
 4. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.
- D. Extinguishing-Agent Containers
1. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.
 - a. Finish: Red **OR** Manufacturer's standard color, **as directed**, enamel or epoxy paint.
 - b. Manifold: Fabricate with valves, pressure switches, and connections for multiple storage containers, as indicated.
OR
Manifold: Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.
 - c. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.
- E. Fire-Extinguishing Clean Agent
1. Clean Agent: HFC 227ea, heptafluoropropane.
OR
Clean Agent: IG-541, mixture of nitrogen, argon, and carbon dioxide inert gases.
- F. Discharge Nozzles
1. Equipment manufacturer's standard one-piece brass or aluminum alloy of type, discharge pattern, and capacity required for application.
- G. Manifold And Orifice Unions
1. Description: NRTL-listed device with minimum 2175-psig (15-MPa) pressure rating, to control flow and reduce pressure of IG-541 gas in piping.
 - a. NPS 2 (DN 50) and Smaller: Piping assembly with orifice, sized for system design requirements.
 - b. NPS 2-1/2 (DN 65) and Larger: Piping assembly with nipple, sized for system design requirements.
- H. Control Panels
1. Description: FMG approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.
 2. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.
 3. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.
 - a. Mounting: Recessed flush with surface **OR** Surface, **as directed**.
 4. Supervised Circuits: Separate circuits for each independent hazard area.
 - a. Detection circuits equal to the required number of zones, or addressable devices assigned to the required number of zones.
 - b. Manual pull-station circuit.
 - c. Alarm circuit.
 - d. Release circuit.
 - e. Abort circuit.
 - f. EPO circuit.
 5. Provide the following control-panel features:
 - a. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.



- b. Automatic switchover to standby power at loss of primary power.
 - c. Storage container, low-pressure indicator.
 - d. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.
6. Annunciator Panel: Graphic type showing protected, hazard-area plans and locations of detectors, abort, EPO, and manual stations. Include lamps to indicate device-initiating alarm, electrical contacts for connection to control panel, and stainless-steel or aluminum enclosure.
 7. Standby Power: Lead-acid or nickel-cadmium batteries with capacity to operate system for 72 hours and alarm for minimum of 15 minutes. Include automatic battery charger, with varying charging rate between trickle and high depending on battery voltage, that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, and suitable enclosure.
- I. Detection Devices
1. Description: Comply with NFPA 2001 and NFPA 72, and include the following types:
 - a. Ionization Detectors: Comply with UL 268, dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.
 - b. Photoelectric Detectors: Comply with UL 268, consisting of LED light source and silicon photodiode receiving element.
 - c. Remote Air-Sampling Detector System: Includes air-sampling pipe network, a laser-based photoelectric detector, a sample transport fan, and a control unit.
 - 1) Comply with UL 268 and NRTL listed, operating at 24-V dc, nominal.
 - 2) Pipe Network: CPVC tubing connects control unit with calibrated sampling holes.
 - 3) Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of four preset values.
 - 4) Sample Transport Fan: Centrifugal type, creating a minimum static pressure of 0.05-inch wg (12.5 Pa) at all sampling ports.
 - 5) Control Unit: Multizone unit as indicated on Drawings. Provides same system power supply, supervision, and alarm features as specified for the control panel plus separate trouble indication for airflow and detector problems.
 - 6) Signals to the Central Fire Alarm Control Panel: Any type of local system trouble is reported to the central fire alarm control panel as a composite "trouble" signal. Alarms on each system zone are individually reported to the central fire alarm control panel as separately identified zones.
- J. Manual Stations
1. General Description: Surface **OR** Semirecessed, **as directed**, FMG approved or NRTL listed, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.
 2. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.
 3. Abort Switch: "ABORT" caption, momentary contact, with green finish.
 4. EPO Switch: "EPO" caption, with yellow finish.
- K. Switches
1. Description: FMG approved or NRTL listed, where available, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.
 - a. Low-Agent Pressure Switches: Pneumatic operation.
 - b. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.
 - c. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.
- L. Alarm Devices
1. Description: FMG approved or NRTL listed, low voltage, and surface mounting, unless otherwise indicated.



2. Bells: Minimum 6-inch (150-mm) diameter.
3. Horns: 90 to 94 dBA.
4. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

M. Electrical Power And Wiring

1. Electrical power, wiring, and devices are specified in Division 22.

1.3 EXECUTION

A. Piping Applications

1. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
2. Fittings Working Pressure: 620 psig (4278 kPa) minimum.
3. Flanged Joints: Class 300 minimum.
4. NPS 2 (DN 50) and Smaller: ASTM B 88, Type K **OR** L, **as directed**, (ASTM B 88M, Type A **OR** B, **as directed**,) copper tube; copper, solder-joint fittings; and brazed joints.
OR
NPS 2 (DN 50) and Smaller: Schedule 40, steel pipe; malleable-iron threaded fittings; and threaded joints.
5. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): ASTM B 88, Type K **OR** L, **as directed**, (ASTM B 88M, Type A **OR** B, **as directed**,) copper tube; copper, solder-joint fittings; and brazed joints.
OR
NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Schedule 40, steel pipe; forged-steel welding fittings; and welded joints.
OR
NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Schedule 40, steel pipe; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.
6. NPS 4 (DN 100) and Larger: Schedule 40, steel pipe; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.
OR
NPS 4 (DN 100) and Larger: Schedule 40, steel pipe; forged-steel welding fittings; and welded joints.

B. Piping Applications

1. Piping between Storage Containers and Orifice Union:
 - a. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
 - b. Fittings Working Pressure: 2175 psig (15 MPa) minimum.
 - c. Flanged Joints: Class 600 minimum.
 - d. All Sizes: Schedule 80, steel pipe; forged-steel welding fittings; and welded joints.
2. Piping Downstream from Orifice Union:
 - a. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
 - b. Fittings Working Pressure: 1000 psig (6900 kPa) minimum.
 - c. Flanged Joints: Class 300 minimum.
 - d. All Sizes: Schedule 40 **OR** 80, **as directed**, steel pipe; forged-steel welding fittings; and welded joints.

C. Clean-Agent Extinguishing Piping Installation

1. Install clean-agent extinguishing piping and other components level and plumb and according to manufacturers' written instructions.
2. Refer to Division 21 Section "Common Work Results For Fire Suppression" for basic pipe installation and joint construction.



3. Grooved Piping Joints: Groove pipe ends according to AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant according to manufacturer's written instructions.
 4. Install extinguishing-agent containers anchored to substrate.
 5. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 2001, Section "Distribution," and in ASME B31.1.
 - a. Install valves designed to prevent entrapment of liquid or install pressure relief devices in valved sections of piping systems.
 - b. Support piping using supports and methods according to NFPA 13.
 - c. Install seismic restraints for extinguishing-agent containers and piping systems.
 - d. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.
- D. Connections
1. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to extinguishing-agent containers to allow service and maintenance.
 3. Connect electrical devices to control panel and to building's fire alarm system. Electrical power, wiring, and devices are specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System".
- E. Labeling
1. Install labeling on piping, extinguishing-agent containers, other equipment, and panels according to NFPA 2001.
 2. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire extinguishing system.
 3. Install signs at entry doors to advise persons outside the room the meaning of the horn(s), bell(s), and strobe light(s) outside the protected space.
- F. Field Quality Control
1. Comply with operating instructions and procedures of NFPA 2001, Section "Approval of Installations." Include the following tests and inspections to demonstrate compliance with requirements:
 - a. Check mechanical items.
 - b. Inspect extinguishing-agent containers and extinguishing agent, and check mountings for adequate anchoring to substrate.
 - c. Check electrical systems.
 - d. Check enclosure integrity. Comply with NFPA 2001, Section "Enclosure Inspection," and Appendix C, "Enclosure Integrity Procedure."
 - e. Perform functional pre-discharge test.
 - f. Perform system functional operational test including, EPO, abort, and manual release.
 - g. Check remote monitoring operations.
 - h. Check control-panel primary power source.
 - i. Perform "puff" test on piping system, using nitrogen.
 2. Perform field-acceptance tests of each clean-agent extinguishing system when installation is complete. Perform system testing only after hazard-area enclosure construction has been completed and openings sealed. Comply with operating instructions and procedures of NFPA 2001, Section "Approval of Installations." Include the following to demonstrate compliance with requirements:
 - a. Perform functional pre-discharge test.
 - b. Perform system functional operational test.
 - c. Check remote monitoring operations.
 - d. Check control-panel primary power source.
 - e. Perform "puff" test on piping system, using nitrogen.



3. Correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment that cannot be corrected or does not perform as specified and indicated, then retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.
 - a. Report test results promptly and in writing to the Owner and authorities having jurisdiction.
 4. Perform the following field tests and inspections and prepare test reports:
 - a. After installing clean-agent extinguishing piping system and after electrical circuitry has been energized, test for compliance with requirements.
 - b. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections "Inspection and Test Procedures" and "System Function Tests." Certify compliance with test parameters.
 - c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
 - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 5. Remove and replace malfunctioning units and retest as specified above.
- G. Cleaning
1. Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, using a suitable nonflammable cleaner. Pipe network shall be free of particulate matter and oil residue before installing nozzles or discharge devices.
- H. System Filling
1. Preparation:
 - a. Verify that piping system installation is completed and cleaned.
 - b. Check for complete enclosure integrity.
 - c. Check operation of ventilation and exhaust systems.
 2. Filling Procedures:
 - a. Fill extinguishing-agent containers with extinguishing agent and pressurize to indicated charging pressure.
 - b. Install filled extinguishing-agent containers.
 - c. Energize circuits.
 - d. Adjust operating controls.
- I. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain clean-agent extinguishing systems.

END OF SECTION 21 22 16 00



Task	Specification	Specification Description
21 22 16 00	01 22 16 00	No Specification Required



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**SECTION 21 24 00 00 - FIBERGLASS REINFORCED POLYESTER (FRP) FLUSH DOORS**

1.1 GENERAL

A. Description of Work

1. This specification covers the furnishing and installation of materials for fiberglass reinforced polyester (FRP) flush doors and aluminum frames. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Performance Requirements

1. General: Provide door assemblies that have been designed and fabricated to comply with specified performance requirements, as demonstrated by testing manufacturer's corresponding standard systems.
2. Air Infiltration: For a single door 3'-0" x 7'-0", test specimen shall be tested in accordance with ASTM E 283 at pressure differential of 6.24 psf. Door shall not exceed 0.90 cfm per linear foot of perimeter crack.
3. Water Resistance: For a single door 3'-0" x 7'-0", test specimen shall be tested in accordance with ASTM E 331 at pressure differential of 7.50 psf. Door shall not have water leakage.
4. Hurricane Test Standards, Single Door with Single-Point Latching:
 - a. Uniform Static Load, ASTM E 330: Plus or minus 75 pounds per square foot.
 - b. Forced Entry Test, 300 Pound Load Applied, SFBC 3603.2 (b)(5): Passed.
 - c. Cyclic Load Test, SFBC PA 203: Plus or minus 53 pounds per square foot.
 - d. Large Missile Impact Test, SFBC PA 201: Passed.
5. Swinging Door Cycle Test, Doors and Frames, ANSI A250.4: Minimum of 20,000,000 cycles.
6. Swinging Security Door Assembly, Doors and Frames, ASTM F 476: Grade 40.
7. Salt Spray, Exterior Doors and Frames, ASTM B 117: Minimum of 500 hours.
8. Sound Transmission, Exterior Doors, STC, ASTM E 90: Minimum of 25.
9. Thermal Transmission, Exterior Doors, U-Value, AAMA 1503-98: Maximum of 0.29 BTU/hr x sf x degrees F. Minimum of 55 CRF value.
10. Surface Burning Characteristics, FRP Doors and Panels, ASTM E 84:
 - a. Flame Spread: Maximum of 200, Class C.
 - b. Smoke Developed: Maximum of 450, Class C.
11. Surface Burning Characteristics, Class A Option On Interior Faces of FRP Exterior Panels and Both Faces of FRP Interior Panels, ASTM E 84:
 - a. Flame Spread: Maximum of 25.
 - b. Smoke Developed: Maximum of 450.
12. Impact Strength, FRP Doors and Panels, Nominal Value, ASTM D 256: 15.0 foot-pounds per inch of notch.
13. Tensile Strength, FRP Doors and Panels, Nominal Value, ASTM D 638: 14,000 psi.
14. Flexural Strength, FRP Doors and Panels, Nominal Value, ASTM D 790: 21,000 psi.
15. Water Absorption, FRP Doors and Panels, Nominal Value, ASTM D 570: 0.20 percent after 24 hours.
16. Indentation Hardness, FRP Doors and Panels, Nominal Value, ASTM D 2583: 55.
17. Abrasion Resistance, Face Sheet, Taber Abrasion Test, 25 Cycles at 1,000 Gram Weight with CS-17 Wheel: Maximum of 0.029 average weight loss percentage.
18. Stain Resistance, ASTM D 1308: Face sheet unaffected after exposure to red cabbage, tea, and tomato acid. Stain removed easily with mild abrasive or FRP cleaner when exposed to Sharpie ink pen and white spray paint.
19. Chemical Resistance, ASTM D 543. Excellent rating.
 - a. Acetic acid, 5 percent solution.
 - b. Chlorine bleach, 10 percent solution.
 - c. Sodium hypochlorite, 4 to 6 percent solution.
 - d. Citric acid, 10 percent solution.
 - e. Sodium carbonate, 20 percent solution.



- f. Turpentine.
- 20. Compressive Strength, Foam Core, Nominal Value, ASTM D 1621: 84.2 psi.
- 21. Compressive Modulus, Foam Core, Nominal Value, ASTM D 1621: 448 psi.
- 22. Tensile Adhesion, Foam Core, Nominal Value, ASTM D 1623: 48 psi.
- 23. Thermal and Humid Aging, Nominal Value, 158 Degrees F and 100 Percent Humidity for 14 Days, ASTM D 2126: Minus 4.89 percent volume change.

C. Submittals

1. Product Data: Submit manufacturer's product data, including description of materials, components, fabrication, finishes, and installation.
2. Shop Drawings: Submit manufacturer's shop drawings, including elevations, sections, and details, indicating dimensions, tolerances, materials, fabrication, doors, panels, framing, hardware schedule, and finish.
3. Samples:
 - a. Door: Submit manufacturer's sample of door showing face sheets, core, framing, and finish.
 - b. Color: Submit manufacturer's samples of standard colors of doors and frames.
4. Test Reports: Submit certified test reports from qualified independent testing agency indicating doors comply with specified performance requirements.
5. Manufacturer's Project References: Submit list of successfully completed projects including project name and location, name of architect, and type and quantity of doors manufactured.
6. Maintenance Manual: Submit manufacturer's maintenance and cleaning instructions for doors, including maintenance and operating instructions for hardware.
7. Warranty: Submit manufacturer's standard warranty.

D. Quality Assurance

1. Manufacturer's Qualifications:
 - a. Continuously engaged in manufacturing of doors of similar type to that specified, with a minimum of 25 years successful experience.
 - b. Door and frame components from same manufacturer.
 - c. Evidence of a compliant documented quality management system.

E. Delivery, Storage, And Handling

1. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying opening door mark and manufacturer.
2. Storage: Store materials in clean, dry area indoors in accordance with manufacturer's instructions.
3. Handling: Protect materials and finish from damage during handling and installation.

F. Warranty

1. Warrant doors, frames, and factory hardware against failure in materials and workmanship, including excessive deflection, faulty operation, defects in hardware installation, and deterioration of finish or construction in excess of normal weathering.
2. Warranty Period: Ten years starting on date of shipment.

1.2 PRODUCTS

A. Manufacturer: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Special-Lite, Inc., PO Box 6, Decatur, Michigan 49045. Toll Free (800) 821-6531. Phone (269) 423-7068. Fax (800) 423-7610. Web Site www.special-lite.com. E-Mail info@special-lite.com.

B. FRP Flush Doors

1. Model: SL-17 Flush Doors with SpecLite3 fiberglass reinforced polyester (FRP) face sheets.
2. Door Opening Size: As indicated on the Drawings **OR as directed**.



3. Construction:
 - a. Door Thickness: 1-3/4 inches.
 - b. Stiles and Rails: Aluminum Alloy 6063-T5, minimum of 2-5/16-inch depth.
 - c. Corners: Mitered.
 - d. Provide joinery of 3/8-inch diameter full-width tie rods through extruded splines top and bottom as standard tubular shaped stiles and rails reinforced to accept hardware as specified.
 - e. Securing Internal Door Extrusions: 3/16-inch angle blocks and locking hex nuts for joinery. Welds, glue, or other methods are not acceptable.
 - f. Furnish extruded stiles and rails with integral reglets to accept face sheets. Lock face sheets into place to permit flush appearance.
 - g. Rail caps or other face sheet capture methods are not acceptable.
 - h. Extrude top and bottom rail legs for interlocking continuous weather bar.
 - i. Meeting Stiles: Pile brush weatherseals. Extrude meeting stile to include integral pocket to accept pile brush weatherseals.
 - j. Bottom of Door: Install bottom weather bar with nylon brush weatherstripping into extruded interlocking edge of bottom rail.
 4. Face Sheet:
 - a. Material: SpecLite3 FRP, 0.120-inch thickness, finish color throughout. Abuse-resistant engineered surface.
 - b. Texture: Pebble.
 - c. Color: **As directed**.
 5. Core:
 - a. Material: Poured-in-place polyurethane foam.
 - b. Density: Minimum of 5 pounds per cubic foot.
 - c. R-Value: Minimum of 9.
 6. Cutouts:
 - a. Manufacture doors with cutouts for required vision lites, louvers, and panels.
 - b. Factory install vision lites, louvers, and panels.
 7. Hardware:
 - a. Premachine doors in accordance with templates from specified hardware manufacturers and hardware schedule.
 - b. Factory install hardware.
- C. Materials
1. Aluminum Members:
 - a. Extrusions: ASTM B 221.
 - b. Sheet and Plate: ASTM B 209.
 - c. Alloy and Temper: As required by manufacturer for strength, corrosion resistance, application of required finish, and control of color.
 2. Components: Door and frame components from same manufacturer.
 3. Fasteners:
 - a. Material: Aluminum, 18-8 stainless steel, or other noncorrosive metal.
 - b. Compatibility: Compatible with items to be fastened.
 - c. Exposed Fasteners: Screws with finish matching items to be fastened.
- D. Fabrication
1. Sizes and Profiles: Required sizes for door and frame units, and profile requirements shall be as indicated on the Drawings.
 2. Coordination of Fabrication: Field measure before fabrication and show recorded measurements on shop drawings.
 3. Assembly:
 - a. Complete cutting, fitting, forming, drilling, and grinding of metal before assembly.
 - b. Remove burrs from cut edges.
 4. Welding: Welding of doors or frames is not acceptable.
 5. Fit:



- a. Maintain continuity of line and accurate relation of planes and angles.
- b. Secure attachments and support at mechanical joints with hairline fit at contacting members.

E. Architectural Panels

1. FRP Panels:
 - a. Model: SL-37 Architectural Panels with SpecLite3 FRP face sheets.
 - b. Size: As indicated on the Drawings **OR as directed**.
 - c. Thickness: 1/4 inch **OR** 1 inch **OR** As indicated on the Drawings **OR as directed**.
2. Face Sheets:
 - a. Material: SpecLite3 FRP, 0.120-inch thickness, finish color throughout. Abuse-resistant engineered surface.
 - b. Texture: Pebble.
 - c. Color: **As directed**.
3. Insulated SpecLite3 FRP Panels:
 - a. Insulated Panels: Two 0.120-inch minimum thickness sheets.
 - b. Core: Foamed polyurethane core of a minimum of 5 pounds per cubic foot density.
 - c. Form components to function as single unit.
 - d. U-Value: Minimum of 0.23 for 1-inch panels.
4. Class A Flame Spread and Smoke Developed Rating, **as directed**:
 - a. Class A flame spread and smoke developed rating on interior faces of exterior panels and both faces of interior panels.
 - b. Flame Spread, ASTM E 84: Maximum of 25.
 - c. Smoke Developed, ASTM E 84: Maximum of 450.

F. Aluminum Door Framing Systems

1. Tubular Framing:
 - a. Size and Type: As indicated on the Drawings.
 - b. Materials: Aluminum Alloy 6063-T5, 1/8-inch minimum wall thickness.
 - c. Applied Door Stops: 0.625-inch high, with screws and weatherstripping. Door stop shall incorporate pressure gasketing for weathering seal. Counterpunch fastener holes in door stop to preserve full metal thickness under fastener head.
 - d. Frame Members: Box type with 4 enclosed sides. Open-back framing is not acceptable.
 - e. Caulking: Caulk joints before assembling frame members.
 - f. Joints:
 - 1) Secure joints with fasteners.
 - 2) Provide hairline butt joint appearance.
 - g. Field Fabrication: Field fabrication of framing using stick material is not acceptable.
 - h. Applied Stops: For side, transom, and borrowed lites and panels. Applied stops shall incorporate pressure gasketing for weathering seal. Reinforce with solid bar stock fill for frame hardware attachments.
 - i. Hardware:
 - 1) Premachine and reinforce frame members for hardware in accordance with manufacturer's standards and hardware schedule.
 - 2) Factory install hardware.
 - j. Anchors:
 - 1) Anchors appropriate for wall conditions to anchor framing to wall materials.
 - 2) Door Jamb and Header Mounting Holes: Maximum of 24-inch centers.
 - 3) Secure head and sill members of transom, side lites, and similar conditions.
 - k. Side Lites:
 - 1) Factory preassemble side lites to greatest extent possible.
 - 2) Mark frame assemblies according to location.
2. Insert Framing System:
 - a. Model: SL-1030 Series, SL-1031 **OR** SL-1032 **OR** SL-1034, **as directed**.
 - b. Insert frame as indicated on the Drawings, using integral stop fitted with weatherstripping.



- c. Corner joints of miter design, secure with furnished aluminum clips, and screw into place.
 - d. Hardware:
 - 1) Premachine and reinforce insert frame members for hardware in accordance with manufacturer's standards and hardware schedule.
 - 2) Factory install hardware.
 - e. Anchors:
 - 1) Anchors of suitable type to fasten insert framing to existing frame materials.
 - 2) Minimum of 5 anchors on jambs up to 7'-4" height, 3 anchors on headers, and 1 additional anchor for each additional foot of frame.
3. Frame Capping:
- a. Model: SL-70.
 - b. Capping: With insert frame as indicated on the Drawings, **OR as directed**.
 - c. Finish: Match framing.
- G. Hardware
- 1. Premachine doors in accordance with templates from specified hardware manufacturers and hardware schedule.
 - 2. Factory install hardware.
 - 3. Hardware Schedule: As specified in Division 08 Section "Door Hardware" **OR** As indicated on the Drawings, **OR as directed**.
 - a. Hinges shall be continuous type.
 - 4. Finish: As specified in Division 08 Section "Door Hardware" **OR** As indicated on the Drawings, **OR as directed**.
- H. Vision Lites
- 1. Factory Glazing: 1/4-inch glass **OR** 1-inch glass insulating units, **as directed**.
 - 2. Lites in Exterior Doors: Allow for thermal expansion.
 - 3. Rectangular Lites:
 - a. Size: 12 inches by 12 inches **OR** Half lite **OR** Full lite **OR** Narrow lite **OR** Double lite **OR** As indicated on the Drawings **OR as directed**.
 - b. Factory glazed with screw-applied aluminum stops anodized to match perimeter door rails.
 - 4. Security Grate: SL-SG349.
 - a. Frame Perimeter: 1-inch by 1-inch by 1/8-inch steel angle.
 - b. Expanded Metal: 1/4-inch diameter, round hole perforated, 14-gauge steel sheet.
 - c. Finish: Factory painted to match door finish.
 - 5. Vandal Screen: SL-SG350.
 - a. Frame Perimeter: Aluminum. Finish to match vision lite.
 - b. Expanded Metal: 1/4-inch diameter, round hole perforated, 16-gauge stainless steel sheet. Powder coat black finish.
- I. Louvers
- 1. Type: Aluminum, inverted Y-type, fixed blade, 12 inches minimum from bottom of door.
 - 2. Size: As indicated on the Drawings **OR** as directed.
 - 3. Installation: Factory installed into standard vision lite kit. Exterior side of louver shall be free of fasteners.
 - 4. Insect screen.
- J. Aluminum Finishes
- 1. Anodized Finish: Class I finish, 0.7 mils thick.
 - a. Clear 215 R1, AA-M10C12C22A41, Class I, 0.7 mils thick.
 - b. Champagne, AA-M10C12C22A44, Class I, 0.7 mils thick.
 - c. Light Bronze, AA-M10C12C22A44, Class I, 0.7 mils thick.
 - d. Medium Bronze, AA-M10C12C22A44, Class I, 0.7 mils thick.
 - e. Dark Bronze, AA-M10C12C22A44, Class I, 0.7 mils thick.
 - f. Black, AA-M10C12C22A44, Class I, 0.7 mils thick.
 - 2. Painted: as directed by the Owner.



1.3 EXECUTION

A. Preparation

1. Ensure openings to receive frames are plumb, level, square, and in tolerance.

B. Installation

1. Install doors in accordance with manufacturer's instructions.
2. Install doors plumb, level, square, true to line, and without warp or rack.
3. Anchor frames securely in place.
4. Separate aluminum from other metal surfaces with bituminous coatings or other means approved by the Owner.
5. Set thresholds in bed of mastic and backseal.
6. Install exterior doors to be weathertight in closed position.
7. Repair minor damages to finish in accordance with manufacturer's instructions and as approved by the Owner.
8. Remove and replace damaged components that cannot be successfully repaired as determined by the Owner.

C. Field Quality Control

1. Manufacturer's Field Services: Manufacturer's representative shall provide technical assistance and guidance for installation of doors.

D. Adjusting

1. Adjust doors, hinges, and locksets for smooth operation without binding.

E. Cleaning

1. Clean doors promptly after installation in accordance with manufacturer's instructions.
2. Do not use harsh cleaning materials or methods that would damage finish.

F. Protection

1. Protect installed doors to ensure that, except for normal weathering, doors will be without damage or deterioration at time of Final Completion.

END OF SECTION 21 24 00 00



Task	Specification	Specification Description
21 24 16 00	21 24 00 00	Fiberglass Reinforced Polyester (FRP) Flush Doors



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**SECTION 21 30 00 00 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for electric-drive, centrifugal fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. End-suction, In-line, and Split-case fire pumps.
 - b. Fire-pump accessories and specialties.
 - c. Flowmeter systems.

C. Performance Requirements

1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.2 PRODUCTS

A. General Requirements For Centrifugal Fire Pumps



1. Description: Factory-assembled and -tested fire-pump and driver unit.
2. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

B. End-Suction Fire Pumps

1. Pump:
 - a. Standard: UL 448, for end-suction pumps for fire service.
 - b. Casing: Radially split case, cast iron with ASME B16.1 pipe-flange connections.
 - c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - d. Wear Rings: Replaceable bronze.
 - e. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - 1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - 2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - f. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
3. Driver:
 - a. Standard: UL 1004A.
 - b. Type: Electric motor; NEMA MG 1, polyphase Design B.

C. In-Line Fire Pumps

1. Pump:
 - a. Standard: UL 448, for in-line pumps for fire service.
 - b. Casing: Radially split case, cast iron with ASME B16.1 pipe-flange connections.
 - c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - d. Wear Rings: Replaceable bronze.
 - e. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - 1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - 2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - f. Mounting: Pump and driver shaft is vertical, with motor above pump and pump on base.
2. Coupling: None or rigid.
3. Driver:
 - a. Standard: UL 1004A.
 - b. Type: Electric motor; NEMA MG 1, polyphase Design B.

D. Horizontally Mounted, Single-Stage, Split-Case Fire Pumps

1. Pump:
 - a. Standard: UL 448, for split-case pumps for fire service.
 - b. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
 - c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - d. Wear Rings: Replaceable bronze.
 - e. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - 1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - 2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - f. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
3. Driver:
 - a. Standard: UL 1004A.
 - b. Type: Electric motor; NEMA MG 1, polyphase Design B.



- E. Horizontally Mounted, Multistage, Split-Case Fire Pumps
1. Pump:
 - a. Standard: UL 448, for split-case pumps for fire service.
 - b. Number of Stages: Two.
 - c. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
 - d. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - e. Wear Rings: Replaceable bronze.
 - f. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - 1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - 2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - g. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
 2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
 3. Driver:
 - a. Standard: UL 1004A.
 - b. Type: Electric motor; NEMA MG 1, polyphase Design B.
- F. Vertically Mounted, Single-Stage, Split-Case Fire Pumps
1. Pump:
 - a. Standard: UL 448, for split-case pumps for fire service.
 - b. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
 - c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - d. Wear Rings: Replaceable bronze.
 - e. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - 1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - 2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - f. Mounting: Pump and driver shafts are vertical, with motor above pump and pump on base.
 2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
 3. Driver:
 - a. Standard: UL 1004A.
 - b. Type: Electric motor; NEMA MG 1, polyphase Design B.
- G. Fire-Pump Accessories And Specialties
1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.
 2. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.
 3. Relief Valves:
 - a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
 4. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.
 5. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.
 6. Discharge Cone: Closed **OR** Open, **as directed**, type.
 7. Hose Valve Manifold Assembly:
 - a. Standard: Comply with requirements in NFPA 20.
 - b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
 - c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
 - d. Automatic Drain Valve: UL 1726.
 - e. Manifold:
 - 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - 2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.



- 3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
- 4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
- 5) Escutcheon Plate: Brass or bronze; rectangular.
- 6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
- 7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, chrome plated, **as directed**.
- 8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

OR

Manifold:

- 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
- 2) Body: Exposed type, brass, with number of outlets required by NFPA 20.
- 3) Escutcheon Plate: Brass or bronze; round.
- 4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
- 5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, chrome plated, **as directed**.
- 6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

H. Flowmeter Systems

1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.
 2. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
 3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
 4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.
 - a. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.
- OR**
- Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

I. Grout

1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

J. Source Quality Control

1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
 - a. Verification of Performance: Rate fire pumps according to UL 448.
2. Fire pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation



1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
 2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.
 4. Support piping and pumps separately so weight of piping does not rest on pumps.
 5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
 6. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
 7. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
 8. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
 9. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
 10. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Alignment
1. Align end-suction and split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
 2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
 3. Align piping connections.
 4. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.
- C. Connections
1. Comply with requirements for piping and valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to pumps and equipment to allow service and maintenance.
 3. Connect relief-valve discharge to drainage piping or point of discharge.
 4. Connect flowmeter-system meters, sensors, and valves to tubing.
 5. Connect fire pumps to their controllers.
- D. Identification
1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.
- E. Field Quality Control
1. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Division 21 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps".



2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
 3. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 4. Tests and Inspections:
 - a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
 - b. Test according to NFPA 20 for acceptance and performance testing.
 - c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 5. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
 6. Prepare test and inspection reports.
 7. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to the Owner.
- F. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 21 30 00 00

**SECTION 21 30 00 00a - DIESEL-DRIVE, CENTRIFUGAL FIRE PUMPS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for diesel-drive, centrifugal fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. End-suction and Split-case fire pumps.
 - b. Fire-pump accessories and specialties.
 - c. Flowmeter systems.

C. Performance Requirements

1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For fire pumps, engine drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.2 PRODUCTS



- A. General Requirements For Centrifugal Fire Pumps
1. Description: Factory-assembled and -tested fire-pump and driver unit.
 2. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
 3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.
- B. End-Suction Fire Pumps
1. Pump:
 - a. Standard: UL 448, for end-suction pumps for fire service.
 - b. Casing: Radially split case, cast iron with ASME B16.1 pipe-flange connections.
 - c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - d. Wear Rings: Replaceable bronze.
 - e. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - 1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - 2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - f. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
 2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
 3. Driver:
 - a. Standard: UL 1247.
 - b. Type: Diesel engine.
 - c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
 - d. Engine Cooling System: Factory-installed radiator.
 - 1) Coolant: Type recommended by driver manufacturer.

OR

Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.
 - 1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
 - e. Engine-Jacket Water Heater: Factory-installed electric elements.
 - f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.
 - g. Fuel System: Comply with NFPA 20.
 - 1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.
 - h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
 - 1) Exhaust Connector: Flexible type.
 - 2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.
- C. Single-Stage, Split-Case Fire Pumps
1. Pump:
 - a. Standard: UL 448, for split-case pumps for fire service.
 - b. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
 - c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - d. Wear Rings: Replaceable bronze.
 - e. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - 1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - 2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - f. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.



2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
 3. Driver:
 - a. Standard: UL 1247.
 - b. Type: Diesel engine.
 - c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
 - d. Engine Cooling System: Factory-installed radiator.
 - 1) Coolant: Type recommended by driver manufacturer.

OR

Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.
 - 1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
 - e. Engine-Jacket Water Heater: Factory-installed electric elements.
 - f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.
 - g. Fuel System: Comply with NFPA 20.
 - 1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.
 - h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
 - 1) Exhaust Connector: Flexible type.
 - 2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.
- D. Multistage, Split-Case Fire Pumps
1. Pump:
 - a. Standard: UL 448, for split-case pumps for fire service.
 - b. Number Stages: Two.
 - c. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
 - d. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - e. Wear Rings: Replaceable bronze.
 - f. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - 1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - 2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - g. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
 2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
 3. Driver:
 - a. Standard: UL 1247.
 - b. Type: Diesel engine.
 - c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
 - d. Engine Cooling System: Factory-installed radiator.
 - 1) Coolant: Type recommended by driver manufacturer.

OR

Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.
 - 1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
 - e. Engine-Jacket Water Heater: Factory-installed electric elements.
 - f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.



- g. Fuel System: Comply with NFPA 20.
 - 1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.
 - h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
 - 1) Exhaust Connector: Flexible type.
 - 2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.
- E. Fire-Pump Accessories And Specialties
1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.
 2. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.
 3. Relief Valves:
 - a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
 4. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.
 5. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.
 6. Discharge Cone: Closed **OR** Open, **as directed**, type.
 7. Hose Valve Manifold Assembly:
 - a. Standard: Comply with requirements in NFPA 20.
 - b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
 - c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
 - d. Automatic Drain Valve: UL 1726.
 - e. Manifold:
 - 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - 2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
 - 3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
 - 4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - 5) Escutcheon Plate: Brass or bronze; rectangular.
 - 6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - 7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
 - 8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."
- OR**
- Manifold:
- 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - 2) Body: Exposed type, brass, with number of outlets required by NFPA 20.
 - 3) Escutcheon Plate: Brass or bronze; round.
 - 4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
 - 5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
 - 6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."
- F. Flowmeter Systems
1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.



2. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.
 - a. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.**OR**
Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

G. Grout

1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

H. Source Quality Control

1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
 - a. Verification of Performance: Rate fire pumps according to UL 448.
2. Fire pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation

1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.
4. Support piping and pumps separately so weight of piping does not rest on pumps.
5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
6. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
7. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
8. Install fuel system according to NFPA 20.
9. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.
10. Install exhaust-system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.



11. Install condensate-drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.
 12. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
 13. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
 14. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Alignment
1. Align end-suction and split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
 2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
 3. Align piping connections.
 4. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.
- C. Connections
1. Comply with requirements for piping and valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to pumps and equipment to allow service and maintenance.
 3. Connect relief-valve discharge to drainage piping or point of discharge.
 4. Connect flowmeter-system meters, sensors, and valves to tubing.
 5. Connect fire pumps to their controllers.
- D. Identification
1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.
- E. Field Quality Control
1. Test each fire pump with its controller as a unit. Comply with requirements for diesel-engine-driver fire-pump controllers specified in Division 21 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps".
 2. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 3. Tests and Inspections:
 - a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
 - b. Test according to NFPA 20 for acceptance and performance testing.
 - c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 4. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
 5. Prepare test and inspection reports.



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6. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to the Owner.

 - F. Startup Service
 1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.

 - G. Demonstration
 1. Train the Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 21 30 00 00a



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**SECTION 21 31 13 00 - PRESSURE-MAINTENANCE PUMPS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for pressure-maintenance pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Multistage, pressure-maintenance pumps.
 - b. Regenerative-turbine, pressure-maintenance pumps.
 - c. Submersible, pressure-maintenance pumps.
 - d. Vertical-turbine, pressure-maintenance pumps.

C. Performance Requirements

1. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For pumps, accessories, and specialties. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Field quality-control reports.
4. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.2 PRODUCTS

A. Multistage, Pressure-Maintenance Pumps

1. Description: Factory-assembled and -tested, multistage, barrel-type vertical pump as defined in HI 2.1-2.2 and HI 2.3; designed for surface installation with pump and motor direct coupled and mounted vertically.
2. Pump Construction:
 - a. Barrel: Stainless steel.
 - b. Suction and Discharge Chamber: Cast iron with flanged inlet and outlet.
 - c. Pump Head/Motor Mount: Cast iron.
 - d. Impellers: Stainless steel, balanced, and keyed to shaft.
 - e. Pump Shaft: Stainless steel.
 - f. Seal: Mechanical type with carbon rotating face and silicon-carbide stationary seat.
 - g. Intermediate Chamber Bearings: Aluminum-oxide ceramic or bronze.
 - h. Chamber-Base Bearing: Tungsten carbide.
 - i. O-Rings: EPDM or NBR.



3. Motor: Single speed with permanently lubricated ball bearings and rigidly mounted to pump head. Comply with requirements in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."
 - a. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.
 4. Nameplate: Permanently attached to pump and indicating capacity and characteristics.
- B. Regenerative-Turbine, Pressure-Maintenance Pumps
1. Description: Factory-assembled and -tested, close-coupled, single-stage, regenerative-turbine centrifugal pump as defined in HI 1.1-1.2 and HI 1.3; with pump and motor mounted horizontally.
 2. Pump Construction:
 - a. Casing: Radially split, cast iron, with threaded inlet and outlet.
 - b. Impeller: Bronze, balanced, and keyed to shaft.
 - c. Pump Shaft: Stainless steel **OR** steel, **as directed**, with deflector.
 - d. Shaft Sleeve: Bronze.
 - e. Seal: Mechanical type with spring-loaded rotating head.
 3. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."
 - a. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.
 4. Nameplate: Permanently attached to pump and indicating capacity and characteristics.
- C. Submersible, Pressure-Maintenance Pumps
1. Description: Factory-assembled and -tested, vertical, multistage, submersible pump as defined in HI 2.1-2.2 and HI 2.3; with pump motor mounted below pump.
 2. Pump Construction:
 - a. Pump Head or Elbow: Cast iron, for surface discharge, with flanged or threaded connections.
 - b. Pump Shaft: Stainless steel.
 - c. Bearings: Bronze.
 - d. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
 - e. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less, with strainer of cast or fabricated bronze or stainless steel between pump and bowl section.
 3. Motor: Single speed with permanently lubricated ball bearings and capable of continuous operation under water. Comply with requirements in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."
 - a. Power Cord: Capable of continuous under-water operation, factory-connected to motor for field connection to controller, and at least 10 feet (3 m) long.
 4. Base: Cast iron or steel with hole for electrical cable.
 5. Nameplate: Permanently attached to pump and indicating capacity and characteristics.
- D. Vertical-Turbine, Pressure-Maintenance Pumps
1. Description: Factory-assembled and -tested, vertical, multistage, open-line-shaft turbine pump as defined in HI 2.1-2.2 and HI 2.3; with pump motor mounted above pump head.
 2. Pump Construction:
 - a. Pump Head: Cast iron, for surface discharge, with flange except connections may be threaded in sizes in which flanges are not available.
 - b. Pump Head Seal: Stuffing box and stuffing.
 - c. For static water levels of 50 feet (15 m) or less and for water-lubricated bearings.
 - 1) Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
 - 2) Line Shaft Bearings: Rubber sleeve, water lubricated.
 - d. For static water levels between 50 and 200 feet (15 and 61 m) and for oil-lubricated bearings.
 - 1) Line Shaft: Steel.



- 2) Line Shaft Bearings: Corrosion resistant, oil lubricated.
 - e. Impeller Shaft: Monel metal or stainless steel.
 - f. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
 - g. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less, with strainer of cast or fabricated bronze or stainless steel at bottom.
 3. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."
 - a. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.
 4. Base: Cast iron or steel with hole for electrical cable.
 5. Nameplate: Permanently attached to pump and indicating capacity and characteristics.
- E. Motors
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."
 - a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.

1.3 EXECUTION

A. Equipment Installation

1. NFPA Standard: Comply with NFPA 20 for installation of pressure-maintenance pumps.
2. Base-Mounted Pump Mounting: Install pumps on concrete bases. Comply with requirements for concrete bases specified in Division 3 Section "Cast-in-Place Concrete."
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - e. Attach pumps to equipment base using anchor bolts.
3. Install multistage and regenerative-turbine, pressure-maintenance pumps according to HI 1.4.
4. Install submersible and vertical-turbine, pressure-maintenance pumps according to HI 2.4.

B. Field Quality Control

1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pressure-maintenance pumps will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

C. Adjusting

1. Lubricate pumps as recommended by manufacturer.



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2. Set field-adjustable pressure-switch ranges as indicated.

END OF SECTION 21 31 13 00



SECTION 21 31 13 00a - CONTROLLERS FOR FIRE-PUMP DRIVERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for controllers for fire-pump drivers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Full-service, full-voltage **OR** reduced-voltage, **as directed**, controllers rated 600 V and less.
 - b. Limited-service controllers rated 600 V and less.
 - c. Controllers for diesel-drive fire pumps.
 - d. Remote alarm panels.
 - e. Low-suction-shutdown panels.

C. Definitions

1. ATS: Automatic transfer switch(es).
2. ECM: Electronic control module.
3. MCCB: Molded-case circuit breaker.
4. N.O.: Normally open.

D. Performance Requirements

1. Seismic Performance: Fire-pump controllers and alarm panels shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For each type of product indicated. Include dimensioned plans, elevations, sections, details, and attachments to other work, including required clearances and service spaces around controller enclosures.
 - a. Show tabulations of the following:
 - 1) Each installed unit's type and details.
 - 2) Enclosure types and details for types other than NEMA 250, Type 2.
 - 3) Factory-installed devices.
 - 4) Nameplate legends.
 - 5) Short-circuit current (withstand) rating of integrated unit.
 - 6) Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
 - 7) Specified modifications.
 - b. Detail equipment assemblies and indicate dimensions, weights, loads, method of field assembly, components, and location and size of each field connection.
 - c. Schematic and Connection Diagrams: For power, signal, alarm, and control wiring and for pressure-sensing tubing.
3. Qualification Data: For qualified testing agency.
4. Seismic Qualification Certificates: For each type of product indicated, from manufacturer.



- a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Product Certificates: For each type of product indicated, from manufacturer.
 6. Manufacturer's factory test reports of fully assembled and tested equipment.
 7. Source quality-control reports.
 8. Field quality-control reports.
 9. Operation and Maintenance Data: For each type of product indicated to include in emergency, operation, and maintenance manuals. Include the following:
 - a. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 - b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor-based logic controls.
- F. Quality Assurance
1. Testing Agency Qualifications: Member company of an NRTL.
 2. Source Limitations: Obtain fire-pump controllers and all associated equipment from single source or producer.
 3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 4. Comply with standards of authorities having jurisdiction pertaining to materials and installation.
 5. Comply with NFPA 20 and NFPA 70.
 6. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."
- G. Delivery, Storage, And Handling
1. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
 2. If stored in areas subject to weather, protect controllers from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller **OR** connect factory-installed space heaters to temporary electrical service, **as directed**.
- H. Project Conditions
1. Environmental Limitations:
 - a. Ambient Temperature Rating: Not less than 40 deg F (5 deg C) and not exceeding 122 deg F (50 deg C) unless otherwise indicated.
 - b. Altitude Rating: Not exceeding 6600 feet (2010 m) unless otherwise indicated.
 2. Interruption of Existing Electric Service: Notify the Owner no fewer than seven days in advance of proposed interruption of electric service, and comply with NFPA 70E.
- I. Coordination
1. Coordinate layout and installation of controllers with other construction including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.
 2. Coordinate sizes and locations of concrete bases with actual equipment provided.



1.2 PRODUCTS

A. Full-Service Controllers

1. General Requirements for Full-Service Controllers:
 - a. Comply with NFPA 20 and UL 218.
 - b. Listed by an NRTL for electric-motor driver for fire-pump service.
 - c. Combined automatic and nonautomatic **OR** Nonautomatic, **as directed**, operation.
 - d. Factory assembled, wired, and tested; continuous-duty rated.
 - e. Service Equipment Label: NRTL labeled for use as service equipment.
2. Method of Starting:
 - a. Pressure **OR** Nonpressure, **as directed**, -switch actuated.
 - 1) Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - 2) System pressure recorder, electric ac driven, with spring backup.
 - 3) Programmable minimum-run-time relay to prevent short cycling.
 - 4) Programmable timer for weekly tests.
 - b. Magnetic Controller: Across-the-line **OR** Autotransformer **OR** Part-winding **OR** Primary-resistor **OR** Wye-delta (open transition) **OR** Wye-delta (closed transition), **as directed**, type.
OR
Solid-State Controller: Reduced-voltage type.
 - c. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.
3. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting **OR** Nonautomatic, **as directed**.
4. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.
5. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.
6. Door-Mounted Operator Interface and Controls:
 - a. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - b. Method of Control and Indication:
 - 1) Microprocessor-based logic controller, with multiline digital readout.
 - 2) Membrane keypad.
 - 3) LED alarm and status indicating lights.
 - c. Local and Remote, **as directed**, Alarm and Status Indications:
 - 1) Controller power on.
 - 2) Motor running condition.
 - 3) Loss-of-line power.
 - 4) Line-power phase reversal.
 - 5) Line-power single-phase condition.
 - d. Audible alarm, with silence push button.
 - e. Nonautomatic START and STOP push buttons or switches.
7. Optional Features:
 - a. Extra Output Contacts:
 - 1) One N.O. contact(s) for motor running condition.
 - 2) One set(s) of contacts for loss-of-line power.
 - 3) One each, Form C contacts for high and low reservoir level.
 - b. Local alarm bell.
 - c. Door-mounted thermal or impact printer for alarm and status logs.
 - d. Operator Interface Communications Ports: USB, Ethernet, and RS485.
8. ATS:
 - a. Complies with NFPA 20, UL 218, and UL 1008.



- b. Integral with controller as a listed combination fire-pump controller and power transfer switch.
- c. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
- d. Allows manual transfer from one source to the other.
- e. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
OR
Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
- f. Local and Remote, **as directed**, Alarm and Status Indications:
 - 1) Normal source available.
 - 2) Alternate source available.
 - 3) In normal position.
 - 4) In alternate position.
 - 5) Isolating means open.
- g. Audible alarm, with silence push button.
- h. Nonautomatic (manual, nonelectric) means of transfer.
- i. Engine test push button.
- j. Start generator output contacts.
- k. Timer for weekly generator tests.

B. Limited-Service Controllers

1. General Requirements for Limited-Service Controllers:
 - a. Comply with NFPA 20 and UL 218.
 - b. Listed by an NRTL for electric-motor driver for fire-pump service.
 - c. Combined automatic and nonautomatic **OR** Nonautomatic, **as directed**, operation.
 - d. Factory assembled, wired, and tested; continuous-duty rated.
 - e. Service Equipment Label: NRTL labeled for use as service equipment.
2. Method of Starting:
 - a. Pressure **OR** Nonpressure, **as directed**, -switch actuated.
 - 1) Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - 2) System pressure recorder, electric ac driven, with spring backup.
 - 3) Programmable minimum-run-time relay to prevent short cycling.
 - 4) Programmable timer for weekly tests.
 - b. Across-the-line magnetic controller.
 - c. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.
3. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting **OR** Nonautomatic, **as directed**.
4. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.
5. Method of Isolation and Overcurrent Protection: Inverse-time, nonadjustable MCCB, with an externally mounted operating handle.
6. Door-Mounted Operator Interface and Controls:
 - a. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - b. Method of Control and Indication:
 - 1) Microprocessor-based logic controller, with multiline LCD digital readout.
 - 2) Membrane keypad.



- 3) LED alarm and status indicating lights.
 - c. Local and Remote, **as directed** Alarm and Status Indications:
 - 1) Controller power on.
 - 2) Motor running condition.
 - 3) Loss-of-line power.
 - 4) Line-power phase reversal.
 - 5) Line-power single-phase condition.
 - d. Audible alarm, with silence push button.
 - e. Nonautomatic START and STOP push buttons.
 - 7. Optional Features:
 - a. Extra Output Contacts:
 - 1) One N.O. contact(s) for motor running condition.
 - 2) One set(s) of contacts for loss-of-line power.
 - 3) One each, Form C contacts for high and low reservoir level.
 - b. Local alarm bell.
 - c. Door-mounted thermal or impact printer for alarm and status logs.
 - d. Operator Interface Communications Ports: USB, Ethernet, and RS485.
 - 8. ATS:
 - a. Complies with NFPA 20, UL 218, and UL 1008.
 - b. Integral with controller as a listed combination fire-pump controller and power transfer switch.
 - c. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
 - d. Allows manual transfer from one source to the other.
 - e. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
OR
Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
 - f. Local and Remote, **as directed**, Alarm and Status Indications:
 - 1) Normal source available.
 - 2) Alternate source available.
 - 3) In normal position.
 - 4) In alternate position.
 - 5) Isolating means open.
 - g. Audible alarm, with silence push button.
 - h. Nonautomatic (manual, nonelectric) means of transfer.
 - i. Engine test push button.
 - j. Start generator output contacts.
 - k. Timer for weekly generator tests.
- C. Standalone ATS
- 1. General Requirements for Standalone ATS:
 - a. Complies with NFPA 20, UL 218, and UL 1008.
 - b. Listed by an NRTL for fire-pump service.
 - c. Automatic and nonautomatic operation.
 - d. Separate from controller and individually listed as a fire-pump-controller power transfer switch.
 - e. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
 - f. Allows manual transfer from one source to the other; factory assembled, wired, and tested.
 - 2. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at ATS location.



3. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
 4. Alternate-Source Isolating and Disconnecting Means:
 - a. Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current.
 - b. Externally mounted operating handle.
 - c. Circuit breaker provided with nonthermal sensing, instantaneous-only, short-circuit overcurrent protection.
 - d. Equipped with a voltage surge arrester.
 5. Door-Mounted Operator Interface and Controls:
 - a. Monitor, display, and control devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - b. Method of Control and Indication:
 - 1) Microprocessor-based logic controller, with multiline LCD readout.
 - 2) Membrane keypad.
 - 3) LED alarm and status indicating lights.
 - c. Local and Remote, **as directed**, Alarm and Status Indications:
 - 1) Normal source available.
 - 2) Alternate source available.
 - 3) In normal position.
 - 4) In alternate position.
 - 5) Isolating means open.
 - d. Audible alarm, with silence push button.
 - e. Nonautomatic (manual, nonelectric) means of transfer.
 - f. Engine test push button.
 - g. Start generator output contacts.
 - h. Timer for weekly generator tests
 6. Optional Features:
 - a. Extra Output Contacts:
 - 1) One each, Form A; isolating means open.
 - 2) One each, Form C; in normal or alternate position
 - b. Door-mounted thermal or impact printer for alarm and status logs.
 - c. Operator Interface Communications Ports: USB, Ethernet, and RS485.
- D. Controllers For Diesel-Drive Fire Pumps
1. General Requirements for Controllers:
 - a. Comply with NFPA 20 and UL 218.
 - b. Listed by an NRTL for diesel-engine driver for fire-pump service.
 - c. Combined automatic and nonautomatic **OR** Nonautomatic, **as directed** operation.
 - d. Factory assembled, wired, and tested.
 2. Method of Starting:
 - a. Pressure **OR** Nonpressure, **as directed**, -switch actuated.
 - 1) Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - 2) System pressure recorder, electric ac driven, with spring backup.
 - 3) Programmable minimum-run-time relay to prevent short cycling.
 - 4) Programmable timer for weekly tests.
 - b. Dual, redundant dc-voltage battery units, with automatic changeover.
 - c. Emergency Control: Bypasses all automatic control circuits during manual starting and running.
 - d. Automatic engine start on loss of ac power to the controller.
 3. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting **OR** Nonautomatic, **as directed**.
 4. Door-Mounted Operator Interface and Controls:



- a. Monitor, display, and control devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - b. Method of Control and Indication:
 - 1) Microprocessor-based logic controller, with multiline LCD readout.
 - 2) Membrane keypad.
 - 3) LED alarm and status indicating lights.
 - c. Local and Remote, **as directed**, Alarm and Status Indications:
 - 1) Controller power on.
 - 2) Engine-lubrication-system critically low oil pressure.
 - 3) Engine-jacket coolant high temperature.
 - 4) Engine fail-to-start.
 - 5) Engine overspeed shutdown.
 - 6) Low fuel level.
 - 7) Missing or failed battery.
 - 8) Battery charger failure.
 - 9) System overpressure.
 - 10) ECM selector switch in alternate ECM position.
 - 11) Fuel injector malfunction.
 - d. Audible alarm.
 - e. Nonautomatic START and STOP push buttons or switches.
 5. Optional Features:
 - a. Extra Output Contacts:
 - 1) One Form C contacts for low pump-room temperature.
 - 2) One each, Form C contacts for high and low fuel levels.
 - 3) One each, Form C contacts for high and low reservoir levels.
 - b. Door-mounted thermal or impact printer for alarm and status logs.
 - c. Operator Interface Communications Ports: USB, Ethernet, and RS485.
 - d. Powered louver contacts.
 - e. Powered engine-oil heater contacts.
 6. Battery Charger System:
 - a. Built-in, independent, dual battery chargers with automatic changeover; 12-V dc **OR** 24-V dc, **as directed**, for lead-acid **OR** nickel-cadmium, **as directed**, batteries.
 - b. Standard: UL 1236.
- E. Remote Alarm Panels
1. General Requirements for Remote Alarm Panels: Comply with NFPA 20 and UL 218; listed by an NRTL for fire-pump service.
 2. General Requirements for Remote Alarm Panels: Factory assembled, wired, and tested.
 3. Supervisory and Normal Control Voltage: 120-V ac **OR** 240-V ac, **as directed**; single **OR** dual, **as directed**, source.
 4. Audible and Visual Alarm and Status Indications:
 - a. Driver running.
 - b. Loss of phase.
 - c. Phase reversal.
 - d. Supervised power on.
 - e. Common **OR** Separate, **as directed**, trouble on the controller.
 - f. Controller connected to alternate power source.
 5. Audible and Visual Alarm and Status Indications: Manufacturer's standard indicating lights; push-to-test **OR** non-push-to-test, with separate test push button, **as directed**.
 - a. Engine running.
 - b. Controller main switch turned to the off or manual position.
 - c. Supervised power on.
 - d. Common **OR** Separate, **as directed**, trouble on the controller or engine.
 - e. Common pump room trouble.
 - f. Controller connected to alternate power source.
 6. Audible alarm, with silence push button.



7. Pump REMOTE START push button.

F. Low-Suction-Shutdown Panels

1. General Requirements for Low-Suction-Shutdown Panels:
 - a. Listed by an NRTL for fire-pump service.
 - b. Factory assembled, wired, and tested.
 - c. Prevents automatic start of fire pump, and shuts down automatically started fire pump, on low-suction pressure.
 - d. Automatic **OR** Manual, **as directed**, reset.
2. Operation: External contact input **OR** Integral pressure switch, **as directed**.
3. Supervisory and Normal Control Voltage: 120-V ac **OR** 240-V ac, **as directed**; single **OR** dual, **as directed**, source.
4. Include audible and visual alarms and status indications, with silence push button, for the following conditions:
 - a. Control power available.
 - b. Low-suction pressure.
 - c. Normal-suction pressure.

G. Enclosures

1. Fire-Pump Controllers, ATS, Remote Alarm Panels, and Low-Suction-Shutdown Panels: NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.
 - a. Indoor, Dry and Clean Locations: Type 1 (IEC IP10).
 - b. Indoor Locations Subject to Dripping Noncorrosive Liquids: Type 2 (IEC IP11).
 - c. Outdoor Locations: Type 3R (IEC IP14) **OR** Type 4 (IEC IP56) **OR** Type 4X (IEC IP56), **as directed**.
 - d. Other Wet or Damp, Indoor Locations: Type 4 (IEC IP56) **OR** Type 4X (IEC IP56), **as directed**.
 - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12 (IEC IP12).
2. Enclosure Color: Manufacturer's standard "fire-pump-controller red".
3. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.
4. Optional Features:
 - a. Floor stands, 12 inches (305 mm) high, for floor-mounted controllers.
 - b. Space heater, 120-V ac **OR** 240-V ac, **as directed**, with humidistat, **as directed**, with thermostat, **as directed**.
 - c. Tropicalization.

H. Source Quality Control

1. Testing: Test and inspect fire-pump controllers according to requirements in NFPA 20 and UL 218.
 - a. Verification of Performance: Rate controllers according to operation of functions and features specified.
2. Fire-pump controllers will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

1.3 EXECUTION

A. Examination

1. Examine areas and surfaces to receive equipment, with Installer present, for compliance with requirements and other conditions affecting performance.
2. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

**B. Controller Installation**

1. Install controllers within sight of their respective drivers.
2. Connect controllers to their dedicated pressure-sensing lines.
3. Wall-Mounting Controllers: Install controllers on walls with disconnect operating handles not higher than 79 inches (2006 mm) above finished floor, and bottom of enclosure not less than 12 inches (305 mm) above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 16 Section "Hangers and Supports for Electrical Systems."
4. Floor-Mounting Controllers: Install controllers on 4-inch (100-mm) nominal-thickness concrete bases, using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches (305 mm) above finished floor. Comply with requirements for concrete bases specified in Division 3 Section "Cast-in-Place Concrete."
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Seismic Bracing: Comply with requirements specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."
6. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
7. Comply with NEMA ICS 15.

C. Standalone ATS Installation

1. Wall-Mounting ATS: Install ATS on walls with disconnect operating handles not higher than 79 inches (2006 mm) above finished floor, and bottom of enclosure not less than 12 inches (305 mm) above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For ATS not on walls, provide freestanding racks complying with Division 16 Section "Hangers and Supports for Electrical Systems."
2. Floor-Mounting ATS: Install ATS on 4-inch (100-mm) nominal-thickness concrete bases, using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches (305 mm) above finished floor. Comply with requirements for concrete bases specified in Division 3 Section "Cast-in-Place Concrete."
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Seismic Bracing: Comply with requirements specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."
4. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Remote Alarm And Low-Suction-Shutdown, as directed, Panel Installation

1. Install panels on walls with tops not higher than 72 inches (1829 mm) above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For ATS not on walls, provide freestanding racks complying with Division 16 Section "Hangers and Supports for Electrical Systems."

E. Power Wiring Installation



1. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Division 16 Section "Conductors and Cables."
 2. Comply with NECA 1.
- F. Control And Alarm Wiring Installation
1. Install wiring between controllers and remote devices and facility's central monitoring system, **as directed**. Comply with requirements in NFPA 20, NFPA 70, and Division 16 Section "Control-Voltage Electrical Power Cables."
 2. Install wiring between remote alarm and low-suction-shutdown, **as directed**, panels and controllers. Comply with requirements in NFPA 20, NFPA 70, and Division 16 Section "Control-Voltage Electrical Power Cables."
 3. Install wiring between controllers and the building's fire-alarm system. Comply with requirements specified in Division 13 Section "Digital, Addressable Fire-Alarm System."
 4. Bundle, train, and support wiring in enclosures.
 5. Connect remote manual and automatic activation devices where applicable.
- G. Identification
1. Comply with requirements in NFPA 20 for marking fire-pump controllers.
 2. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20 and as specified in Division 16 Section "Electrical Identification."
- H. Field Quality Control
1. Perform tests and inspections.
 2. Acceptance Testing Preparation:
 - a. Inspect and Test Each Component:
 - 1) Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
 - 2) Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
 - 3) Test continuity of each circuit.
 - b. Verify and Test Each Electric-Driver Controller:
 - 1) Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for any motor, notify the Owner before starting the motor(s).
 - 2) Test each motor for proper phase rotation.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Field Acceptance Tests:
 - a. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to the Owner and authorities having jurisdiction.
 - b. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
 - c. Engage manufacturer's factory-authorized service representative to be present during the testing.
 - d. Perform field acceptance tests as outlined in NFPA 20.
 4. Controllers will be considered defective if they do not pass tests and inspections.
 5. Prepare test and inspection reports.
- I. Startup Service
1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.



- J. Adjusting
 - 1. Adjust controllers and battery charger systems, **as directed**, to function smoothly and as recommended by manufacturer.
 - 2. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.
 - 3. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Final Completion.
 - 4. Set field-adjustable pressure switches.

- K. Protection
 - 1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
 - 2. Replace controllers whose interiors have been exposed to water or other liquids prior to Final Completion.

- L. Demonstration
 - 1. Train the Owner's maintenance personnel to adjust, operate, and maintain controllers, remote alarm panels, **as directed**, low-suction-shutdown panels, **as directed**, and to use and reprogram microprocessor-based controls within this equipment, **as directed**.

END OF SECTION 21 31 13 00a



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Task	Specification	Specification Description
21 31 13 00	21 30 00 00	Electric-Drive, Centrifugal Fire Pumps
21 31 16 00	21 30 00 00a	Diesel-Drive, Centrifugal Fire Pumps
21 31 16 00	21 31 13 00	Pressure-Maintenance Pumps
21 31 16 00	21 31 13 00a	Controllers for Fire-Pump Drivers



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**SECTION 22 01 40 81 - PLUMBING FIXTURES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for plumbing fixtures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following conventional plumbing fixtures and related components:
 - a. Faucets for lavatories, bathtubs, bathtub/showers, showers, and sinks.
 - b. Laminar-flow faucet-spout outlets.
 - c. Flushometers.
 - d. Toilet seats.
 - e. Protective shielding guards.
 - f. Fixture supports.
 - g. Interceptors.
 - h. Shower receptors.
 - i. Dishwasher air-gap fittings.
 - j. Disposers.
 - k. Hot-water dispensers.
 - l. Water closets.
 - m. Urinals.
 - n. Bidets.
 - o. Lavatories.
 - p. Commercial sinks.
 - q. Shampoo bowls.
 - r. Wash fountains.
 - s. Bathtubs.
 - t. Individual showers.
 - u. Group showers.
 - v. Whirlpool bathtubs.
 - w. Kitchen sinks.
 - x. Service sinks.
 - y. Service basins.
 - z. Laundry trays.
 - aa. Sacristy sinks.

C. Definitions

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
3. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.
4. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.
5. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.
6. FRP: Fiberglass-reinforced plastic.
7. PMMA: Polymethyl methacrylate (acrylic) plastic.
8. PVC: Polyvinyl chloride plastic.



9. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

D. Submittals

1. Product Data: For each type of plumbing fixture indicated.
2. LEED Submittal:
 - a. Product Data for Credit WE 2, 3.1, and 3.2: Documentation indicating flow and water consumption requirements.
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Operation and maintenance data
5. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities" **OR** Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act", **as directed**; for plumbing fixtures for people with disabilities.
3. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
4. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
5. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
6. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
 - a. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
 - b. Plastic Bathtubs: ANSI Z124.1.
 - c. Plastic Lavatories: ANSI Z124.3.
 - d. Plastic Laundry Trays: ANSI Z124.6.
 - e. Plastic Mop-Service Basins: ANSI Z124.6.
 - f. Plastic Shower Enclosures: ANSI Z124.2.
 - g. Plastic Sinks: ANSI Z124.6.
 - h. Plastic Urinal Fixtures: ANSI Z124.9.
 - i. Plastic Whirlpool Bathtubs: ANSI Z124.1 and ASME A112.19.7M.
 - j. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
 - k. Slip-Resistant Bathing Surfaces: ASTM F 462.
 - l. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
 - m. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
 - n. Stainless-Steel Residential Sinks: ASME A112.19.3.
 - o. Vitreous-China Fixtures: ASME A112.19.2M.
 - p. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
 - q. Water-Closet, Flushometer Tank Trim: ASSE 1037.
 - r. Whirlpool Bathtub Fittings: ASME A112.19.8M.
7. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
 - a. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
 - b. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
 - c. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
 - d. Faucets: ASME A112.18.1.
 - e. Hose-Connection Vacuum Breakers: ASSE 1011.
 - f. Hose-Coupling Threads: ASME B1.20.7.
 - g. Integral, Atmospheric Vacuum Breakers: ASSE 1001.



- h. NSF Potable-Water Materials: NSF 61.
 - i. Pipe Threads: ASME B1.20.1.
 - j. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
 - k. Supply Fittings: ASME A112.18.1.
 - l. Brass Waste Fittings: ASME A112.18.2.
8. Comply with the following applicable standards and other requirements specified for bathtub, bathtub/shower, and shower faucets:
- a. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
 - b. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
 - c. Deck-Mounted Bath/Shower Transfer Valves: ASME 18.7.
 - d. Faucets: ASME A112.18.1.
 - e. Hand-Held Showers: ASSE 1014.
 - f. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
 - g. Hose-Coupling Threads: ASME B1.20.7.
 - h. Manual-Control Antiscald Faucets: ASTM F 444.
 - i. Pipe Threads: ASME B1.20.1.
 - j. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
 - k. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
 - l. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
9. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
- a. Atmospheric Vacuum Breakers: ASSE 1001.
 - b. Brass and Copper Supplies: ASME A112.18.1.
 - c. Dishwasher Air-Gap Fittings: ASSE 1021.
 - d. Manual-Operation Flushometers: ASSE 1037.
 - e. Plastic Tubular Fittings: ASTM F 409.
 - f. Brass Waste Fittings: ASME A112.18.2.
 - g. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
10. Comply with the following applicable standards and other requirements specified for miscellaneous components:
- a. Disposers: ASSE 1008 and UL 430.
 - b. Dishwasher Air-Gap Fittings: ASSE 1021.
 - c. Flexible Water Connectors: ASME A112.18.6.
 - d. Floor Drains: ASME A112.6.3.
 - e. Grab Bars: ASTM F 446.
 - f. Hose-Coupling Threads: ASME B1.20.7.
 - g. Hot-Water Dispensers: ASSE 1023 and UL 499.
 - h. Off-Floor Fixture Supports: ASME A112.6.1M.
 - i. Pipe Threads: ASME B1.20.1.
 - j. Plastic Shower Receptors: ANSI Z124.2.
 - k. Plastic Toilet Seats: ANSI Z124.5.
 - l. Supply and Drain Protective Shielding Guards: ICC A117.1.
 - m. Whirlpool Bathtub Equipment: UL 1795.

F. Warranty

1. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Commercial Applications: One **OR** Three, **as directed**, year(s) from date of Final Completion.
 - b. Warranty Period for Residential Applications of Shells: Five **OR** 20 **OR** 30, **as directed**, years from date of Final Completion.
 - c. Warranty Period for Residential Applications of Pumps and Blowers: Five **OR** 20, **as directed**, years from date of Final Completion.



- d. Warranty Period for Residential Applications of Electronic Controls: Five years from date of Final Completion.

1.2 PRODUCTS

A. Lavatory Faucets

1. Description: Single-control mixing **OR** Single-control nonmixing **OR** Two-handle mixing, **as directed**, valve. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
 - a. Body Material: Commercial, solid brass **OR** General-duty, solid brass **OR** General-duty, solid brass or copper or brass underbody with brass cover plate **OR** General-duty, copper or brass underbody with brass cover plate **OR** Residential, nonmetallic underbody with brass cover plate **OR** Residential, nonmetallic underbody with nonmetallic cover plate, **as directed**.
 - b. Finish: Polished chrome plate **OR** Polished brass **OR** Nonmetallic, **as directed**.
 - c. Maximum Flow Rate: 0.5 gpm (1.5 L/min.) **OR** 2.2 gpm (8.3 L/min.) **OR** 2.5 gpm (9.5 L/min.), **as directed**.
OR
Maximum Flow: 0.25 gal. (0.95 L).
 - d. Centers: 3-3/8 inches (86 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** Single hole **OR** Adjustable, **as directed**.
 - e. Mounting: Deck, exposed **OR** Deck, concealed **OR** Back/wall, exposed **OR** Back/wall, concealed, **as directed**.
 - f. Valve Handle(s): Lever **OR** Knob **OR** Knob, nonmetallic **OR** Cross, four arm **OR** Wrist blade, 4 inches (102 mm) **OR** Elbow, 6 inches (152 mm) **OR** Push button **OR** Not applicable, **as directed**.
 - g. Inlet(s): NPS 3/8 (DN 10) tubing, plain end **OR** NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor **OR** NPS 1/2 (DN 15) male shank **OR** NPS 1/2 (DN 15) female shank, **as directed**.
 - h. Spout: Rigid **OR** Swing **OR** Rigid, gooseneck **OR** Swivel, gooseneck, **as directed**, type.
 - i. Spout Outlet: Aerator **OR** Spray **OR** Laminar flow **OR** Plain end **OR** Spray, 0.5 gpm (1.5 L/min.), **as directed**.
 - j. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor **OR** Self-closing, metering, **as directed**.
 - k. Drain: Not required **OR** Pop up **OR** Stopper with chain **OR** Grid **OR** Lift and turn, **as directed**.
 - l. Tempering Device: Mechanical **OR** Thermostatic **OR** Pressure balance **OR** Not required, **as directed**.

B. Bathtub Faucets

1. Description: Single-control mixing **OR** Two-handle mixing **OR** Three-handle mixing **OR** Push-button, metering, nonmixing, **as directed**, valve. Include hot- and cold-water indicators and tub spout. Coordinate faucet inlets with supplies.
 - a. Body Material: Solid brass.
 - b. Finish: Polished chrome plate **OR** Polished brass, **as directed**.
 - c. Mounting: Deck **OR** Exposed, over rim **OR** Wall, **as directed**.
 - d. Valve Handle(s): Lever **OR** Knob **OR** Knob, nonmetallic **OR** Cross, four arm **OR** Not applicable, **as directed**.
 - e. Bathtub Spout: Chrome-plated brass with diverter, **as directed**.
 - f. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor, **as directed**.
 - g. Supply Connections: NPS 1/2 (DN 15) **OR** NPS 1/2 (DN 15), union **OR** Sweat, **as directed**.

C. Bathtub/Shower Faucets



1. Description: Single-handle pressure-balance **OR** thermostatic **OR** thermostatic/pressure-balance, **as directed**, valve for bathtub and for shower. Include hot- and cold-water indicators; check stops; tub spout; and shower head, arm, and flange. Coordinate faucet inlets with supplies; coordinate outlet with diverter valve.
 - a. Body Material: Solid brass with nonmetallic trim, **as directed**.
 - b. Finish: Polished chrome plate **OR** Polished brass, **as directed**.
 - c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
 - d. Diverter Valve: Integral **OR** Not integral, **as directed**, with mixing valve.
 - e. Mounting: Wall.
 - f. Bathtub Spout: Chrome-plated brass with diverter, **as directed**.
 - g. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor, **as directed**.
 - h. Antiscald Device: Integral with mixing valve **OR** Separate unit, **as directed**.
 - i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
 - j. Supply Connections: NPS 1/2 (DN 15) **OR** NPS 1/2 (DN 15), union **OR** Sweat, **as directed**.
 - k. Backflow Protection Device for Hand-Held Shower: Required **OR** Not required, **as directed**.
 - l. Shower Head Type: Ball joint **OR** Without ball joint **OR** Ball joint and head integral with mounting flange **OR** Integral with mounting flange **OR** Hand held, slide-bar mounted **OR** Hand held, hook mounted, **as directed**.
 - m. Shower Head Material: Metallic **OR** Nonmetallic **OR** Combined, metallic and nonmetallic, **as directed**, with chrome-plated finish.
 - n. Spray Pattern: Fixed **OR** Adjustable, **as directed**.
 - o. Integral Volume Control: Required **OR** Not required, **as directed**.
 - p. Shower-Arm Flow-Control Fitting: Not required **OR** 1.5 gpm (5.7 L/min.) **OR** 2.0 gpm (7.6 L/min.), **as directed**.
- D. Shower Faucets
 1. Description: Single-handle pressure-balance **OR** thermostatic **OR** thermostatic and pressure-balance, **as directed**, valve. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies and outlet with diverter valve.
 - a. Body Material: Solid brass with nonmetallic trim, **as directed**.
 - b. Finish: Polished chrome plate **OR** Polished brass, **as directed**.
 - c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
 - d. Diverter Valve: Not required **OR** Integral with mixing valve **OR** Not integral with mixing valve, **as directed**.
 - e. Mounting: Exposed **OR** Concealed, **as directed**.
 - f. Backflow Protection Device for Hand-Held Shower: Required **OR** Not required, **as directed**.
 - g. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor, **as directed**.
 - h. Antiscald Device: Integral with mixing valve **OR** Separate unit **OR** Not required, **as directed**.
 - i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
 - j. Supply Connections: NPS 1/2 (DN 15) **OR** NPS 1/2 (DN 15), union **OR** Sweat, **as directed**.
 - k. Shower Head Type: Ball joint **OR** Without ball joint **OR** Ball joint and head integral with mounting flange **OR** Integral with mounting flange **OR** Hand held, slide-bar mounted **OR** Hand held, hook mounted, **as directed**.
 - l. Shower Head Material: Metallic **OR** Nonmetallic **OR** Combined, metallic and nonmetallic, **as directed**, with chrome-plated finish.
 - m. Spray Pattern: Fixed **OR** Adjustable, **as directed**.
 - n. Integral Volume Control: Required **OR** Not required, **as directed**.
 - o. Shower-Arm Flow-Control Fitting: Not required **OR** 1.5 gpm (5.7 L/min.) **OR** 2.0 gpm (7.6 L/min.), **as directed**.



- p. Temperature Indicator: Not required **OR** Integral with faucet, **as directed**.

E. Sink Faucets

1. Description: Kitchen faucet with spray, three-hole fixture **OR** Kitchen faucet with spray, four-hole fixture **OR** Kitchen faucet without spray **OR** Laundry tray faucet **OR** Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook **OR** Bar sink faucet, **as directed**. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
 - a. Body Material: Commercial, solid brass **OR** General-duty, solid brass **OR** General-duty, solid brass or copper or brass underbody with brass cover plate **OR** General-duty, copper or brass underbody with brass cover plate **OR** Residential, nonmetallic underbody with brass cover plate **OR** Residential, nonmetallic underbody with nonmetallic cover plate, **as directed**.
 - b. Finish: Polished chrome plate **OR** Polished brass **OR** Nonmetallic **OR** Polished or rough brass **OR** Rough brass, **as directed**.
 - c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
 - d. Mixing Valve: Single control **OR** Two-lever handle, **as directed**.
 - e. Backflow Protection Device for Hose Outlet: Required **OR** Not required, **as directed**.
 - f. Backflow Protection Device for Side Spray: Required **OR** Not required, **as directed**.
 - g. Centers: 3-3/8 inches (86 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** Single hole **OR** Adjustable, **as directed**.
 - h. Mounting: Deck **OR** Back/wall, **as directed**, exposed **OR** concealed, **as directed**.
 - i. Handle(s): Lever **OR** Knob **OR** Knob, nonmetallic **OR** Cross, four arm **OR** Wrist blade, 4 inches (102 mm) **OR** Elbow, 6 inches (152 mm) **OR** Not applicable, **as directed**.
 - j. Inlet(s): NPS 3/8 (DN 10) plain-end tubing **OR** NPS 3/8 (DN 10) tubing with NPS 1/2 (DN 15) male adapter **OR** NPS 1/2 (DN 15) male shank **OR** NPS 1/2 (DN 15) female shank, **as directed**.
 - k. Spout Type: Rigid, solid brass **OR** Rigid, solid brass with wall brace **OR** Swing, round tubular **OR** Swing, shaped tube **OR** Swing, solid brass **OR** Rigid gooseneck **OR** Swivel gooseneck, **as directed**.
 - l. Spout Outlet: Aerator **OR** Swivel aerator/spray **OR** Spray **OR** Laminar flow **OR** Hose thread **OR** Plain end, **as directed**.
 - m. Vacuum Breaker: Required **OR** Not required, **as directed**.
 - n. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor, **as directed**.
 - o. Drain: Not required **OR** Pop up **OR** Stopper with chain **OR** Grid **OR** Lift and turn, **as directed**.

F. Laminar-Flow Faucet-Spout Outlets

1. Description: Chrome-plated-brass faucet-spout outlet that produces non-aerating, laminar stream. Include male or female thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

G. Flushometers

1. Description: Flushometer for urinal-type **OR** water-closet-type, **as directed**, fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, **as directed**, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.
 - a. Internal Design: Diaphragm **OR** Piston, **as directed**, operation.
 - b. Style: Exposed **OR** Concealed, **as directed**.
 - c. Inlet Size: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**.
 - d. Trip Mechanism: Oscillating, lever-handle actuator **OR** Mechanical, push-button actuator with stainless-steel access plate **OR** Hydraulic, push-button actuator **OR** Foot-pedal actuator **OR** Hard-wired, electric-sensor actuator **OR** Battery-operated sensor actuator, **as directed**.



- e. Consumption: 0.5 gal./flush (1.9 L/flush) **OR** 1.0 gal./flush (3.8 L/flush) **OR** 1.5 gal./flush (5.7 L/flush) **OR** 1.6 gal./flush (6.0 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
 - f. Tailpiece Size: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, and standard, **as directed**, length to top of bowl.
- H. Toilet Seats
- 1. Description: Toilet seat for water-closet-type fixture.
 - a. Material: Molded, solid plastic with antimicrobial agent, **as directed**.
 - b. Configuration: Closed **OR** Open, **as directed**, front with **OR** without, **as directed**, cover.
 - c. Size: Elongated **OR** Regular, **as directed**.
 - d. Hinge Type: CK, check **OR** SS, self-sustaining **OR** SC, self-sustaining, check **OR** SR, self-raising, **as directed**.
 - e. Class: Residential **OR** Standard commercial **OR** Heavy-duty commercial, **as directed**.
 - f. Color: White **OR** Black, **as directed**.
- I. Protective Shielding Guards
- 1. Protective Shielding Pipe Covers:
 - a. Description: Manufactured plastic wraps for covering plumbing fixture hot-water supply **OR** hot- and cold-water supplies, **as directed**, and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
 - 2. Protective Shielding Piping Enclosures:
 - a. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.
- J. Fixture Supports
- 1. Water-Closet Supports:
 - a. Description: Combination carrier designed for accessible **OR** standard, **as directed**, mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
 - 2. Urinal Supports:
 - a. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture **OR** Type II, urinal carrier with hanger and bearing plates, **as directed**, for wall-mounting, urinal-type fixture. Include steel uprights with feet.
 - b. Accessible-Fixture Support: Include rectangular steel uprights.
 - 3. Lavatory Supports:
 - a. Description: Type I, lavatory carrier with exposed arms and tie rods **OR** Type II, lavatory carrier with concealed arms and tie rod **OR** Type III, lavatory carrier with hanger plate and tie rod, **as directed**, for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
 - b. Accessible-Fixture Support: Include rectangular steel uprights.
 - 4. Sink Supports:
 - a. Description: Type I, sink carrier with exposed arms and tie rods **OR** Type II, sink carrier with hanger plate, bearing studs, and tie rod **OR** Type III, sink carrier with hanger plate and exposed arms, **as directed**, for sink-type fixture. Include steel uprights with feet.
- K. Interceptors
- 1. Hair Interceptors:
 - a. Description: Manufactured unit with removable screen or strainer and removable cover; designed to trap and retain hair.
 - 1) Material: Brass **OR** Stainless-steel, **as directed**, body.
 - 2) Pipe Connections: NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**.
 - 2. Sediment Interceptors:



- a. Description: Manufactured unit with removable screens or strainer and removable cover; designed to trap and retain waste material.
- 1) Material: Cast-iron or steel body with acid-resistant lining and coating **OR** Carbon-steel body with acid-resistant lining and coating **OR** Stainless-steel, **as directed**.
 - 2) Pipe Connections: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**.
- L. Shower Receptors
1. Description: Cast-polymer **OR** FRP **OR** PMMA **OR** Precast-terrazzo **OR** Solid-surface, **as directed**, base for built-up-type shower fixture.
 - 1) Type: Standard, residential **OR** Handicapped/wheelchair, **as directed**.
 - 2) Size: 32 by 32 inches (813 by 813 mm) **OR** 36 by 36 inches (914 by 914 mm) **OR** 32 by 42 inches (813 by 1067 mm) **OR** 48 by 60 inches (1219 by 1524 mm), **as directed**.
 - 3) Color: White.
 - 4) Outlet: Cast-in-floor drain **OR** Drain, **as directed**, with NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, outlet.
- M. Dishwasher Air-Gap Fittings
1. Description: Fitting suitable for use with domestic dishwashers and for deck mounting; with plastic body, chrome-plated brass cover, **as directed**; and capacity of at least 5 gpm (0.32 L/s); and inlet pressure of at least 5 psig (35 kPa) at a temperature of at least 140 deg F (60 deg C). Include 5/8-inch- (16-mm-) ID inlet and 7/8-inch- (22-mm-) ID outlet hose connections.
 2. Hoses: Rubber and suitable for temperature of at least 140 deg F (60 deg C).
 - a. Inlet Hose: 5/8-inch (16-mm) ID and 48 inches (1219 mm) long.
 - b. Outlet Hose: 7/8-inch (22-mm) ID and 48 inches (1219 mm) long.
- N. Disposers
1. Description: Batch-feed **OR** Continuous-feed, **as directed**, household, food-waste disposer. Include reset button; wall switch; corrosion-resistant chamber with jam-resistant, cutlery- or stainless-steel grinder or shredder; NPS 1-1/2 (DN 40) outlet; quick-mounting, stainless-steel sink flange; antisplash guard; and combination cover/stopper.
 - a. Type: Batch-feed **OR** Continuous-feed, **as directed**, household.
 - b. Model: Not applicable **OR** Sound-insulated chamber **OR** Sound-insulated chamber and stainless-steel outer shell, **as directed**.
 - c. Motor: 115-V ac, 1725 rpm, 1/3 **OR** 1/2 **OR** 3/4 **OR** 1, **as directed**, hp with overload protection.
- O. Hot-Water Dispensers
1. Description: Gooseneck spout with lever-handle **OR** Spout with twist-knob or push-button, **as directed**, flow control, household-type dispenser with instant on-off control; insulated, corrosion-resistant-metal storage tank that is open to atmosphere; electric heating element; chrome-plated faucet or spout; removable strainer; thermostat control for water temperature up to 190 deg F (88 deg C); and thermal-overload protection.
 - a. Storage Tank Capacity: 0.5 gal. (1.5 L).
 - b. Heating Element: 750 W minimum, 115-V ac.
- P. Water Closets
1. Water Closets, Wall-Mounting, Back-Outlet Type:
 - a. Description Accessible, wall-mounting **OR** Wall-mounting, **as directed**, back-outlet, vitreous-china fixture designed for flushometer-tank **OR** gravity-type tank **OR** flushometer valve, **as directed**, operation.
 - 1) Style: Close coupled **OR** One piece, **as directed**.
 - a) Bowl Type: Elongated **OR** Round front, **as directed**, with siphon-jet design.
 - b) Design Consumption: 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.



- c) Tank: Gravity type with trim **OR** Flushometer-tank type with trim and pressurized tank, **as directed**. Include cover.
 - d) Trip Mechanism: Lever-handle **OR** Push-button, **as directed**, actuator.
 - e) Color: White.
 - 2) Supply: NPS 1/2 (DN 15) chrome-plated brass or copper with wheel-handle **OR** screwdriver **OR** loose-key, **as directed**, stop.
 - 3) Style: Flushometer valve.
 - a) Bowl Type: Elongated **OR** Round front, **as directed**, with siphon-jet **OR** blowout, **as directed**, design.
 - b) Design Consumption: 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
 - c) Color: White.
 - 4) Fixture Support: Water-closet support <Insert designation> combination carrier.
 - 2. Water Closets, Floor-Mounting, Floor-Outlet Type:
 - a. Description: Accessible, floor-mounting **OR** Floor-mounting, **as directed**, floor-outlet, vitreous-china fixture designed for gravity-type tank **OR** flushometer tank **OR** flushometer valve, **as directed**, operation.
 - 1) Style: Close coupled **OR** One piece, **as directed**.
 - a) Bowl Type: Elongated **OR** Round front, **as directed**, with siphon-jet design. Include bolt caps matching fixture.
 - b) Height: Standard **OR** Accessible **OR** Juvenile **OR** Child, **as directed**.
 - c) Design Consumption: 1 gal./flush (3.8 L/flush) **OR** 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
 - d) Tank: Gravity type with trim **OR** Flushometer-tank type with trim and pressurized tank, **as directed**. Include cover.
 - e) Trip Mechanism: Lever-handle **OR** Push-button, **as directed**, actuator.
 - f) Color: White.
 - 2) Supply: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated brass or copper with wheel-handle **OR** screwdriver **OR** loose-key, **as directed**, stop.
 - 3) Style: Flushometer valve.
 - a) Bowl Type: Elongated **OR** Round front, **as directed**, with siphon-jet **OR** reverse-trap **OR** blowout **OR** siphon-vortex **OR** siphon-wash **OR** washdown, **as directed**, design. Include bolt caps matching fixture.
 - b) Height: Standard **OR** Accessible **OR** Juvenile **OR** Child, **as directed**.
 - c) Design Consumption: 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
 - d) Color: White.
 - a. Description: Accessible, floor-mounting **OR** Floor-mounting, **as directed**, back-outlet, vitreous-china fixture designed for gravity-tank **OR** flushometer-tank **OR** flushometer-valve, **as directed**, operation.
 - 1) Style: Close coupled.
 - a) Bowl Type: Elongated with siphon-jet design. Include bolt caps matching fixture.
 - b) Height: Standard **OR** Accessible, **as directed**.
 - c) Design Consumption: 1.6 gal./flush (6 L/flush).
 - d) Tank: Gravity type with trim. Include cover.
 - e) Trip Mechanism: Lever-handle actuator.
 - f) Color: White.
 - 2) Supply: NPS 1/2 (DN 15) chrome-plated brass or copper with wheel-handle **OR** screwdriver **OR** loose-key, **as directed**, stop.
 - 3) Style: Flushometer valve.
 - a) Bowl Type: Elongated with siphon-jet design. Include bolt caps matching fixture.
 - b) Height: Standard **OR** Accessible, **as directed**.



- c) Design Consumption: 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
- d) Color: White.
- 4) Wall Support: Manufactured waste fitting with seal and fixture bolts.

Q. Urinals

1. Urinals, Wall-Mounting, Back-Outlet Type:
 - a. Description: Accessible, wall-mounting **OR** Wall-mounting, **as directed**, back-outlet, vitreous-china fixture designed for flushometer valve operation.
 - 1) Type: Blowout **OR** Siphon jet **OR** Blowout with extended shields **OR** Siphon jet with extended shields **OR** Washout with extended shields, **as directed**.
 - 2) Strainer or Trapway: Integral cast strainer **OR** Separate removable strainer **OR** Open trapway, **as directed**, with integral trap.
 - 3) Design Consumption: 0.5 gal./flush (1.9 L/flush) **OR** 1 gal./flush (3.8 L/flush) **OR** 1.5 gal./flush (5.7 L/flush), **as directed**.
 - 4) Color: White.
 - 5) Supply Spud Size: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**.
 - 6) Outlet Size: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**.
 - 7) Fixture Support: Urinal chair carrier.
2. Urinals, Wall-Mounting, Bottom-Outlet Type:
 - a. Description: Accessible, wall-mounting **OR** Wall-mounting, **as directed**, bottom-outlet, vitreous-china fixture designed for flushometer valve operation.
 - 1) Type: Washout **OR** Washdown, **as directed**.
 - 2) Strainer or Trapway: Integral cast strainer **OR** Separate removable strainer **OR** Open trapway, **as directed**.
 - 3) Design Consumption: 0.5 gal./flush (1.9 L/flush) **OR** 1 gal./flush (3.8 L/flush), **as directed**.
 - 4) Color: White.
 - 5) Supply Spud Size: NPS 3/4 (DN 20).
 - 6) Outlet Size: NPS 1-1/2 (DN 40).
 - 7) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.
 - 8) Flushing Device: Fixture manufacturer's standard matching fixture.
 - 9) Flushometer: **As directed**.
 - 10) Fixture Support: Urinal chair carrier.
3. Urinals, Stall-Type, Bottom-Outlet:
 - a. Description Stall-type, bottom-outlet, vitreous-china fixture designed for flushometer valve operation.
4. Urinals, Wall-Mounting, Bottom-Outlet, Trough-Type:
 - a. Description: Wall-mounting, bottom-outlet, trough-type, enameled, cast-iron fixture modified for flushometer valve operation.
 - 1) Style: Similar to wash sink with back and without pedestal.
 - 2) Size: 36 inches (915 mm) **OR** 48 inches (1219 mm) **OR** 60 inches (1525 mm) **OR** 72 inches (1830 mm), **as directed**.
 - 3) Color: White.
 - 4) Drain: Separate removable dome strainer.
 - 5) Design Consumption: Not applicable.
 - 6) Supply: NPS 1/2 (DN 15).
 - 7) Outlet Size: NPS 1-1/2 (DN 40).
 - 8) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.
 - 9) Flushing Device: Fixture manufacturer's standard, with washdown pipe, matching fixture.



- 10) Fixture Support: Sink chair carrier.
5. Urinals, Wall-Mounting, Back-Outlet Dry Type:
 - a. Description Accessible, wall-mounting **OR** Wall-mounting, **as directed**, back-outlet dry, plastic **OR** vitreous-china, **as directed**, fixture designed for liquid-trap-seal operation.
 - 1) Type: Without water supply.
 - 2) Trap-Seal Method: Proprietary cartridge or trap system.
 - 3) Color: White.
 - 4) Outlet Size: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**. Include transition coupling, if required.
 - 5) Trap-Sealing Liquid: Proprietary.
 - 6) Fixture Support: Urinal chair carrier.
- R. Bidets
 1. Description: Floor-mounting, vitreous-china fixture with fittings.
 - a. Type: With spray **OR** flushing rim **OR** spray and flushing rim, **as directed**, and overflow. Include bolt caps matching fixture.
 - b. Faucet Hole Punching: One **OR** Two **OR** Three **OR** Four **OR** No, **as directed**, hole(s).
 - c. Color: White.
 - d. Faucet: Fixture manufacturer's standard, or two-valve supply, provided by fixture supplier, with vacuum breaker, diverter, submerged spray, **OR** over-rim filling, **as directed**, pop-up waste, and chrome-plated finish.
 - e. Supplies: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated copper with stops.
 - f. Drain Piping: NPS 1-1/4 (DN 32) chrome-plated, cast-brass P-trap; 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.
- S. Lavatories
 1. Lavatories, Wall-Mounting Type:
 - a. Description: Accessible, wall-mounting **OR** Wall-mounting **OR** Wall-and-pedestal-mounting, **as directed**, enameled, cast-iron **OR** vitreous-china, **as directed**, fixture.
 - 1) Type: With back **OR** Ledge back **OR** Shelf back **OR** Slab **OR** Pedestal, **as directed**.
 - 2) Size: 18 by 15 inches (457 by 381 mm) **OR** 19 by 16 inches (483 by 406 mm) **OR** 20 by 18 inches (508 by 457 mm) **OR** 24 by 20 inches (610 by 508 mm), **as directed**, rectangular.
 - 3) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.
 - 4) Faucet Hole Location: Top **OR** Front wall **OR** Inclined panel, **as directed**.
 - 5) Pedestal: Not required **OR** Required, **as directed**.
 - 6) Color: White.
 - 7) Faucet: Lavatory with pop-up waste **OR** for separate drain, **as directed**.
 - 8) Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
 - 9) Drain: See faucet **OR** Grid **OR** Grid with offset waste, **as directed**.
 - a) Location: Not applicable **OR** Near back of bowl, **as directed**.
 - 10) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, tubular waste to wall; and wall escutcheon.
 - a) Exception: Omit P-trap if hair interceptor is required.
 - 11) Hair Interceptor: Not required.
 - 12) Protective Shielding Guard(s): **As directed**.



- 13) Fixture Support: Lavatory.
2. Lavatories, Counter-Mounting Type:
- a. Description: Accessible **OR** Counter-mounting **OR** Undercounter-mounting, **as directed**, enameled, cast-iron **OR** FRP **OR** PMMA **OR** porcelain-enameled, formed-steel **OR** solid-surface **OR** stainless-steel **OR** vitreous-china, **as directed** fixture.
- 1) Type: Flat rim with ledge **OR** Self-rimming, **as directed**.
 - 2) Rectangular Lavatory Size: 18 by 15 inches (457 by 381 mm) **OR** 19 by 16 inches (483 by 406 mm) **OR** 20 by 18 inches (508 by 457 mm) **OR** 24 by 20 inches (610 by 508 mm), **as directed**.
 - 3) Oval Lavatory Size: 19 by 16 inches (483 by 406 mm) **OR** 20 by 17 inches (508 by 432 mm), **as directed**.
 - 4) Round Lavatory Size: 18 inches (457 mm) **OR** 19 inches (483 mm), **as directed**, in diameter.
 - 5) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.
 - 6) Faucet Hole Location: Top **OR** Front wall **OR** Inclined panel, **as directed**.
 - 7) Color: White.
 - 8) Faucet: Lavatory with pop-up waste **OR** for separate drain, **as directed**.
 - 9) Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
 - 10) Drain: See faucet **OR** Grid **OR** Grid with offset waste, **as directed**.
 - a) Location: Not applicable **OR** Near back of bowl, **as directed**.
 - 11) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.

OR

 Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, tubular waste to wall; and wall escutcheon.
 - a) Exception: Omit P-trap if hair interceptor is required.
 - 12) Hair Interceptor: Not required.
 - 13) Protective Shielding Guard(s): **As directed**.
3. Lavatories, Countertop With Integral Bowl Type:
- a. Description: Countertop **OR** Accessible countertop, **as directed**, with integral bowl fixtures for mounting on base unit.
- 1) Backsplash: Integral with countertop **OR** Separate, same material as countertop **OR** Not required, **as directed**.
 - 2) Overall Rectangular Top Size: 25 by 17 inches (635 by 432 mm) **OR** 31 by 19 inches (787 by 483 mm) **OR** 49 by 22 inches (1245 by 559 mm) **OR** 73 by 22 inches (1854 by 559 mm), **as directed**, with 1 **OR** 2 **OR** 3 **OR** 4, **as directed**, bowl(s).
 - a) Bowl Size: Oval 19 by 16 inches (483 by 406 mm) **OR** 20 by 17 inches (508 by 432 mm), **as directed**.
 - 3) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.
 - 4) Faucet Hole Location: Countertop.
 - 5) Color: White.
 - 6) Faucet(s): Lavatory with pop-up waste **OR** with separate drain, **as directed**, for each bowl.
 - 7) Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
 - 8) Drain(s): See faucets **OR** Grid **OR** Grid with offset waste, **as directed**.
 - a) Location: Not applicable **OR** Near back of bowl, **as directed**.
 - 9) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.



- OR**
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, tubular waste to wall; and wall escutcheon.
- 10) Hair Interceptor(s): **As directed** for bowls as indicated.
 - 11) Protective Shielding Guard(s): **As directed** for bowls as indicated.
4. Lavatories, For Wheelchair-Bound Persons:
- a. Description: Accessible, wall-mounting, vitreous-china fixture designed for people in wheelchairs.
 - 1) Type: Ledge back **OR** Shelf back **OR** Slab, **as directed**.
 - 2) Size: 20 by 26 inches (508 by 660 mm) minimum; rectangular.
 - 3) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers **OR** Three holes, 8-inch (203-mm) centers **OR** Three holes, 12-inch (305-mm) centers, **as directed**.
 - 4) Color: White.
 - 5) Faucet: Lavatory for separate drain.
 - 6) Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
 - 7) Drain: Grid **OR** Grid with offset waste, **as directed**.
 - 8) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.

OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, tubular waste to wall; and wall escutcheon.
 - 9) Fixture Support: Lavatory.
- T. Commercial Sinks
1. Commercial Sinks, Counter-Mounting Type:
 - a. Description: One-compartment **OR** Two-compartment **OR** Three-compartment, **as directed**, counter-mounting, stainless-steel commercial sink with backsplash.
 - 1) Metal Thickness: 0.050 inch (1.3 mm).
 - 2) Compartment (for single-compartment sink):
 - a) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain **OR** Grid with NPS 2 (DN 50) tailpiece and twist drain **OR** NPS 1-1/2 (DN 40) tailpiece with stopper **OR** NPS 1-1/2 (DN 40) tailpiece with pop-up waste, **as directed**.
 - i. Location: Centered in compartment **OR** Near back of compartment **OR** Near left side of compartment **OR** Near right side of compartment, **as directed**.
 - 3) Each Compartment (for multiple-compartment sink):
 - a) Drains: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain **OR** Grid with NPS 2 (DN 50) tailpiece and twist drain **OR** NPS 1-1/2 (DN 40) tailpiece with stopper **OR** NPS 1-1/2 (DN 40) tailpiece with pop-up waste, **as directed**.
 - i. Location: Centered in compartment **OR** Near back of compartment, **as directed**.
 - 4) Faucet(s): Sink.
 - a) Number Required: One **OR** Two, **as directed**.
 - b) Mounting: Deck.
 - 5) Supplies: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**, chrome-plated copper with stops or shutoff valves.
 - 6) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass **OR** copper pipe, **as directed**, waste to wall; continuous waste, **as directed**; and wall escutcheon(s).
 2. Commercial Sinks, Freestanding Type:



- a. Description: One-compartment **OR** Two-compartment **OR** Three-compartment, **as directed**, freestanding, stainless-steel commercial sink with backsplash.
- 1) Metal Thickness: 0.050 inch (1.3 mm) **OR** 0.063 inch (1.6 mm), **as directed**.
 - 2) Compartment (for single-compartment sink):
 - a) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain **OR** Grid with NPS 2 (DN 50) tailpiece and twist drain **OR** NPS 1-1/2 (DN 40) tailpiece with stopper **OR** NPS 1-1/2 (DN 40) tailpiece with pop-up waste, **as directed**.
 - i. Location: Centered in compartment **OR** Near back of compartment **OR** Near left side of compartment **OR** Near right side of compartment, **as directed**.
 - 3) Each Compartment (for multiple-compartment sink):
 - a) Drains: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain **OR** Grid with NPS 2 (DN 50) tailpiece and twist drain **OR** NPS 1-1/2 (DN 40) tailpiece with stopper **OR** NPS 1-1/2 (DN 40) tailpiece with pop-up waste, **as directed**.
 - i. Location: Centered in compartment **OR** Near back of compartment, **as directed**.
 - 4) Drainboard(s): Not required **OR** Both **OR** Left **OR** Right, **as directed**, side(s).
 - a) Dimensions Each: Not applicable.
 - 5) Supports: Adjustable-length, steel legs.
 - 6) Faucet(s): Sink.
 - a) Number Required: One **OR** Two, **as directed**.
 - b) Mounting: In backsplash.
 - 7) Supplies: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**, chrome-plated copper with stops or shutoff valves.
 - 8) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass **OR** copper pipe, **as directed**, waste to wall; continuous waste, **as directed**; and wall escutcheon(s).
3. Commercial Sinks, Handwash Type:
- a. Description: Wall-mounting, stainless-steel, commercial, handwash-sink fixture.
- 1) Type: Basin with radius corners, back for faucet, and support brackets.
 - 2) Size; Approximately 17 by 16 by 5 inches (432 by 406 by 127 mm).
 - 3) Faucet: Back-mounting, chrome-plated, solid-brass, gooseneck type with individual valves.
 - 4) Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
 - 5) Drain: Grid.
 - 6) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.
 - 7) Fixture Support: Sink for wall-mounting installation.

U. Shampoo Bowls

1. Description: Enameled, cast-iron **OR** PMMA, **as directed**, fixture shaped for head rest. Include vacuum breaker, faucet, hose and spray, drain, and mounting brackets.
 - a. Color: White.
 - b. Supplies: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated copper with stops.
 - c. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.

OR

 Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap; tubular waste to wall; and wall escutcheon.
 - d. Hair Interceptor: **As directed**
 - e. Fixture Support for Counter Mounting: Brackets or forms.

OR

 Fixture Support for Wall Mounting: Sink.



V. Wash Fountains

1. Wash Fountains, Freestanding Type:
 - a. Description: Accessible, Circular, freestanding-design, wash-up fixture.
 - 1) Arrangement: Wash-up stations facing central spray head.
 - 2) Receptor Material: Precast terrazzo **OR** Stainless steel **OR** Solid surface, **as directed**, on base.
 - 3) Receptor Color or Finish: Not applicable.
 - 4) Size: 36- to 39-inch (914- to 990-mm) **OR** 54-inch (1370-mm), **as directed**, diameter.
 - 5) Number of Stations: Two **OR** Three **OR** Four **OR** Five **OR** Six **OR** Eight, **as directed**.
 - 6) Control: Collective **OR** Individual, **as directed**, push-button **OR** foot-pedal **OR** sensor, **as directed**, actuation with thermostatic valve and check stops or field-installed check valves.
 - 7) Liquid Soap Dispensers: Manual **OR** Sensor, **as directed**, for each station.
 - 8) Mounting: Floor.
 - 9) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves from bottom **OR** top, **as directed**.
 - 10) Shroud: Not required **OR** Stainless steel of size to cover supplies and vent piping, **as directed**.
 - 11) Drain: Grid with NPS 2 (DN 50) tailpiece.
 - 12) Trap Fitting: Not required **OR** NPS 2 (DN 50) trap with waste and vent connections, **as directed**.
 - 13) Drain Piping: NPS 1-1/2 (DN 40), **OR** NPS 2 (DN 50), **as directed**, waste to floor.
 - 14) Vent Piping: Not required **OR** NPS 1-1/2 (DN 40) to ceiling, **as directed**.
2. Wash Fountains, Semicircular Or Corner Type:
 - a. Description: Accessible, Semicircular **OR** Corner, **as directed**, design, wash-up fixture.
 - 1) Arrangement: Wash-up stations facing central spray head.
 - 2) Receptor Material: Precast terrazzo **OR** Stainless steel **OR** Solid surface, **as directed**, on base.
 - 3) Receptor Color or Finish: Not applicable.
 - 4) Size: 36- to 39-inch (914- to 990-mm) **OR** 54-inch (1370-mm), **as directed**, diameter.
 - 5) Number of Stations: Two **OR** Three **OR** Four, **as directed**.
 - 6) Control: Collective **OR** Individual, **as directed**, push-button **OR** foot-pedal **OR** sensor, **as directed**, actuation with thermostatic valve and check stops or field-installed check valves.
 - 7) Liquid Soap Dispensers: Manual **OR** Sensor, **as directed**, for each station.
 - 8) Mounting: Floor and flush-to-wall with wall bracket.
 - 9) Supplies: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**, copper tubing with ball, gate, or globe valves.
 - 10) Drain: Grid with NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, tailpiece.
 - 11) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, P-trap, waste to wall, and wall flange.
3. Wash Fountains, Wall-Mounting Type:
 - a. Description: Accessible, **as directed**, Flush-to-wall, **as directed**, linear design, wash-up fixture.
 - 1) Arrangement: Wash-up stations facing spray heads.
 - 2) Receptor Material: Precast terrazzo **OR** Stainless steel **OR** Solid surface, **as directed**, on base.
 - 3) Receptor Color or Finish: Not applicable.
 - 4) Number of Stations: One **OR** Two **OR** Three **OR** Four, **as directed**.
 - 5) Control: Collective **OR** Individual, **as directed**, push-button **OR** sensor, **as directed**, actuation with thermostatic valve and check stops or field-installed check valves.
 - 6) Liquid Soap Dispensers: Manual **OR** Sensor, **as directed**, for each station.



- 7) Mounting: Floor mounting with bracket for attaching to wall.
- 8) Faucet(s): Push-button **OR** Sensor-actuated, **as directed**, mixing valve with check stops.
- 9) Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves.
- 10) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece.
- 11) Drain Piping: NPS 1-1/2 (DN 40) P-trap, waste to wall, and wall flange.

W. Bathtubs

1. Description: Enameled, cast-iron **OR** FRP **OR** PMMA **OR** Porcelain-enameled, formed-steel, **as directed**, fixture.
 - a. Bathing Surface: Slip resistant.
 - b. Size: 48 by 30 inches (1220 by 765 mm) **OR** 60 by 30 inches (1525 by 765 mm) **OR** 66 by 30 inches (1680 by 765 mm), **as directed**, with front apron **OR** drop-in type, **as directed**.
 - c. Color: White.
 - d. Drain Location: Left **OR** Right, **as directed**, end.
 - e. Accessibility Options: Include grab bar and bench.
 - f. Faucet: Bathtub **OR** Bathtub/shower, **as directed**.
 - g. Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves.
 - h. Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
 - i. Drain Piping: NPS 1-1/2 (DN 40) cast-brass P-trap and waste.
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap and waste.

X. Individual Showers

1. Individual Showers, Enclosure Type:
 - a. Description: Accessible, **as directed**, FRP **OR** PMMA, **as directed**, shower enclosure with slip-resistant bathing surface and shower rod with curtain.
 - 1) Size: 36 by 34 inches (915 by 865 mm) **OR** 42 by 36 inches (1065 by 915 mm) **OR** 43 by 39 inches (1090 by 990 mm) **OR** 48 by 34 inches (1220 by 865 mm) **OR** 52 by 36 inches (1320 by 915 mm) **OR** 60 by 36 inches (1525 by 915 mm) **OR** 72 by 36 inches (1830 by 915 mm), **as directed**.
 - 2) Surround: One piece or sealed, multiple piece, **as directed**.
OR
Surround: One piece.
 - 3) Color: White.
 - 4) Drain Location: Left side **OR** Center **OR** Right side, **as directed**.
 - 5) Accessibility Options: Include grab bar and bench.
 - 6) Faucet: Shower.
 - 7) Drain: Grid, NPS 2 (DN 50).
2. Individual Showers, Built-Up Type:
 - a. Description: Components for built-up shower.
 - 1) Receptor: Not required.
3. Individual Showers, Cabinet Type:
 - a. Description: Factory-fabricated, accessible, **as directed**, cabinet type with faucet and receptor.
 - 1) Size: 30 by 30 inches (760 by 760 mm) **OR** 32 by 32 inches (815 by 815 mm) **OR** 36 by 36 inches (915 by 915 mm) **OR** 36 by 39 inches (915 by 990 mm) **OR** 45 by 39 inches (1145 by 990 mm), **as directed**.
 - 2) Material: Steel **OR** Composite **OR** Plastic, **as directed**, front **OR** corner **OR** front and rear, **as directed**, access.
 - 3) Color: Not applicable.
 - 4) Accessibility Options: Grab bar and bench.
 - 5) Faucet: Shower.



- 6) Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves, **as directed**.
- 7) Drain: Grid, NPS 2 (DN 50).

Y. Group Showers

1. Group Showers, Column Type:
 - a. Description: Stainless-steel column fixture with two **OR** three **OR** four **OR** five **OR** six, **as directed**, individual showers.
 - 1) Height to Shower Heads: 66 inches (1675 mm) **OR** 72 inches (1830 mm), **as directed**.
 - 2) Control: Thermostatic **OR** Pressure-balance, **as directed**, valve with individual hot-and cold-water mixing valve operation.
OR
Control: Thermostatic valve with individual tempered-water supply and push-button **OR** sensor, **as directed**, operation.
 - 3) Flow Control: 2 gpm (7.6 L/min.) **OR** 2.5 gpm (9.5 L/min.), **as directed**, for each shower head.
 - 4) Liquid Soap Dispenser: For each shower.
 - 5) Mounting: Floor flange.
 - 6) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves from bottom **OR** top, **as directed**.
 - 7) Shroud: Not required **OR** Stainless steel of size to cover supplies and vent piping, **as directed**.
 - 8) Drain Fitting: NPS 3 (DN 80) **OR** NPS 4 (DN 100), **as directed**, outlet with NPS 2 (DN 50) vent, integral with base of column.
 - 9) Vent Piping: Not required **OR** NPS 2 (DN 50) to ceiling, **as directed**.
2. Group Showers, Wall-Mounting Type:
 - a. Description: Wall-mounting fixture with stainless-steel surface enclosure with two **OR** three, **as directed**, individual showers.
 - 1) Control: Thermostatic **OR** Pressure-balance, **as directed**, valve with individual hot-and cold-water mixing valve operation.
OR
Control: Thermostatic valve with individual tempered-water supply and push-button **OR** sensor, **as directed**, operation.
 - 2) Flow Control: 2 gpm (7.6 L/min.) **OR** 2.5 gpm (9.5 L/min.), **as directed**, for each shower head.
 - 3) Liquid Soap Dispenser: For each shower.
 - 4) Mounting: Wall bracket.
 - 5) Supplies: NPS 3/4 (DN 20) copper tubing with ball, gate, or globe valves.
3. Group Showers, Freestanding, Plastic Type:
 - a. Description: Freestanding, plastic group-shower fixture.
 - 1) Number of Shower Stations: One **OR** Two **OR** Three **OR** Four, **as directed**, with individual self-closing control valve(s).
 - 2) Number of Foot Wash Stations: One **OR** Two, **as directed**, with individual self-closing control valve(s).
 - 3) Hose Bibb: Not **OR** One, **as directed**, required.
 - 4) Control-Valve Mounting Height: 50 inches (1270 mm) **OR** 48 inches (1219 mm), **as directed**.
 - 5) Material: Cast-filled-polymer plastic.
 - 6) Color: Gray.
 - 7) Internal Piping: Factory installed.
 - 8) Mounting: Base flange with bolt holes.
4. Group Showers, Freestanding, Steel Type:
 - a. Description: Freestanding, steel group-shower fixture.
 - 1) Number of Shower Stations: One **OR** Two, **as directed**, with individual self-closing control valve(s).



- 2) Number of Foot Wash Stations: One **OR** Two, **as directed**, with individual self-closing control valve(s).
- 3) Material: Painted steel pipe.
- 4) Color: Blue.
- 5) Internal Piping: Factory installed.
- 6) Mounting: Base flange with bolt holes.

Z. Whirlpool Bathtubs

1. Whirlpool Bathtubs, Water-Circulation Hydromassage Type:

- a. Description: Packaged, enameled, cast-iron **OR** FRP **OR** PMMA **OR** porcelain-enameled, formed-steel, **as directed**, hydromassage bathtub with air-entrained-water jet nozzles and water circulation.
 - 1) Seating Capacity: One **OR** Two, **as directed**, person(s).
 - 2) Bathing Surface: Slip resistant.
 - 3) Size: 60 by 30 inches (1525 by 765 mm) **OR** 66 by 30 inches (1680 by 765 mm) **OR** 60 by 42 inches (1525 by 1065 mm), **as directed**.
 - 4) Base for Drop-in Unit: **<Insert description>** with access panel.
OR
Apron: Matching unit, covering exposed front and sides, and with access panel.
 - 5) Color: White.
 - 6) Drain Location: Left **OR** Right, **as directed**, end.
 - 7) Controls: For pump, timer, **as directed**, and water heater, **as directed**.
 - 8) Faucet: Fixture manufacturer's individual valves **OR** mixing valve, **as directed**, with over-rim tub filler.
 - 9) Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves.
 - 10) Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
 - 11) Drain Piping: NPS 1-1/2 (DN 40) cast-brass P-trap and waste.
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap and waste.
 - 12) Water-Circulating System: Electric circulating pump and plastic piping.
 - 13) Water Heater: Electric, inline, **as directed**.

2. Whirlpool Bathtubs, Airmassage Type:

- a. Description: Packaged, PMMA airmassage bathtub with air-injection nozzles.
 - 1) Seating Capacity: One **OR** Two, **as directed**, person(s).
 - 2) Bathing Surface: Slip resistant.
 - 3) Size: 60 by 30 inches (1525 by 765 mm) **OR** 66 by 30 inches (1680 by 765 mm) **OR** 60 by 42 inches (1525 by 1065 mm), **as directed**.
 - 4) Base for Drop-in Unit: **<Insert description>** with access panel.
OR
Apron: Matching unit, covering exposed front and sides, and with access panel.
 - 5) Color: White.
 - 6) Drain Location: Left **OR** Right, **as directed**, end.
 - 7) Controls: For blower, timer, **as directed**, and water heater, **as directed**.
 - 8) Faucet: Fixture manufacturer's individual valves **OR** mixing valve, **as directed**, with over-rim tub filler.
 - 9) Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves.
 - 10) Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
 - 11) Drain Piping: NPS 1-1/2 (DN 40) cast-brass P-trap and waste.
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap and waste.



- 12) Air-Injection System: Electric, blower **OR** combination blower/heater, **as directed**, and plastic piping.

AA. Kitchen Sinks

1. Kitchen Sinks:

- a. Description: One-bowl **OR** Two-bowl **OR** Three-bowl, **as directed**, residential, counter-mounting, enameled, cast-iron **OR** PMMA **OR** porcelain-enameled, formed-steel **OR** solid-surface **OR** stainless-steel, **as directed**, kitchen sink.
 - 1) Metal Thickness: 0.038 inch (1.0 mm) **OR** 0.050 inch (1.3 mm), **as directed**.
 - 2) Bowl (single bowl):
 - a) Drain: 3-1/2-inch (89-mm) crumb cup **OR** grid **OR** grid with offset waste **OR** outlet for disposer, **as directed**.
 - i. Location: Centered in bowl **OR** Near back of bowl, **as directed**.
 - 3) Left Bowl:
 - a) Drain: 3-1/2-inch (89-mm) crumb cup **OR** grid **OR** grid with offset waste **OR** outlet for disposer, **as directed**.
 - i. Location: Centered in bowl **OR** Near back of bowl, **as directed**.
 - 4) Right Bowl:
 - a) Drain: 3-1/2-inch (89-mm) crumb cup **OR** grid **OR** grid with offset waste **OR** outlet for disposer, **as directed**.
 - i. Location: Centered in bowl **OR** Near back of bowl, **as directed**.
 - 5) Center Bowl:
 - a) Drain: 1-1/2-inch (38-mm) **OR** 3-1/2-inch (89-mm), **as directed**, crumb cup **OR** grid **OR** grid with offset waste, **as directed**.
 - i. Location: Centered in bowl.
 - 6) Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
 - 7) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; continuous waste, **as directed**; and wall escutcheon(s).
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap; tubular waste to wall; continuous waste, **as directed**; and wall escutcheon(s).
 - 8) Disposer: Not required.
 - 9) Dishwasher Air-Gap Fitting: Required **OR** Not required, **as directed**.
 - 10) Hot-Water Dispenser: Not required.

2. Bar Sinks:

- a. Description: Single-bowl, residential, counter-mounting, enameled, cast-iron **OR** PMMA **OR** stainless-steel **OR** porcelain-enameled, cast-iron **OR** solid-surface, **as directed**, bar sink.
 - 1) Supplies: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated copper with stops.
 - 2) Drain: 1-1/2-inch (38-mm) **OR** 3-1/2-inch (89-mm), **as directed**, crumb cup **OR** grid **OR** grid with offset waste, **as directed**.
 - 3) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap; tubular waste to wall; and wall escutcheon.
 - 4) Protective Shielding Guard(s): **As directed**.

BB. Service Sinks

1. Service Sinks, Standard Type:

- a. Description: Trap-standard- and wall-mounting, enameled, cast-iron fixture with roll-rim **OR** vitreous-china fixture, **as directed**, with plain **OR** two faucet holes in, **as directed**, back and rim guard on front and sides.



- 1) Size (cast-iron fixture): 22 by 18 inches (560 by 460 mm) **OR** 24 by 20 inches (610 by 510 mm), **as directed**.
- 2) Size (vitreous-china fixture): 19 by 16 inches (480 by 405 mm) **OR** 22 by 20 inches (560 by 510 mm), **as directed**.
- 3) Color: White.
- 4) Faucet: Sink type. Polished **OR** rough, as directed, chrome-plated, solid-brass faucet. Include integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook. Provide type with wall brace if faucet will be mounted above back.
- 5) Drain: Grid with NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, outlet.
- 6) Trap Standard: NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, enameled, cast iron with cleanout and floor flange.
- 7) Fixture Support: Sink.

2. Service Sinks, Floor-Mounting Type:

- a. Description: Floor-mounting, enameled, cast-iron fixture with front apron, raised back, and coated, wire rim guard. (This type of service sink requires a drainage piping trap under the fixture. This trap is not part of fixture fittings)
 - 1) Size: 28 by 28 inches (710 by 710 mm).
 - 2) Color: White.
 - 3) Faucet: Sink type. Polished **OR** rough, as directed, chrome-plated, solid-brass faucet with wall brace. Include integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook..
 - 4) Drain: Grid with NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, outlet.

CC. Service Basins

1. Description: Flush-to-wall, floor-mounting, precast terrazzo **OR** cast-polymer, **as directed**, fixture with rim guard. (This type of fixture requires a drainage piping trap under the fixture. This trap is not part of fixture fittings.)
 - a. Shape: Square **OR** Rectangular **OR** Five sided **OR** Radial front, **as directed**.
 - b. Size: 24 by 24 inches (610 by 610 mm) **OR** 28 by 28 inches (710 by 710 mm) **OR** 24 by 36 inches (610 by 915 mm) **OR** 32 by 32 inches (815 by 815 mm) **OR** 36 by 36 inches (915 by 915 mm), **as directed**.
 - c. Height: 6 inches (150 mm) **OR** 10 inches (255 mm) **OR** 12 inches (305 mm) **OR** 12 inches (305 mm) with dropped front, **as directed**.
 - d. Tiling Flange: Not required **OR** On one side **OR** On two sides **OR** On three sides, **as directed**.
 - e. Rim Guard: On front **OR** all, **as directed**, top surfaces.
 - f. Color: Not applicable.
 - g. Faucet: Sink type. Polished **OR** rough, as directed, chrome-plated, solid-brass faucet with wall brace. Include integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.
 - h. Drain: Grid with NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, outlet.

DD. Laundry Trays

1. Description: Stand-mounting **OR** Counter-mounting, **as directed**, enameled, cast-iron **OR** plastic, **as directed**, laundry trays.
 - a. Size: 24 by 21 inches (610 by 535 mm) **OR** 25 by 22 inches (635 by 560 mm), **as directed**.
 - b. Color: Not applicable.
 - c. Faucet: Sink type, polished, chrome-plated, solid brass, for fixture-ledge **OR** wall **OR** counter, **as directed**, mounting.
 - d. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops **OR** copper tubing with ball, gate, or globe valves, **as directed**.
 - e. Drain: Grid with NPS 1-1/2 (DN 40) outlet.
 - f. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.

**OR**

Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap; tubular waste to wall; and wall escutcheon.

- g. Stand: Not required **OR** Painted steel, **as directed**.

EE. Sacristy Sinks

1. Description: Two-bowl, counter-mounting, stainless-steel fixture.
 - a. Size: Approximately 22 by 42 inches (560 by 1070 mm).
 - b. Cover: Hinged with lock on left **OR** right, **as directed**, bowl.
 - c. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
 - d. Drains: One with stopper and one with grid.
 - e. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, tubular-brass waste. Include one trap, one direct waste without trap, separate waste piping, and wall flanges.

1.3 EXECUTION

A. Installation

1. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
2. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 - a. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - b. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - c. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
3. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
4. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
5. Install wall-mounting fixtures with tubular waste piping attached to supports.
6. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.
7. Install counter-mounting fixtures in and attached to casework.
8. Install fixtures level and plumb according to roughing-in drawings.
9. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - a. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
10. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
11. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
12. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
13. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.
14. Install toilet seats on water closets.
15. Install trap-seal liquid in dry urinals.
16. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
17. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.
18. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
19. Install shower flow-control fittings with specified maximum flow rates in shower arms.
20. Install traps on fixture outlets.
 - a. Exception: Omit trap on fixtures with integral traps.



- b. Exception: Omit trap on indirect wastes, unless otherwise indicated.
21. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.
 22. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install in sink deck **OR** on countertop at sink, **as directed**. Connect inlet hose to dishwasher and outlet hose to disposer.
 23. Install hot-water dispensers in back top surface of sink or in countertop with spout over sink.
 24. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results For Plumbing".
 25. Set bathtubs, shower receptors, and service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results For Plumbing".
 26. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants".

B. Connections

1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
2. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
3. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
4. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
5. Install fresh batteries in sensor-operated mechanisms.

D. Adjusting

1. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
2. Operate and adjust disposers, hot-water dispensers, and controls. Replace damaged and malfunctioning units and controls.
3. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.
4. Replace washers and seals of leaking and dripping faucets and stops.
5. Install fresh batteries in sensor-operated mechanisms.

E. Cleaning

1. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 - a. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
 - b. Remove sediment and debris from drains.
2. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.



- F. Protection
 - 1. Provide protective covering for installed fixtures and fittings.
 - 2. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by the Owner.

END OF SECTION 22 01 40 81



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SECTION 22 01 40 81a - EMERGENCY PLUMBING FIXTURES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for emergency plumbing fixtures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work

B. Summary

1. This Section includes the following emergency plumbing fixtures:
 - a. Emergency showers.
 - b. Eyewash equipment.
 - c. Self-contained eyewash equipment.
 - d. Personal eyewash equipment.
 - e. Eye/face wash equipment.
 - f. Hand-held drench hoses.
 - g. Combination units.
 - h. Water-tempering equipment.

C. Definitions

1. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
2. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
3. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.
4. Tepid: Moderately warm.

D. Submittals

1. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."
3. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.
4. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

1.2 PRODUCTS

A. Emergency Showers:

1. Description: Plumbed, single-shower-head horizontal, wall-mounting **OR** vertical, ceiling-mounting **OR** freestanding, **as directed**, emergency shower.
 - a. Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.



- b. Supply Piping: NPS 1 (DN 25) **OR** NPS 1-1/4 (DN 32) **OR** galvanized steel **OR** chrome-plated brass or stainless steel **OR** PVC, **as directed**, with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Pull rod **OR** chain, **as directed**.
 - d. Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel **OR** plastic, **as directed**.
2. Description: Plumbed, multiple-spray emergency shower with eight **OR** 12 **OR** 16, **as directed**, small shower heads or nozzles.
- a. Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1-1/4 (DN 32) minimum galvanized **OR** chrome-plated brass or stainless, **as directed**, steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle **OR** Treadle, **as directed**.
3. Description: Plumbed, freeze-protected, freestanding emergency shower.
- a. Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1-1/4 (DN 32) galvanized steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Pull rod **OR** chain, **as directed**.
 - d. Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel **OR** plastic, **as directed**.
 - e. Heating System: 120 **OR** 240, **as directed**, -V ac electric; and insulation with protective jacket.

B. Eyewash Equipment

1. Description: Plumbed, freestanding eyewash equipment.
- a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle **OR** Push bar **OR** Treadle, **as directed**.
 - d. Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed**, bowl.
 - e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2 **OR** Omit drain piping **OR** Include galvanized-steel indirect connection to drainage system, **as directed**.
2. Description: Plumbed, accessible, **as directed**, wall-mounting eyewash equipment with receptor and wall bracket.
- a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
 - d. Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed**, bowl.
 - e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.
3. Description: Plumbed, accessible, **as directed**, wall-mounting eyewash equipment with wall bracket.
- a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle **OR** Movement sensor, **as directed**.
4. Description: Plumbed, adjacent-to-sink, swivel, counter-mounting eyewash equipment.
- a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.



- b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
- C. Self-Contained Eyewash Equipment:
- 1. Description: Portable, pressurized, self-contained eyewash equipment.
 - a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
 - b. Tank: 10 gal. (3.8 L), stainless steel, cylindrical, and suitable for on-floor installation.
 - c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
 - d. Piping: Chrome-plated copper alloy or stainless steel with flow regulator and stay-open control valve.
 - e. Control-Valve Actuator: Paddle.
 - f. Spray Heads: Twin with covers.
 - 2. Description: Static, nonpressurized, self-contained eyewash equipment.
 - a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
 - b. Tank: 14 gal. (53 L) minimum, plastic, and suitable for shelf mounting.
 - c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
 - d. Actuator: Pull-down front panel.
 - e. Spray Heads: Protected, twin.
 - 3. Description: Freeze-protected, static, nonpressurized, self-contained eyewash equipment with heating system.
 - a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
 - b. Tank: 14 gal. (53 L) minimum **OR** 20 gal. (76 L) minimum, **as directed**, plastic, and suitable for shelf mounting.
 - c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
 - d. Actuator: Pull-down front panel.
 - e. Spray Heads: Protected, twin.
 - f. Heating System: Electric, 120-V ac; and insulation with protective jacket.
- D. Personal Eyewash Equipment:
- 1. Description: Portable, pressurized, personal eyewash equipment with spray heads.
 - a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.), **as directed**.
 - b. Tank: 5 gal. (19 L), stainless steel, cylindrical, and with base suitable for on-floor installation.
 - c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
 - d. Piping: Chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - e. Control-Valve Actuator: Paddle.
 - f. Spray Heads: Twin with covers.
 - 2. Description: Portable, pressurized, personal eyewash equipment with spray heads and drench hose.
 - a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.), **as directed**.
 - b. Tank: 5 gal. (19 L), stainless steel, cylindrical, and with base suitable for on-floor installation.
 - c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
 - d. Piping: Chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - e. Spray-Head, Control-Valve Actuator: Paddle.



- f. Spray Heads: Twin with covers.
 - g. Drench Hose: Rubber or plastic.
 - 1) Control-Valve Actuator: Hand-held squeeze valve.
 - 2) Spray Head: Single with cover.
- E. Eye/Face Wash Equipment:
1. Description: Plumbed, freestanding, pedestal eye/face wash equipment.
 - a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle **OR** Push bar **OR** Treadle, **as directed**.
 - d. Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed**, bowl.
 - e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2. Include galvanized-steel indirect connection to drainage system.
 2. Description: Plumbed, accessible, **as directed**, wall-mounting eye/face wash equipment with receptor and wall bracket.
 - a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
 - d. Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed**, bowl.
 - e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.
 3. Description: Plumbed, accessible, **as directed**, wall-mounting eye/face wash equipment without receptor and with wall bracket.
 - a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
 4. Description: Plumbed, adjacent-to-sink, swivel, counter-mounting eye/face wash equipment.
 - a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
- F. Hand-Held Drench Hoses:
1. Description: Plumbed, wall-mounting, hand-held drench hose with wall bracket.
 - a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
 - d. Hose: Coiled **OR** Plain, **as directed**, rubber or plastic.
 - e. Spray Heads: Single **OR** Twin, **as directed**.
 2. Description: Plumbed, counter-mounting, hand-held drench hose.
 - a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - b. Supply Fitting: NPS 1/2 (DN 15) brass with flow regulator.
 - c. Hose: Rubber or plastic.
 - d. Control-Valve Actuator: Hand-held squeeze valve.



e. Spray Heads: Single **OR** Twin, **as directed**.

G. Combination Units:

1. Description: Plumbed, accessible, **as directed**, freestanding, with emergency shower and eyewash **OR** eye/face wash **OR** drench hose, **as directed**, equipment.
 - a. Piping: Galvanized steel **OR** Chrome-plated brass or stainless steel **OR** PVC, **as directed**.
 - 1) Unit Supply: NPS 1-1/4 (DN 32) minimum **OR** NPS 1-1/2 (DN 40), **as directed**, from top **OR** side, **as directed**.
 - 2) Unit Drain: Outlet at side near bottom.
 - 3) Shower Supply: NPS 1 (DN 25) with flow regulator and stay-open control valve.
 - 4) Eyewash **OR** Eye/Face Wash **OR** Drench Hose, **as directed**, Supply: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
 - b. Shower Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
 - 1) Control-Valve Actuator: Pull rod **OR** Pull chain **OR** Treadle, **as directed**.
 - 2) Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel **OR** plastic, **as directed**.
 - c. Eyewash Equipment: With capacity to deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
 - 1) Control-Valve Actuator: Paddle **OR** Push bar, **as directed**.
 - 2) Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed**, bowl.
 - d. Eye/Face Wash Equipment: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - 1) Control-Valve Actuator: Paddle **OR** Push bar, **as directed**.
 - 2) Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed**, bowl.
 - e. Hand-Held Drench Hose: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - 1) Hose: Rubber or plastic.
 - 2) Control-Valve Actuator: Hand-held squeeze valve.
 - 3) Spray Head(s): Single **OR** Twin, **as directed**.
2. Description: Plumbed, accessible, **as directed**, freeze-protected, freestanding, with emergency shower and eye/face wash equipment.
 - a. Piping: Galvanized steel.
 - 1) Unit Supply: NPS 1-1/4 (DN 32) minimum **OR** NPS 1-1/2 (DN 40), **as directed**, from top **OR** side **OR** bottom, **as directed**.
 - 2) Shower Supply: NPS 1 (DN 25) with flow regulator and stay-open control valve.
 - 3) Eye/Face Wash Supply: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
 - b. Heating System: Electric, 120 **OR** 240, **as directed**, -V ac; and insulation with protective jacket.
 - c. Shower Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
 - 1) Control-Valve Actuator: Pull rod **OR** Pull chain **OR** Treadle, **as directed**.
 - 2) Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel **OR** plastic, **as directed**.
 - d. Eye/Face Wash Equipment: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - 1) Control-Valve Actuator: Paddle **OR** Push bar, **as directed**.

H. Water-Tempering Equipment:

1. Description: Factory-fabricated, hot- and cold-water-tempering equipment with thermostatic mixing valve.
 - a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue



- cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
2. Description: Factory-fabricated, steam and cold-water, water-tempering equipment with thermostatic mixing valve.
 - a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, steam controls, heat exchanger, high-temperature-limit and freeze-protection devices, metal piping, and corrosion-resistant enclosure.
 3. Description: Factory-fabricated, water-tempering equipment with electric heating.
 - a. Heating System: Electric, designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, heating coils, high-temperature-limit device, metal piping, and corrosion-resistant enclosure.
 - 1) Electrical Characteristics: 208-V ac, 38 **OR** 220-V ac, 40 **OR** 277-V ac, 32, **as directed**, A, single phase, 60 Hz.

1.3 EXECUTION

A. Installation

1. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
2. Install fixtures level and plumb.
3. Fasten fixtures to substrate.
4. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
 - a. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency plumbing fixture.
 - b. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.
5. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping.
6. Install dielectric fitting in supply piping to fixture if piping and fixture connections are made of different metals. Dielectric fittings are specified in Division 22 Section "Common Work Results For Plumbing".
7. Install thermometers in supply and outlet piping connections to water-tempering equipment. Thermometers are specified in Division 22 Section "Meters And Gages For Plumbing Piping".
8. Install trap and waste to wall on drain outlet of fixture receptors that are indicated to be directly connected to drainage system.
9. Install indirect waste piping to wall on drain outlet of fixture receptors that are indicated to be indirectly connected to drainage system. Drainage piping is specified in Division 22 Section "Sanitary Waste And Vent Piping".
10. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Escutcheons are specified in Division 22 Section "Common Work Results For Plumbing".
11. Fill self-contained fixtures with flushing fluid.
12. Install equipment nameplates or equipment markers on fixtures and equipment signs on water-tempering equipment. Identification materials are specified in Division 22 Section "Identification For Plumbing Piping And Equipment".
13. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
14. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment.



15. Connect hot- and cold-water-supply piping to hot- and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.
 16. Connect cold-water and steam supply and condensate return piping to steam and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.
 17. Connect cold water and electrical power to electric heating water-tempering equipment.
 18. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary drainage and vent piping.
 19. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary or storm drainage piping.
 20. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 21. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- B. Field Quality Control
1. Electrical-Component Testing: After electrical circuitry has been energized, test for compliance with requirements.
 - a. Test and adjust controls and safeties.
 2. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.
- C. Adjusting
1. Adjust or replace fixture flow regulators for proper flow.
 2. Adjust equipment temperature settings.

END OF SECTION 22 01 40 81a



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**SECTION 22 05 13 00 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common motor requirements for plumbing equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

C. Coordination

1. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - a. Motor controllers.
 - b. Torque, speed, and horsepower requirements of the load.
 - c. Ratings and characteristics of supply circuit and required control sequence.
 - d. Ambient and environmental conditions of installation location.

1.2 PRODUCTS

A. General Motor Requirements

1. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
2. Comply with NEMA MG 1 unless otherwise indicated.
3. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics

1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
 - a. For motors with 2:1 speed ratio, consequent pole, single winding.
 - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:
 - a. Motors 15 HP and Larger: NEMA starting Code F or Code G.



- b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- 11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Polyphase Motors With Additional Requirements

- 1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- 2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- 3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors

- 1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split phase.
 - c. Capacitor start, inductor run.
 - d. Capacitor start, capacitor run.
- 2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- 3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- 4. Motors 1/20 HP and Smaller: Shaded-pole type.
- 5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.3 EXECUTION (Not Applicable)

END OF SECTION 22 05 13 00



SECTION 22 05 16 00 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for expansion fittings and loops for plumbing piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Flexible-hose packless expansion joints.
 - b. Metal-bellows packless expansion joints.
 - c. Rubber packless expansion joints.
 - d. Grooved-joint expansion joints.
 - e. Pipe loops and swing connections.
 - f. Alignment guides and anchors.

C. Performance Requirements

1. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
2. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

D. Submittals

1. Product Data: For each type of product indicated.
2. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - b. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - c. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - d. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
3. Welding certificates.
4. Product Certificates: For each type of expansion joint, from manufacturer.
5. Maintenance Data: For expansion joints to include in maintenance manuals.

E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. ASME Boiler and Pressure Vessel Code: Section IX.

1.2 PRODUCTS

A. Packless Expansion Joints

1. Flexible-Hose Packless Expansion Joints:
 - a. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
 - b. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.



- c. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
 - 1) Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
 - 2) Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
- d. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
 - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.
 - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.
- e. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Stainless-steel fittings with threaded end connections.
 - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
 - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.
- f. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Stainless-steel fittings with flanged end connections.
 - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
 - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
- g. Expansion Joints for Steel Piping NPS 8 to NPS 12 (DN 200 to DN 300): Stainless-steel fittings with flanged end connections.
 - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.
 - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.
2. Metal-Bellows Packless Expansion Joints:
 - a. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
 - b. Type: Circular, corrugated bellows with external tie rods.
 - c. Minimum Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa), **as directed**, unless otherwise indicated.
 - d. Configuration: Single joint **OR** Single joint with base and double joint with base, **as directed**, class(es) unless otherwise indicated.
 - e. Expansion Joints for Copper Tubing: Single **OR** Multi, **as directed**, -ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
 - 1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
 - 2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Solder joint or threaded.
 - 3) End Connections for Copper Tubing NPS 5 (DN 125) and Larger: Flanged.
3. Rubber Packless Expansion Joints:



- a. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
 - b. Material: Fabric-reinforced rubber complying with FSA-NMEJ-703.
 - c. Arch Type: Single **OR** Multiple, **as directed**, arches with external control rods, **as directed**.
 - d. Spherical Type: Single **OR** Multiple, **as directed** spheres with external control rods, **as directed**.
 - e. Minimum Pressure Rating for NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C).
 - f. Minimum Pressure Rating for NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C).
 - g. Minimum Pressure Rating for NPS 8 to NPS 12 (DN 200 to DN 300): 140 psig (966 kPa) at 180 deg F (82 deg C).
 - h. Material for Fluids Containing Acids, Alkalies, or Chemicals: BR **OR** CSM **OR** EPDM, **as directed**.
 - i. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N **OR** CR, **as directed**.
 - j. Material for Water: BR **OR** Buna-N **OR** CR **OR** CSM **OR** EPDM **OR** NR, **as directed**.
 - k. End Connections: Full-faced, integral steel flanges with steel retaining rings.
- B. Grooved-Joint Expansion Joints
1. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
 2. Standard: AWWA C606, for grooved joints.
 3. Nipples: Galvanized, **as directed**, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
 4. Couplings: Five **OR** Seven **OR** 10 **OR** 12, **as directed**, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water **OR** EPDM gasket suitable for cold and hot water, **as directed**, and bolts and nuts.
- C. Alignment Guides And Anchors
1. Alignment Guides:
 - a. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.
 2. Anchor Materials:
 - a. Steel Shapes and Plates: ASTM A 36/A 36M.
 - b. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
 - c. Washers: ASTM F 844, steel, plain, flat washers.
 - d. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - 1) Stud: Threaded, zinc-coated carbon steel.
 - 2) Expansion Plug: Zinc-coated steel.
 - 3) Washer and Nut: Zinc-coated steel.
 - e. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - 1) Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - 2) Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
 - 3) Washer and Nut: Zinc-coated steel.



1.3 EXECUTION

- A. Expansion-Joint Installation
 1. Install expansion joints of sizes matching sizes of piping in which they are installed.
 2. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
 3. Install rubber packless expansion joints according to FSA-NMEJ-702.
 4. Install grooved-joint expansion joints to grooved-end steel piping

- B. Pipe Loop And Swing Connection Installation
 1. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
 2. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.
 3. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.
 4. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.

- C. Alignment-Guide And Anchor Installation
 1. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
 2. Install one **OR** two, **as directed**, guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
 3. Attach guides to pipe and secure guides to building structure.
 4. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
 5. Anchor Attachments:
 - a. Anchor Attachment to Black-Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - b. Anchor Attachment to Galvanized-Steel Pipe: Attach with pipe hangers. Use MSS SP-69, Type 42, riser clamp welded to anchor.
 - c. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
 6. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - a. Anchor Attachment to Steel Structural Members: Attach by welding.
 - b. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
 7. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 22 05 16 00



Task	Specification	Specification Description
22 05 19 00	21 05 19 00a	Meters and Gages for Plumbing Piping



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SECTION 22 05 23 00 - PIPED UTILITIES BASIC MATERIALS AND METHODS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for piped utilities - basic materials and methods. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Piping joining materials.
 - b. Transition fittings.
 - c. Dielectric fittings.
 - d. Sleeves.
 - e. Identification devices.
 - f. Grout.
 - g. Flowable fill.
 - h. Piped utility demolition.
 - i. Piping system common requirements.
 - j. Equipment installation common requirements.
 - k. Painting.
 - l. Concrete bases.
 - m. Metal supports and anchorages.

C. Definitions

1. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.
2. Concealed Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
3. ABS: Acrylonitrile-butadiene-styrene plastic.
4. CPVC: Chlorinated polyvinyl chloride plastic.
5. PE: Polyethylene plastic.
6. PVC: Polyvinyl chloride plastic.

D. Submittals

1. Product Data: For the following:
 - a. Dielectric fittings.
 - b. Identification devices.
2. Welding certificates.

E. Quality Assurance

1. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Steel Piping Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
3. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.



F. Delivery, Storage, And Handling

1. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.2 PRODUCTS

A. Piping Joining Materials

1. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - a. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness, unless otherwise indicated.
 - 1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - 2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - b. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
3. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
4. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
5. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BA_g1, silver alloy for refrigerant piping, unless otherwise indicated.
6. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
7. Solvent Cements for Joining Plastic Piping:
 - a. ABS Piping: ASTM D 2235.
 - b. CPVC Piping: ASTM F 493.
 - c. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - d. PVC to ABS Piping Transition: ASTM D 3138.
8. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

B. Transition Fittings

1. Transition Fittings, General: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
2. Transition Couplings NPS 1-1/2 (DN 40) and Smaller:
 - a. Underground Piping: Manufactured piping coupling or specified piping system fitting.
 - b. Aboveground Piping: Specified piping system fitting.
3. AWWA Transition Couplings NPS 2 (DN 50) and Larger:
 - a. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.
4. Plastic-to-Metal Transition Fittings:
 - a. Description: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint or threaded end.
5. Plastic-to-Metal Transition Unions:
 - a. Description: MSS SP-107, CPVC and PVC four-part union. Include brass or stainless-steel threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.
6. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:
 - a. Description: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.



- C. Dielectric Fittings
1. Dielectric Fittings, General: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
 2. Dielectric Unions:
 - a. Description: Factory fabricated, union, NPS 2 (DN 50) and smaller.
 - 1) Pressure Rating: 150 psig (1035 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**, at 180 deg F (82 deg C).
 - 2) End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.
 3. Dielectric Flanges:
 - a. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and larger.
 - 1) Pressure Rating: 150 psig (1035 kPa) minimum **OR** 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - 2) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
 4. Dielectric-Flange Kits:
 - a. Description: Nonconducting materials for field assembly of companion flanges, NPS 2-1/2 (DN 65) and larger.
 - 1) Pressure Rating: 150 psig (1035 kPa) minimum.
 - 2) Gasket: Neoprene or phenolic.
 - 3) Bolt Sleeves: Phenolic or polyethylene.
 - 4) Washers: Phenolic with steel backing washers.
 5. Dielectric Couplings:
 - a. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, NPS 3 (DN 80) and smaller.
 - 1) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - 2) End Connections: Threaded.
 6. Dielectric Nipples:
 - a. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.
 - 1) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - 2) End Connections: Threaded or grooved.
- D. Sleeves
1. Mechanical sleeve seals for pipe penetrations are specified in Division 22 Section "Common Work Results For Plumbing".
 2. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
 3. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized, plain ends.
 4. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
 5. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
 6. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.
 7. Molded PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- E. Identification Devices
1. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.
 - a. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
 - b. Location: Accessible and visible.
 2. Stencils: Standard stencils prepared with letter sizes complying with recommendations in ASME A13.1. Minimum letter height is 1-1/4 inches (30 mm) for ducts, and 3/4 inch (20 mm) for access door signs and similar operational instructions.
 - a. Material: Fiberboard **OR** Brass, **as directed**.



- b. Stencil Paint: Exterior, oil-based, alkyd-gloss black enamel, unless otherwise indicated. Paint may be in pressurized spray-can form.
- c. Identification Paint: Exterior, oil-based, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.
- 3. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.
- 4. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive-vinyl type with permanent adhesive.
- 5. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers, extending 360 degrees around pipe at each location.
- 6. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.
- 7. Lettering: Manufacturer's standard preprinted captions as selected by the Owner.
- 8. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
 - a. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.
- 9. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least 3 mils (0.08 mm) thick.
 - a. Width: 1-1/2 inches (40 mm) on pipes with OD, including insulation, less than 6 inches (150 mm); 2-1/2 inches (65 mm) for larger pipes.
 - b. Color: Comply with ASME A13.1, unless otherwise indicated.
- 10. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) sequenced numbers. Include 5/32-inch (4-mm) hole for fastener.
 - a. Material: 0.032-inch- (0.8-mm-) thick, polished brass **OR** aluminum, **as directed**.
 - b. Material: 0.0375-inch- (1-mm-) thick stainless steel.
 - c. Material: 3/32-inch- (2.4-mm-) thick plastic laminate with 2 black surfaces and a white inner layer.
 - d. Material: Valve manufacturer's standard solid plastic.
 - e. Size: 1-1/2 inches (40 mm) in diameter, unless otherwise indicated.
 - f. Shape: As indicated for each piping system.
- 11. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.
- 12. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
 - a. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
 - b. Thickness: 1/16 inch (1.6 mm), for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) in length, and 1/8 inch (3 mm) for larger units.
 - c. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.
- 13. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:
 - a. Green: Cooling equipment and components.
 - b. Yellow: Heating equipment and components.
 - c. Brown: Energy reclamation equipment and components.
 - d. Blue: Equipment and components that do not meet criteria above.
 - e. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
 - f. Terminology: Match schedules as closely as possible. Include the following:
 - 1) Name and plan number.
 - 2) Equipment service.
 - 3) Design capacity.
 - 4) Other design parameters such as pressure drop, entering and leaving conditions, and speed.



- g. Size: 2-1/2 by 4 inches (65 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.
14. Plasticized Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with mat finish suitable for writing.
 - a. Size: 3-1/4 by 5-5/8 inches (83 by 143 mm).
 - b. Fasteners: Brass grommets and wire.
 - c. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
15. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in piped utility identification with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of piped utility systems and equipment.
 - a. Multiple Systems: Identify individual system number and service if multiple systems of same name are indicated.

F. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.

G. Flowable Fill

1. Description: Low-strength-concrete, flowable-slurry mix.
 - a. Cement: ASTM C 150, Type I, portland.
 - b. Density: 115- to 145-lb/cu. ft. (1840- to 2325-kg/cu. m).
 - c. Aggregates: ASTM C 33, natural sand, fine and crushed gravel or stone, coarse
OR
Aggregates: ASTM C 33, natural sand, fine with admixture, ASTM C 618, fly-ash mineral.
 - d. Water: Comply with ASTM C 94/C 94M.
 - e. Strength: 100 to 200 psig (690 to 1380 kPa) at 28 days.

1.3 EXECUTION

A. Piped Utility Demolition

1. Refer to Division 01 Section(s) "Cutting And Patching" AND Division 02 Section(s) "Selective Structure Demolition" for general demolition requirements and procedures.
2. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
 - e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to the Owner.
3. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

B. Dielectric Fitting Applications

1. Dry Piping Systems: Connect piping of dissimilar metals with the following:
 - a. NPS 2 (DN 50) and Smaller: Dielectric unions.
 - b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Dielectric flanges or dielectric flange kits.



2. Wet Piping Systems: Connect piping of dissimilar metals with the following:
 - a. NPS 2 (DN 50) and Smaller: Dielectric couplings **OR** dielectric nipples, **as directed**.
 - b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric nipples.
 - c. NPS 2-1/2 to NPS 8 (DN 65 to DN 200): Dielectric nipples or dielectric flange kits.
 - d. NPS 10 and NPS 12 (DN 250 and DN 300): Dielectric flange kits.

C. Piping Installation

1. Install piping according to the following requirements and Division 33 specifying piping systems.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on the Coordination Drawings.
3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
4. Install piping to permit valve servicing.
5. Install piping at indicated slopes.
6. Install piping free of sags and bends.
7. Install fittings for changes in direction and branch connections.
8. Select system components with pressure rating equal to or greater than system operating pressure.
9. Sleeves are not required for core-drilled holes, unless directed otherwise.
10. Permanent sleeves are not required for holes formed by removable PE sleeves, unless directed otherwise.
11. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
 - a. Cut sleeves to length for mounting flush with both surfaces.
 - 1) Exception: Extend sleeves installed in floors of equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
 - b. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - 1) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - 2) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
12. Verify final equipment locations for roughing-in.
13. Refer to equipment specifications in other Sections for roughing-in requirements.

D. Piping Joint Construction

1. Join pipe and fittings according to the following requirements and Division 33 specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
5. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1.1 "Quality Assurance" Article.
6. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
7. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.



8. Soldered Joints: Apply ASTM B 813 water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B 32.
 9. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
 10. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.
 11. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
 - c. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - d. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - e. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - f. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.
 12. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
 13. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
 14. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - a. Plain-End PE Pipe and Fittings: Use butt fusion.
 - b. Plain-End PE Pipe and Socket Fittings: Use socket fusion.
 15. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- E. Piping Connections
1. Make connections according to the following, unless otherwise indicated:
 - a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - c. Install dielectric fittings at connections of dissimilar metal pipes.
- F. Equipment Installation
1. Install equipment level and plumb, unless otherwise indicated.
 2. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.
 3. Install equipment to allow right of way to piping systems installed at required slope.
- G. Painting
1. Painting of piped utility systems, equipment, and components is specified in Division 09.
 2. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.
- H. Identification
1. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
 - a. Stenciled Markers: According to ASME A13.1.
 - b. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
 - c. Locate pipe markers on exposed piping according to the following:
 - 1) Near each valve and control device.



- 2) Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
 - 3) Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
 - 4) At manholes and similar access points that permit view of concealed piping.
 - 5) Near major equipment items and other points of origination and termination.
2. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.
 - a. Lettering Size: Minimum 1/4 inch (6.4 mm) high for name of unit if viewing distance is less than 24 inches (610 mm), 1/2 inch (13 mm) high for distances up to 72 inches (1800 mm), and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
 - b. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
 3. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

I. Concrete Bases

1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of base.
 - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - g. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

J. Erection Of Metal Supports And Anchorages

1. Refer to Division 05 Section "Metal Fabrications" for structural steel.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.
3. Field Welding: Comply with AWS D1.1/D1.1M.

K. Grouting

1. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.
2. Clean surfaces that will come into contact with grout.
3. Provide forms as required for placement of grout.
4. Avoid air entrapment during placement of grout.
5. Place grout, completely filling equipment bases.
6. Place grout on concrete bases and provide smooth bearing surface for equipment.
7. Place grout around anchors.
8. Cure placed grout.

END OF SECTION 22 05 23 00

**SECTION 22 05 23 00a - GENERAL-DUTY VALVES FOR PLUMBING PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of general-duty valves for plumbing piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Bronze angle valves.
 - b. Brass ball valves.
 - c. Bronze ball valves.
 - d. Iron ball valves.
 - e. Iron, single-flange butterfly valves.
 - f. Iron, grooved-end butterfly valves.
 - g. Bronze lift check valves.
 - h. Bronze swing check valves.
 - i. Iron swing check valves.
 - j. Iron swing check valves with closure control.
 - k. Iron, grooved-end swing check valves.
 - l. Iron, center-guided check valves.
 - m. Iron, plate-type check valves.
 - n. Bronze gate valves.
 - o. Iron gate valves.
 - p. Bronze globe valves.
 - q. Iron globe valves.
 - r. Lubricated plug valves.
 - s. Chainwheels.

C. Definitions

1. CWP: Cold working pressure.
2. EPDM: Ethylene propylene copolymer rubber.
3. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
4. NRS: Nonrising stem.
5. OS&Y: Outside screw and yoke.
6. RS: Rising stem.
7. SWP: Steam working pressure.

D. Submittals

1. Product Data: For each type of valve indicated.

E. Quality Assurance

1. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
2. ASME Compliance:
 - a. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - b. ASME B31.1 for power piping valves.
 - c. ASME B31.9 for building services piping valves.
3. NSF Compliance: NSF 61 for valve materials for potable-water service.

F. Delivery, Storage, And Handling



1. Prepare valves for shipping as follows:
 - a. Protect internal parts against rust and corrosion.
 - b. Protect threads, flange faces, grooves, and weld ends.
 - c. Set angle, gate, and globe valves closed to prevent rattling.
 - d. Set ball and plug valves open to minimize exposure of functional surfaces.
 - e. Set butterfly valves closed or slightly open.
 - f. Block check valves in either closed or open position.
2. Use the following precautions during storage:
 - a. Maintain valve end protection.
 - b. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
3. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.2 PRODUCTS

A. General Requirements For Valves

1. Refer to valve schedule articles for applications of valves.
2. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
3. Valve Sizes: Same as upstream piping unless otherwise indicated.
4. Valve Actuator Types:
 - a. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
 - b. Handwheel: For valves other than quarter-turn types.
 - c. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller except plug valves, **as directed**.
 - d. Wrench: For plug valves with square heads. Furnish the Owner with 1 wrench for every 5 **OR 10, as directed**, plug valves, for each size square plug-valve head.
 - e. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
5. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
 - a. Gate Valves: With rising stem.
 - b. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - c. Butterfly Valves: With extended neck.
6. Valve-End Connections:
 - a. Flanged: With flanges according to ASME B16.1 for iron valves.
 - b. Grooved: With grooves according to AWWA C606.
 - c. Solder Joint: With sockets according to ASME B16.18.
 - d. Threaded: With threads according to ASME B1.20.1.
7. Valve Bypass and Drain Connections: MSS SP-45.

B. Bronze Angle Valves

1. Class 125, Bronze Angle Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded.
 - 5) Stem and Disc: Bronze.
 - 6) Packing: Asbestos free.
 - 7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, Bronze Angle Valves with Nonmetallic Disc:



- a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: PTFE or TFE.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
 3. Class 150, Bronze Angle Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem and Disc: Bronze.
 - 6) Packing: Asbestos free.
 - 7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
 4. Class 150, Bronze Angle Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: PTFE or TFE.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
- C. Brass Ball Valves
1. One-Piece, Reduced-Port, Brass Ball Valves with Brass Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Design: One piece.
 - 4) Body Material: Forged brass.
 - 5) Ends: Threaded.
 - 6) Seats: PTFE or TFE.
 - 7) Stem: Brass.
 - 8) Ball: Chrome-plated brass.
 - 9) Port: Reduced.
 2. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Brass.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Full.
 3. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.



- 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Full.
4. Two-Piece, Regular-Port, Brass Ball Valves with Brass Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Brass.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Regular.
 5. Two-Piece, Regular-Port, Brass Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Brass or bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Regular.
 6. Three-Piece, Full-Port, Brass Ball Valves with Brass Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Three piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Brass.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Full.
 7. Three-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Three piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.



- 9) Ball: Stainless steel, vented.
- 10) Port: Full.

D. Bronze Ball Valves

1. One-Piece, Reduced-Port, Bronze Ball Valves with Bronze Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Design: One piece.
 - 4) Body Material: Bronze.
 - 5) Ends: Threaded.
 - 6) Seats: PTFE or TFE.
 - 7) Stem: Bronze.
 - 8) Ball: Chrome-plated brass.
 - 9) Port: Reduced.
2. One-Piece, Reduced-Port, Bronze Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) CWP Rating: 600 psig (4140 kPa).
 - 3) Body Design: One piece.
 - 4) Body Material: Bronze.
 - 5) Ends: Threaded.
 - 6) Seats: PTFE or TFE.
 - 7) Stem: Stainless steel.
 - 8) Ball: Stainless steel, vented.
 - 9) Port: Reduced.
3. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Bronze.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Full.
4. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Full.
5. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.



- 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Bronze.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Regular.
6. Two-Piece, Regular-Port, Bronze Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Regular.
 7. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Three piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Bronze.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Full.
 8. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Three piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Full.
- E. Iron Ball Valves
1. Class 125, Iron Ball Valves:
 - a. Description:
 - 1) Standard: MSS SP-72.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Split body.
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Ends: Flanged.
 - 6) Seats: PTFE or TFE.
 - 7) Stem: Stainless steel.
 - 8) Ball: Stainless steel.
 - 9) Port: Full.



F. Iron, Single-Flange Butterfly Valves

1. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Aluminum bronze.
2. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: NBR.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Aluminum bronze.
3. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
4. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: NBR.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
5. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Stainless steel.
6. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).



- 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
- 5) Seat: NBR.
- 6) Stem: One- or two-piece stainless steel.
- 7) Disc: Stainless steel.

G. Iron, Grooved-End Butterfly Valves

1. 175 CWP, Iron, Grooved-End Butterfly Valves:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 175 psig (1200 kPa).
 - 3) Body Material: Coated, ductile iron.
 - 4) Stem: Two-piece stainless steel.
 - 5) Disc: Coated, ductile iron.
 - 6) Seal: EPDM.
2. 300 CWP, Iron, Grooved-End Butterfly Valves:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) NPS 8 (DN 200) and Smaller CWP Rating: 300 psig (2070 kPa).
 - 3) NPS 10 (DN 250) and Larger CWP Rating: 200 psig (1380 kPa).
 - 4) Body Material: Coated, ductile iron.
 - 5) Stem: Two-piece stainless steel.
 - 6) Disc: Coated, ductile iron.
 - 7) Seal: EPDM.

H. Bronze Lift Check Valves

1. Class 125, Lift Check Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Vertical flow.
 - 4) Body Material: ASTM B 61 or ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: Bronze.
2. Class 125, Lift Check Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Vertical flow.
 - 4) Body Material: ASTM B 61 or ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: NBR, PTFE, or TFE.

I. Bronze Swing Check Valves

1. Class 125, Bronze Swing Check Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 3.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Horizontal flow.
 - 4) Body Material: ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: Bronze.
2. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
 - a. Description:



- 1) Standard: MSS SP-80, Type 4.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Horizontal flow.
 - 4) Body Material: ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: PTFE or TFE.
3. Class 150, Bronze Swing Check Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 3.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Design: Horizontal flow.
 - 4) Body Material: ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: Bronze.
 4. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 4.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Design: Horizontal flow.
 - 4) Body Material: ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: PTFE or TFE.
- J. Iron Swing Check Valves
1. Class 125, Iron Swing Check Valves with Metal Seats:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Clear or full waterway.
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 5) Ends: Flanged.
 - 6) Trim: Bronze.
 - 7) Gasket: Asbestos free.
 2. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Clear or full waterway.
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 5) Ends: Flanged.
 - 6) Trim: Composition.
 - 7) Seat Ring: Bronze.
 - 8) Disc Holder: Bronze.
 - 9) Disc: PTFE or TFE.
 - 10) Gasket: Asbestos free.
 3. Class 250, Iron Swing Check Valves with Metal Seats:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Design: Clear or full waterway.
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 5) Ends: Flanged.
 - 6) Trim: Bronze.
 - 7) Gasket: Asbestos free.

K. Iron Swing Check Valves With Closure Control



1. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Clear or full waterway.
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 5) Ends: Flanged.
 - 6) Trim: Bronze.
 - 7) Gasket: Asbestos free.
 - 8) Closure Control: Factory-installed, exterior lever and spring.
2. Class 125, Iron Swing Check Valves with Lever- and Weight-Closure Control:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Clear or full waterway.
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 5) Ends: Flanged.
 - 6) Trim: Bronze.
 - 7) Gasket: Asbestos free.
 - 8) Closure Control: Factory-installed, exterior lever and weight.

L. Iron, Grooved-End Swing Check Valves

1. 300 CWP, Iron, Grooved-End Swing Check Valves:
 - a. Description:
 - 1) CWP Rating: 300 psig (2070 kPa).
 - 2) Body Material: ASTM A 536, ductile iron.
 - 3) Seal: EPDM.
 - 4) Disc: Spring-operated, ductile iron or stainless steel.

M. Iron, Center-Guided Check Valves

1. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 126, gray iron.
 - 4) Style: Compact wafer.
 - 5) Seat: Bronze.
2. Class 125, Iron, Globe, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 126, gray iron.
 - 4) Style: Globe, spring loaded.
 - 5) Ends: Flanged.
 - 6) Seat: Bronze.
3. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 4) Style: Compact wafer.
 - 5) Seat: Bronze.
4. Class 150, Iron, Globe, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.



- 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 4) Style: Globe, spring loaded.
 - 5) Ends: Flanged.
 - 6) Seat: Bronze.
5. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Material: ASTM A 126, gray iron.
 - 4) Style: Compact wafer, spring loaded.
 - 5) Seat: Bronze.
6. Class 250, Iron, Globe, Center-Guided Check Valves with Metal Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Material: ASTM A 126, gray iron.
 - 4) Style: Globe, spring loaded.
 - 5) Ends: Flanged.
 - 6) Seat: Bronze.
7. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 4) Style: Compact wafer, spring loaded.
 - 5) Seat: Bronze.
8. Class 300, Iron, Globe, Center-Guided Check Valves with Metal Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 4) Style: Globe, spring loaded.
 - 5) Ends: Flanged.
 - 6) Seat: Bronze.
9. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 126, gray iron.
 - 4) Style: Compact wafer.
 - 5) Seat: EPDM **OR** NBR, **as directed**.
10. Class 125, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 126, gray iron.
 - 4) Style: Globe, spring loaded.
 - 5) Ends: Flanged.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
11. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 4) Style: Compact wafer.



- 5) Seat: EPDM **OR** NBR, **as directed**.
 12. Class 150, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 4) Style: Globe, spring loaded.
 - 5) Ends: Flanged.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
 13. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Material: ASTM A 126, gray iron.
 - 4) Style: Compact wafer, spring loaded.
 - 5) Seat: EPDM **OR** NBR, **as directed**.
 14. Class 250, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Material: ASTM A 126, gray iron.
 - 4) Style: Globe, spring loaded.
 - 5) Ends: Flanged.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
 15. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 4) Style: Compact wafer, spring loaded.
 - 5) Seat: EPDM **OR** NBR, **as directed**.
 16. Class 300, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 4) Style: Globe, spring loaded.
 - 5) Ends: Flanged.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
- N. Iron, Plate-Type Check Valves
1. Class 125, Iron, Dual-Plate Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Wafer, spring-loaded plates.
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Seat: Bronze.
 2. Class 150, Iron, Dual-Plate Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Design: Wafer, spring-loaded plates.
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Seat: Bronze.



3. Class 250, Iron, Dual-Plate Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Design: Wafer, spring-loaded plates.
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Seat: Bronze.
4. Class 300, Iron, Dual-Plate Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Design: Wafer, spring-loaded plates.
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Seat: Bronze.
5. Class 125, Iron, Single-Plate Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Wafer, spring-loaded plate.
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Seat: EPDM **OR** NBR, **as directed**.
6. Class 125, Iron, Dual-Plate Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Wafer, spring-loaded plates.
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Seat: EPDM **OR** NBR, **as directed**.
7. Class 150, Iron, Dual-Plate Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Design: Wafer, spring-loaded plates.
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Seat: EPDM **OR** NBR, **as directed**.
8. Class 250, Iron, Wafer, Single-Plate Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Design: Wafer, spring-loaded plate.
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Seat: EPDM **OR** NBR, **as directed**.
9. Class 250, Iron, Dual-Plate Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Design: Wafer, spring-loaded plates.
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Seat: EPDM **OR** NBR, **as directed**.
10. Class 300, Iron, Dual-Plate Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Design: Wafer, spring-loaded plates.
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Seat: EPDM **OR** NBR, **as directed**.



O. Bronze Gate Valves

1. Class 125, NRS Bronze Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded or solder joint, **as directed**.
 - 5) Stem: Bronze.
 - 6) Disc: Solid wedge; bronze.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, RS Bronze Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded or solder joint, **as directed**.
 - 5) Stem: Bronze.
 - 6) Disc: Solid wedge; bronze.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, NRS Bronze Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: Solid wedge; bronze.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
4. Class 150, RS Bronze Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: Solid wedge; bronze.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

P. Iron Gate Valves

1. Class 125, NRS, Iron Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-70, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 4) Ends: Flanged.
 - 5) Trim: Bronze.
 - 6) Disc: Solid wedge.
 - 7) Packing and Gasket: Asbestos free.
2. Class 125, OS&Y, Iron Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-70, Type I.



- 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 4) Ends: Flanged.
 - 5) Trim: Bronze.
 - 6) Disc: Solid wedge.
 - 7) Packing and Gasket: Asbestos free.
3. Class 250, NRS, Iron Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-70, Type I.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 4) Ends: Flanged.
 - 5) Trim: Bronze.
 - 6) Disc: Solid wedge.
 - 7) Packing and Gasket: Asbestos free.
 4. Class 250, OS&Y, Iron Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-70, Type I.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 4) Ends: Flanged.
 - 5) Trim: Bronze.
 - 6) Disc: Solid wedge.
 - 7) Packing and Gasket: Asbestos free.

Q. Bronze Globe Valves

1. Class 125, Bronze Globe Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded or solder joint, **as directed**.
 - 5) Stem and Disc: Bronze.
 - 6) Packing: Asbestos free.
 - 7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, Bronze Globe Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded or solder joint, **as directed**.
 - 5) Stem: Bronze.
 - 6) Disc: PTFE or TFE.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, Bronze Globe Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: PTFE or TFE.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.



R. Iron Globe Valves

1. Class 125, Iron Globe Valves:
 - a. Description:
 - 1) Standard: MSS SP-85, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 4) Ends: Flanged.
 - 5) Trim: Bronze.
 - 6) Packing and Gasket: Asbestos free.
2. Class 250, Iron Globe Valves:
 - a. Description:
 - 1) Standard: MSS SP-85, Type I.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 4) Ends: Flanged.
 - 5) Trim: Bronze.
 - 6) Packing and Gasket: Asbestos free.

S. Lubricated Plug Valves

1. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type II.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 4) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 5) Plug: Cast iron or bronze with sealant groove.
2. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type II.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 4) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 5) Plug: Cast iron or bronze with sealant groove.
3. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type IV.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 4) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 5) Plug: Cast iron or bronze with sealant groove.
4. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type IV.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 4) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 5) Plug: Cast iron or bronze with sealant groove.
5. Class 250, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type II.
 - 2) CWP Rating: 400 psig (2760 kPa).



- 3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 4) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 5) Plug: Cast iron or bronze with sealant groove.
6. Class 250, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
- a. Description:
 - 1) Standard: MSS SP-78, Type II.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 4) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 5) Plug: Cast iron or bronze with sealant groove.
7. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:
- a. Description:
 - 1) Standard: MSS SP-78, Type IV.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 4) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 5) Plug: Cast iron or bronze with sealant groove.
8. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:
- a. Description:
 - 1) Standard: MSS SP-78, Type IV.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Material: ASTM A 48/A 48M or ASTM A 126, Grade 40 cast iron with lubrication-sealing system.
 - 4) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 5) Plug: Cast iron or bronze with sealant groove.

T. Chainwheels

1. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
 - a. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
 - b. Attachment: For connection to ball **OR** butterfly **OR** plug, **as directed**, valve stems.
 - c. Sprocket Rim with Chain Guides: Ductile iron **OR** Cast iron **OR** Aluminum **OR** Bronze, **as directed**, of type and size required for valve. Include zinc coating, **as directed**.
 - d. Chain: Hot-dip, galvanized steel **OR** Brass **OR** Stainless steel, **as directed**, of size required to fit sprocket rim.

1.3 EXECUTION

A. Valve Installation

1. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
2. Locate valves for easy access and provide separate support where necessary.
3. Install valves in horizontal piping with stem at or above center of pipe.
4. Install valves in position to allow full stem movement.
5. Install chainwheels on operators for ball **OR** butterfly **OR** gate **OR** globe **OR** plug, **as directed**, valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.
6. Install check valves for proper direction of flow and as follows:
 - a. Swing Check Valves: In horizontal position with hinge pin level.
 - b. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
 - c. Lift Check Valves: With stem upright and plumb.



- B. Adjusting
1. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.
- C. General Requirements For Valve Applications
1. If valve applications are not indicated, use the following:
 - a. Shutoff Service: Ball **OR** butterfly **OR** gate **OR** plug, **as directed**, valves.
 - b. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 - c. Throttling Service: Globe **OR** angle **OR** ball **OR** butterfly, **as directed**, valves.
 - d. Pump-Discharge Check Valves:
 - 1) NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze **OR** nonmetallic, **as directed**, disc.
 - 2) NPS 2-1/2 (DN 65) and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal **OR** resilient, **as directed**, -seat check valves.
 - 3) NPS 2-1/2 (DN 65) and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
 2. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
 3. Select valves, except wafer types, with the following end connections:
 - a. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 - b. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - c. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
 - d. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
 - e. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - f. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
 - g. For Grooved-End Copper Tubing and Steel Piping: Valve ends may be grooved.
- D. Low-Pressure, Compressed-Air Valve Schedule (150 psig (1035 kPa) Or Less)
1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
 - b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - c. Bronze Lift Check Valves: Class 125, bronze **OR** nonmetallic, **as directed**, disc.
 - d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
 2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - c. Iron, Grooved-End Butterfly Valves: 175 **OR** 300, **as directed**, CWP.
 - d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - e. Iron, Grooved-End Swing Check Valves: 300 CWP.
 - f. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.
 - g. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.



- h. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
- E. High-Pressure, Compressed-Air Valve Schedule (150 to 200 psig (1035 to 1380 kPa))
- 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
 - b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - c. Bronze Lift Check Valves: Class 125, bronze **OR** nonmetallic, **as directed**, disc.
 - d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
 - 2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - c. Iron, Grooved-End Butterfly Valves: 175 **OR** 300, **as directed**, CWP.
 - d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - e. Iron, Grooved-End Swing Check Valves: 300 CWP.
 - f. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.
 - g. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
 - h. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
- F. Domestic, Hot- And Cold-Water Valve Schedule
- 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
 - b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
 - f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - 2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron Ball Valves: Class 150.
 - c. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - d. Iron, Grooved-End Butterfly Valves: 175 **OR** 300, **as directed**, CWP.
 - e. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - f. Iron Swing Check Valves with Closure Control: Class 125, lever and spring **OR** weight, **as directed**.
 - g. Iron, Grooved-End Swing Check Valves: 300 CWP.
 - h. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.



- i. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
- j. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
- k. Iron Globe Valves: Class 125 **OR** Class 250, **as directed**.

G. Sanitary-Waste And Storm-Drainage Valve Schedule

1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
 - b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic **OR** stainless-steel, **as directed**, disc.
 - c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
 - f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron Ball Valves: Class 150.
 - c. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - d. Iron Swing Check Valves with Closure Control: Class 125, lever and spring **OR** weight, **as directed**.
 - e. Iron, Grooved-End Swing Check Valves: 300 CWP.
 - f. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
 - g. Iron Globe Valves: Class 125 **OR** Class 250, **as directed**.
 - h. Lubricated Plug Valves: Class 125 **OR** Class 250, **as directed**, regular gland **OR** cylindrical, **as directed**, threaded **OR** flanged, **as directed**.

END OF SECTION 22 05 23 00a



Task	Specification	Specification Description
22 05 23 00	01 22 16 00	No Specification Required



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**SECTION 22 05 29 00 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for hangers and supports for plumbing piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Metal pipe hangers and supports.
 - b. Trapeze pipe hangers.
 - c. Fiberglass pipe hangers.
 - d. Metal framing systems.
 - e. Fiberglass strut systems.
 - f. Thermal-hanger shield inserts.
 - g. Fastener systems.
 - h. Pipe stands.
 - i. Pipe positioning systems.
 - j. Equipment supports.

C. Definitions

1. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

D. Performance Requirements

1. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - a. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - b. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - c. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - a. Trapeze pipe hangers.
 - b. Metal framing systems.
 - c. Fiberglass strut systems.
 - d. Pipe stands.
 - e. Equipment supports.
3. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of trapeze hangers.



- b. Design Calculations: Calculate requirements for designing trapeze hangers.
4. Welding certificates.

F. Quality Assurance

1. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.2 PRODUCTS

A. Metal Pipe Hangers And Supports

1. Carbon-Steel Pipe Hangers and Supports:
 - a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - b. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - c. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - d. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
2. Stainless-Steel Pipe Hangers and Supports:
 - a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - b. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - c. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
3. Copper Pipe Hangers:
 - a. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
 - b. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel **OR** stainless steel, **as directed**.

B. Trapeze Pipe Hangers

1. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

C. Fiberglass Pipe Hangers

1. Clevis-Type, Fiberglass Pipe Hangers:
 - a. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
 - b. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass, polyurethane or stainless steel.
2. Strap-Type, Fiberglass Pipe Hangers:
 - a. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
 - b. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

D. Metal Framing Systems

1. MFMA Manufacturer Metal Framing Systems:
 - a. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
 - b. Standard: MFMA-4.



- c. Channels: Continuous slotted steel channel with inturned lips.
 - d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
 - f. Metallic Coating: Electroplated zinc **OR** Hot-dipped galvanized **OR** Mill galvanized **OR** In-line, hot galvanized **OR** Mechanically-deposited zinc, **as directed**.
OR
Paint Coating: Vinyl **OR** Vinyl alkyd **OR** Epoxy **OR** Polyester **OR** Acrylic **OR** Amine **OR** Alkyd, **as directed**.
OR
Plastic Coating: PVC **OR** Polyurethane **OR** Epoxy **OR** Polyester, **as directed**.
OR
Combination Coating: **<Insert coating materials in order of application>**.
2. Non-MFMA Manufacturer Metal Framing Systems:
- a. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
 - b. Standard: Comply with MFMA-4.
 - c. Channels: Continuous slotted steel channel with inturned lips.
 - d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
 - f. Coating: Zinc **OR** Paint **OR** PVC, **as directed**.
- E. Fiberglass Strut Systems
- 1. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
 - a. Channels: Continuous slotted fiberglass or other plastic channel with inturned lips.
 - b. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - c. Hanger Rods: Continuous-thread rod, nuts, and washer made of fiberglass **OR** stainless steel, **as directed**.
- F. Thermal-Hanger Shield Inserts
- 1. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
 - 2. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa), ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
 - 3. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
 - 4. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
 - 5. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.
- G. Fastener Systems
- 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated **OR** stainless-, **as directed**, steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- H. Pipe Stands



1. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
 2. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 3. Low-Type, Single-Pipe Stand: One-piece plastic **OR** stainless-steel, **as directed**, base unit with plastic roller, for roof installation without membrane penetration.
 4. High-Type, Single-Pipe Stand:
 - a. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - b. Base: Plastic **OR** Stainless steel, **as directed**.
 - c. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - d. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
 5. High-Type, Multiple-Pipe Stand:
 - a. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - b. Bases: One or more; plastic.
 - c. Vertical Members: Two or more protective-coated-steel channels.
 - d. Horizontal Member: Protective-coated-steel channel.
 - e. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
 6. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.
- I. Pipe Positioning Systems
1. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.
- J. Equipment Supports
1. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.
- K. Miscellaneous Materials
1. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
 2. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - a. Properties: Nonstaining, noncorrosive, and nongaseous.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

1.3 EXECUTION

A. Hanger And Support Installation

1. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
2. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - a. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.



- b. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
3. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
4. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
5. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
6. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
7. Fastener System Installation:
 - a. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - b. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
8. Pipe Stand Installation:
 - a. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - b. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 7 Section "Roof Accessories" for curbs.
9. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. See Division 15 plumbing fixture Sections for requirements for pipe positioning systems for plumbing fixtures.
10. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
11. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
12. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
13. Install lateral bracing with pipe hangers and supports to prevent swaying.
14. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
15. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
16. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
17. Insulated Piping:
 - a. Attach clamps and spacers to piping.
 - 1) Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - 2) Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - 3) Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - b. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - c. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.



- 1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - d. Shield Dimensions for Pipe: Not less than the following:
 - 1) NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - 2) NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - 3) NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - 4) NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - 5) NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
 - e. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - f. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
- B. Equipment Supports
1. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
 2. Grouting: Place grout under supports for equipment and make bearing surface smooth.
 3. Provide lateral bracing, to prevent swaying, for equipment supports.
- C. Metal Fabrications
1. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
 2. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
 3. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.
- D. Adjusting
1. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
 2. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).
- E. Painting
1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

OR

Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting Sections **OR** Section "High-Performance Coatings", **as directed**.
 2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.



F. Hanger And Support Schedule

1. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
2. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
3. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
4. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
5. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
6. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant attachments for hostile environment applications.
7. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
8. Use padded hangers for piping that is subject to scratching.
9. Use thermal-hanger shield inserts for insulated piping and tubing.
10. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - a. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - b. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 - c. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 - d. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 - e. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 - f. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 - g. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - h. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - i. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - j. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 - k. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 - l. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - m. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - n. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - o. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 - p. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.



- q. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
 - r. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
 - s. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 - t. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 - u. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
11. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
- a. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 - b. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
12. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
- a. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 - b. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 - c. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 - d. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 - e. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
13. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
- a. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - b. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 - c. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - d. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - e. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - f. C-Clamps (MSS Type 23): For structural shapes.
 - g. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 - h. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 - i. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 - j. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 - k. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 - l. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:



- 1) Light (MSS Type 31): 750 lb (340 kg).
 - 2) Medium (MSS Type 32): 1500 lb (680 kg).
 - 3) Heavy (MSS Type 33): 3000 lb (1360 kg).
 - m. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 - n. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 - o. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
14. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
- a. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - b. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - c. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
15. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
- a. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 - b. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 - c. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 - d. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 - e. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 - f. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 - g. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 - h. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - 1) Horizontal (MSS Type 54): Mounted horizontally.
 - 2) Vertical (MSS Type 55): Mounted vertically.
 - 3) Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
16. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
17. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
18. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
19. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 22 05 29 00



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Task	Specification	Specification Description
22 05 33 00	07 72 56 00b	Heat Tracing for Plumbing Piping



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**SECTION 22 05 48 13 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of vibration and seismic controls for plumbing piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Isolation pads.
 - b. Isolation mounts.
 - c. Restrained elastomeric isolation mounts.
 - d. Freestanding and Restrained spring isolators.
 - e. Housed spring mounts.
 - f. Elastomeric hangers.
 - g. Spring hangers.
 - h. Spring hangers with vertical-limit stops.
 - i. Pipe riser resilient supports.
 - j. Resilient pipe guides.
 - k. Seismic snubbers.
 - l. Restraining braces and cables.
 - m. Steel and Inertia, vibration isolation equipment bases.

C. Definitions

1. IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. Performance Requirements

1. Seismic-Restraint Loading:
 - a. Site Class as Defined in the IBC: **A OR B OR C OR D OR E OR F, as directed.**
 - b. Assigned Seismic Use Group or Building Category as Defined in the IBC: **I OR II OR III, as directed.**
 - 1) Component Importance Factor: **1.0 OR 1.5, as directed.**
 - 2) Component Response Modification Factor: **1.5 OR 2.5 OR 3.5 OR 5.0, as directed.**
 - 3) Component Amplification Factor: **1.0 OR 2.5, as directed.**
 - c. Design Spectral Response Acceleration at Short Periods (0.2 Second): Percentage as directed.
 - d. Design Spectral Response Acceleration at 1-Second Period: Percentage as directed.

E. Submittals

1. Product Data: For each product indicated.
2. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Qualification Data: For professional engineer.
5. Field quality-control test reports.

F. Quality Assurance

Vibration And Seismic Controls For Plumbing Piping And
Equipment



1. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproved by ICC-ES, or preapproved by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.2 PRODUCTS

A. Vibration Isolators

1. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
 - a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
3. Restrained Mounts: All-directional mountings with seismic restraint.
 - a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
4. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
 - a. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - b. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - c. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - d. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - e. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
 - f. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
5. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
 - a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.



- b. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 - c. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - d. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - e. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - f. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
 - a. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
 - b. Base: Factory drilled for bolting to structure.
 - c. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel up or down before contacting a resilient collar.
 7. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
 8. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
 - a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 - g. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
 9. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
 - a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - g. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 - h. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
 10. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.
 11. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion



and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

B. Vibration Isolation Equipment Bases

1. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
 - a. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - 1) Include supports for suction and discharge elbows for pumps.
 - b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
 - c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
2. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
 - a. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - 1) Include supports for suction and discharge elbows for pumps.
 - b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
 - c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 - d. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

C. Seismic-Restraint Devices

1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - a. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 - b. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - c. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.
3. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
4. Restraint Cables: ASTM A 603 galvanized-steel **OR** ASTM A 492 stainless-steel, **as directed**, cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
5. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
6. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.



7. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
8. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
9. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
10. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

D. Factory Finishes

1. Finish:

- a. Manufacturer's standard prime-coat finish ready for field painting.

OR

Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

- 1) Powder coating on springs and housings.
- 2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
- 3) Baked enamel or powder coat for metal components on isolators for interior use.
- 4) Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

1.3 EXECUTION

A. Applications

1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Vibration-Control And Seismic-Restraint Device Installation

1. Equipment Restraints:

- a. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
- b. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches (3.2 mm).
- c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.

2. Piping Restraints:

- a. Comply with requirements in MSS SP-127.
- b. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.



- c. Brace a change of direction longer than 12 feet (3.7 m).
 3. Install cables so they do not bend across edges of adjacent equipment or building structure.
 4. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
 5. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
 6. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
 7. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
 8. Drilled-in Anchors:
 - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - e. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - f. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.
- C. Accommodation Of Differential Seismic Motion
1. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 22 Section "Domestic Water Piping" for piping flexible connections.
- D. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - b. Schedule test with the Owner before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - c. Obtain approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - d. Test at least four of each type and size of installed anchors and fasteners selected.
 - e. Test to 90 percent of rated proof load of device.
 - f. Measure isolator restraint clearance.
 - g. Measure isolator deflection.
 - h. Verify snubber minimum clearances.
 - i. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.



-
- j. Air-Mounting System Operational Test: Test the compressed-air leveling system.
 - k. Test and adjust air-mounting system controls and safeties.
 - l. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
3. Remove and replace malfunctioning units and retest as specified above.
 4. Prepare test and inspection reports.
- E. Adjusting
1. Adjust isolators after piping system is at operating weight.
 2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
 3. Adjust active height of sprint isolators.
 4. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 22 05 48 13



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SECTION 22 05 53 00 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for identification for plumbing piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Equipment labels.
 - b. Warning signs and labels.
 - c. Pipe labels.
 - d. Stencils.
 - e. Valve tags.
 - f. Warning tags.

C. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Equipment Labels

1. Metal Labels for Equipment:
 - a. Material and Thickness: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - b. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 - c. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - d. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
 - e. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
2. Plastic Labels for Equipment:
 - a. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
 - b. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - c. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - d. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 - e. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 - f. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - g. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
 - h. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.



3. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
 4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.
- B. Warning Signs And Labels
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
 2. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 3. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
 9. Label Content: Include caution and warning information, plus emergency notification instructions.
- C. Pipe Labels
1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
 2. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover **OR** cover full, **as directed**, circumference of pipe and to attach to pipe without fasteners or adhesive.
 3. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
 4. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - a. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - b. Lettering Size: At least 1-1/2 inches (38 mm) high.
- D. Stencils
1. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
 - a. Stencil Material: Aluminum **OR** Brass **OR** Fiberboard, **as directed**.
 - b. Stencil Paint: Exterior, gloss, alkyd enamel **OR** acrylic enamel, **as directed**, black unless otherwise indicated. Paint may be in pressurized spray-can form.
 - c. Identification Paint: Exterior, alkyd enamel **OR** acrylic enamel, **as directed**, in colors according to ASME A13.1 unless otherwise indicated.
- E. Valve Tags
1. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
 - a. Tag Material: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.



- b. Fasteners: Brass wire-link chain **OR** beaded chain **OR** S-hook, **as directed**.
2. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - a. Valve-tag schedule shall be included in operation and maintenance data.

F. Warning Tags

1. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - a. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum **OR** Approximately 4 by 7 inches (100 by 178 mm), **as directed**.
 - b. Fasteners: Brass grommet and wire **OR** Reinforced grommet and wire or string, **as directed**.
 - c. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - d. Color: Yellow background with black lettering.

1.3 EXECUTION

A. Preparation

1. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

B. Equipment Label Installation

1. Install or permanently fasten labels on each major item of mechanical equipment.
2. Locate equipment labels where accessible and visible.

C. Pipe Label Installation

1. Piping Color-Coding: Painting of piping is specified in Division 09 Section(s) "Interior Painting" **OR** "High-performance Coatings", **as directed**.
2. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles **OR** complying with ASME A13.1, **as directed**, on each piping system.
 - a. Identification Paint: Use for contrasting background.
 - b. Stencil Paint: Use for pipe marking.
3. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - a. Near each valve and control device.
 - b. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - c. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - d. At access doors, manholes, and similar access points that permit view of concealed piping.
 - e. Near major equipment items and other points of origination and termination.
 - f. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
 - g. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
4. Pipe Label Color Schedule:
 - a. Low-Pressure, Compressed-Air Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - b. Medium-Pressure, Compressed-Air Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.



- 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
- c. Domestic Water Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
- d. Sanitary Waste and Storm Drainage Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

D. Valve-Tag Installation

1. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
2. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - a. Valve-Tag Size and Shape:
 - 1) Cold Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 2) Hot Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 3) Low-Pressure Compressed Air: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 4) High-Pressure Compressed Air: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - b. Valve-Tag Color:
 - 1) Cold Water: Natural **OR** Green, **as directed**.
 - 2) Hot Water: Natural **OR** Green, **as directed**.
 - 3) Low-Pressure Compressed Air: Natural **OR** Green, **as directed**.
 - 4) High-Pressure Compressed Air: Natural **OR** Green, **as directed**.
 - c. Letter Color:
 - 1) Cold Water: Black **OR** White, **as directed**.
 - 2) Hot Water: Black **OR** White, **as directed**.
 - 3) Low-Pressure Compressed Air: Black **OR** White, **as directed**.
 - 4) High-Pressure Compressed Air: Black **OR** White, **as directed**.

E. Warning-Tag Installation

1. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 22 05 53 00

**SECTION 22 05 76 00 - SANITARY SEWERAGE**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for sanitary sewerage. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pipe and fittings.
 - b. Nonpressure and pressure couplings.
 - c. Expansion joints and deflection fittings.
 - d. Backwater valves.
 - e. Cleanouts.
 - f. Encasement for piping.
 - g. Manholes.

C. Definitions

1. FRP: Fiberglass-reinforced plastic.

D. Submittals

1. Product Data: For the following:
 - a. Expansion joints and deflection fittings.
 - b. Backwater valves.
2. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.
3. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewer system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
4. Profile Drawings: Show system piping in elevation. Draw profiles to horizontal scale of not less than 1 inch equals 50 feet (1:500) and to vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.
5. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.
6. Field quality-control reports.

E. Delivery, Storage, And Handling

1. Do not store plastic manholes, pipe, and fittings in direct sunlight.
2. Protect pipe, pipe fittings, and seals from dirt and damage.
3. Handle manholes according to manufacturer's written rigging instructions.

F. Project Conditions

1. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of service.
 - b. Do not proceed with interruption of service without the Owner written permission.



1.2 PRODUCTS

- A. Hub-And-Spigot, Cast-Iron Soil Pipe And Fittings
1. Pipe and Fittings: ASTM A 74, Service class **OR** Service and Extra-Heavy classes **OR** Extra-Heavy class, **as directed**.
 2. Gaskets: ASTM C 564, rubber.
 3. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.
- B. Hubless Cast-Iron Soil Pipe And Fittings
1. Pipe and Fittings: ASTM A 888 or CISPI 301.
 2. CISPI-Trademark, Shielded Couplings:
 - a. Description: ASTM C 1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
 3. Heavy-Duty, Shielded Couplings:
 - a. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
 4. Cast-Iron, Shielded Couplings:
 - a. Description: ASTM C 1277 with ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.
 5. Unshielded Couplings:
 - a. Description: ASTM C 1277 and ASTM C 1461, rigid, sleeve-type, reducing- or transition-type mechanical coupling, with integral, center pipe stop, molded from ASTM C 1440, TPE material; with corrosion-resistant-metal tension band and tightening mechanism on each end.
- C. Ductile-Iron, Gravity Sewer Pipe And Fittings
1. Pipe: ASTM A 746, for push-on joints.
 2. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
 3. Compact Fittings: AWWA C153, ductile iron, for push-on joints.
 4. Gaskets: AWWA C111, rubber.
- D. Ductile-Iron, Pressure Pipe And Fittings
1. Push-on-Joint Piping:
 - a. Pipe: AWWA C151.
 - b. Standard Fittings: AWWA C110, ductile or gray iron.
 - c. Compact Fittings: AWWA C153.
 - d. Gaskets: AWWA C111, rubber, of shape matching pipe and fittings.
 2. Mechanical-Joint Piping:
 - a. Pipe: AWWA C151, with bolt holes in bell.
 - b. Standard Fittings: AWWA C110, ductile or gray iron, with bolt holes in bell.
 - c. Compact Fittings: AWWA C153, with bolt holes in bells.
 - d. Glands: Cast or ductile iron; with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
 - e. Gaskets: AWWA C111, rubber, of shape matching pipe, fittings, and glands.
- E. ABS Pipe And Fittings
1. ABS Sewer Pipe and Fittings: ASTM D 2751, with bell-and-spigot ends for gasketed joints.
 - a. NPS 3 to NPS 6 (DN 80 to DN 150): SDR 35.
 - b. NPS 8 to NPS 12 (DN 200 to DN 300): SDR 42.
 2. Gaskets: ASTM F 477, elastomeric seals.
- F. PVC Pipe And Fittings



1. PVC Cellular-Core Sewer Piping:
 - a. Pipe: ASTM F 891, Sewer and Drain Series, PS 50 minimum stiffness, PVC cellular-core pipe with plain ends for solvent-cemented joints.
 - b. Fittings: ASTM D 3034, SDR 35, PVC socket-type fittings.
 2. PVC Corrugated Sewer Piping:
 - a. Pipe: ASTM F 949, PVC corrugated pipe with bell-and-spigot ends for gasketed joints.
 - b. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
 - c. Gaskets: ASTM F 477, elastomeric seals.
 3. PVC Profile Sewer Piping:
 - a. Pipe: ASTM F 794, PVC profile, gravity sewer pipe with bell-and-spigot ends for gasketed joints.
 - b. Fittings: ASTM D 3034, PVC with bell ends.
 - c. Gaskets: ASTM F 477, elastomeric seals.
 4. PVC Type PSM Sewer Piping:
 - a. Pipe: ASTM D 3034, SDR 35, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
 - b. Fittings: ASTM D 3034, PVC with bell ends.
 - c. Gaskets: ASTM F 477, elastomeric seals.
 5. PVC Gravity Sewer Piping:
 - a. Pipe and Fittings: ASTM F 679, T-1 **OR** T-2, **as directed**, wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.
 6. PVC Pressure Piping:
 - a. Pipe: AWWA C900, Class 100 **OR** Class 150 **OR** Class 200, **as directed**, PVC pipe with bell-and-spigot ends for gasketed joints.
 - b. Fittings: AWWA C900, Class 100 **OR** Class 150 **OR** Class 200, **as directed**, PVC pipe with bell ends.
 - c. Gaskets: ASTM F 477, elastomeric seals.
 7. PVC Water-Service Piping:
 - a. Pipe: ASTM D 1785, Schedule 40 **OR** Schedule 80, **as directed**, PVC, with plain ends for solvent-cemented joints.
 - b. Fittings: ASTM D 2466, Schedule 40 **OR** ASTM D 2467, Schedule 80, **as directed**, PVC, socket type.
- G. Fiberglass Pipe And Fittings
1. Fiberglass Sewer Pipe: ASTM D 3262, RTRP, for gasketed joints fabricated with Type 2, polyester **OR** Type 4, epoxy, **as directed**, resin.
 - a. Liner: Reinforced thermoset **OR** Nonreinforced thermoset **OR** Thermoplastic **OR** No liner, **as directed**.
 - b. Grade: Reinforced, surface layer matching pipe resin **OR** Nonreinforced, surface layer matching pipe resin **OR** No surface layer, **as directed**.
 - c. Stiffness: 9 psig (62 kPa) **OR** 18 psig (124 kPa) **OR** 36 psig (248 kPa) **OR** 72 psig (496 kPa), **as directed**.
 2. Fiberglass Nonpressure Fittings: ASTM D 3840, RTRF, for gasketed joints.
 - a. Laminating Resin: Type 1, polyester **OR** Type 2, epoxy, **as directed**, resin.
 - b. Reinforcement: Grade with finish compatible with resin.
 3. Gaskets: ASTM F 477, elastomeric seals.
- H. Concrete Pipe And Fittings
1. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 (ASTM C 14M), Class 1 **OR** Class 2 **OR** Class 3, **as directed**, with bell-and-spigot **OR** tongue-and-groove, **as directed**, ends for gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets.
 2. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M).
 - a. Bell-and-spigot **OR** tongue-and-groove, **as directed**, ends for gasketed joints, with ASTM C 443 (ASTM C 443M), rubber gaskets.
 - b. Class II, Wall A **OR** Wall B **OR** Wall C, **as directed**.



- c. Class III, Wall A **OR** Wall B **OR** Wall C, **as directed**.
 - d. Class IV, Wall A **OR** Wall B **OR** Wall C, **as directed**.
 - e. Class V, Wall A **OR** Wall B, **as directed**.
- I. Nonpressure-Type Transition Couplings
1. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.
 2. Sleeve Materials:
 - a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - b. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
 - c. For Fiberglass Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - d. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - e. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
 3. Unshielded, Flexible Couplings:
 - a. Description: Elastomeric sleeve, with stainless-steel shear ring, **as directed**, and corrosion-resistant-metal tension band and tightening mechanism on each end.
 4. Shielded, Flexible Couplings:
 - a. Description: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 5. Ring-Type, Flexible Couplings:
 - a. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.
 6. Nonpressure-Type, Rigid Couplings:
 - a. Description: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling, molded from ASTM C 1440, TPE material; with corrosion-resistant-metal tension band and tightening mechanism on each end.
- J. Pressure-Type Pipe Couplings
1. Tubular-Sleeve Couplings: AWWA C219, with center sleeve, gaskets, end rings, and bolt fasteners.
 2. Metal, bolted, sleeve-type, reducing or transition coupling, for joining underground pressure piping. Include 150-psig (1035-kPa) **OR** 200-psig (1380-kPa), **as directed**, minimum pressure rating and ends of same sizes as piping to be joined.
 3. Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
 4. Gasket Material: Natural or synthetic rubber.
 5. Metal Component Finish: Corrosion-resistant coating or material.
- K. Expansion Joints And Deflection Fittings
1. Ductile-Iron, Flexible Expansion Joints:
 - a. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig (1725-kPa) minimum working pressure and for offset and expansion indicated.
 2. Ductile-Iron Expansion Joints:
 - a. Description: Three-piece assembly of telescoping sleeve with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Include rating for 250-psig (1725-kPa) minimum working pressure and for expansion indicated.
 3. Ductile-Iron Deflection Fittings:



- a. Description: Compound coupling fitting with ball joint, flexing section, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include rating for 250-psig (1725-kPa) minimum working pressure and for up to 15 degrees of deflection.
- L. Backwater Valves
1. Cast-Iron Backwater Valves:
 - a. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
 - b. Horizontal type; with swing check valve and hub-and-spigot ends.
 - c. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
 - d. Terminal type; with bronze seat, swing check valve, and hub inlet.
 2. PVC Backwater Valves:
 - a. Description: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.
- M. Cleanouts
1. Cast-Iron Cleanouts:
 - a. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
 - b. Top-Loading Classification(s): Light Duty **OR** Medium Duty **OR** Heavy Duty **OR** Extra-Heavy Duty, **as directed**.
 - c. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.
 2. PVC Cleanouts:
 - a. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.
- N. Encasement For Piping
1. Standard: ASTM A 674 or AWWA C105.
 2. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) **OR** high-density, cross-laminated polyethylene film of 0.004-inch (0.10-mm), **as directed**, minimum thickness.
 3. Form: Sheet **OR** Tube, **as directed**.
 4. Color: Black **OR** Natural, **as directed**.
- O. Manholes
1. Standard Precast Concrete Manholes:
 - a. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
 - b. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
 - c. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
 - d. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (100-mm) minimum thickness for walls and base riser section; with separate base slab or base section with integral floor.
 - e. Riser Sections: 4-inch (100-mm) minimum thickness, of length to provide depth indicated.
 - f. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated; with top of cone of size that matches grade rings.
 - g. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
 - h. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
 - i. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**; wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor



- steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
- j. Adjusting Rings: Interlocking HDPE rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
OR
Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.
2. Designed Precast Concrete Manholes:
 - a. Description: ASTM C 913; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for sealant joints.
 - b. Ballast: Increase thickness of one or more precast concrete sections or add concrete to manhole as required to prevent flotation.
 - c. Joint Sealant: ASTM C 990 (ASTM 990M), bitumen or butyl rubber.
 - d. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
 - e. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**; wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
 - f. Adjusting Rings: Interlocking HDPE rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
OR
Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.
 3. Fiberglass Manholes:
 - a. Description: ASTM D 3753.
 - b. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
 - c. Ballast: Increase thickness of concrete base as required to prevent flotation.
 - d. Base Section: Concrete, 6-inch (150-mm) minimum thickness.
 - e. Resilient Pipe Connectors (if required): ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
 - f. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
 - g. Adjusting Rings: Interlocking HDPE rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
OR
Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.
 4. Manhole Frames and Covers:



- a. Description: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser, with 4-inch- (100-mm-) minimum-width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
 - b. Material: ASTM A 536, Grade 60-40-18 ductile **OR** ASTM A 48/A 48M, Class 35 gray, **as directed**, iron unless otherwise indicated.
5. Manhole-Cover Inserts:
- a. Description: Manufactured, plastic form, of size to fit between manhole frame and cover and designed to prevent stormwater inflow. Include handle for removal and gasket for gastight sealing.
 - b. Type: Solid **OR** Drainage with vent holes **OR** Valve, **as directed**.

P. Concrete

1. General: Cast-in-place concrete complying with ACI 318, ACI 350/350R (ACI 350M/350RM), and the following:
 - a. Cement: ASTM C 150, Type II.
 - b. Fine Aggregate: ASTM C 33, sand.
 - c. Coarse Aggregate: ASTM C 33, crushed gravel.
 - d. Water: Potable.
2. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.
 - a. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
 - b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.
3. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
 - a. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
 - 1) Invert Slope: **1 OR 2, as directed**, percent through manhole.
 - b. Benches: Concrete, sloped to drain into channel.
 - 1) Slope: **4 OR 8, as directed**, percent.
4. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.
 - a. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
 - b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

1.3 EXECUTION

A. Earthwork

1. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Piping Installation

1. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
2. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
3. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
4. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.



5. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
6. Install gravity-flow, nonpressure, drainage piping according to the following:
 - a. Install piping pitched down in direction of flow, at minimum slope of 1 **OR** 2, **as directed**, percent unless otherwise indicated.
 - b. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
 - c. Install piping with 36-inch (915-mm) **OR** 48-inch (1220-mm) **OR** 60-inch (1520-mm) **OR** 72-inch (1830-mm), **as directed**, minimum cover.
 - d. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 - e. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 - f. Install ductile-iron, gravity sewer piping according to ASTM A 746.
 - g. Install ABS sewer piping according to ASTM D 2321 and ASTM F 1668.
 - h. Install PVC cellular-core sewer piping according to ASTM D 2321 and ASTM F 1668.
 - i. Install PVC corrugated sewer piping according to ASTM D 2321 and ASTM F 1668.
 - j. Install PVC profile sewer piping according to ASTM D 2321 and ASTM F 1668.
 - k. Install PVC Type PSM sewer piping according to ASTM D 2321 and ASTM F 1668.
 - l. Install PVC gravity sewer piping according to ASTM D 2321 and ASTM F 1668.
 - m. Install fiberglass sewer piping according to ASTM D 3839 and ASTM F 1668.
 - n. Install nonreinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
 - o. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
7. Install force-main, pressure piping according to the following:
 - a. Install piping with restrained joints at tee fittings and at horizontal and vertical changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
 - b. Install piping with 36-inch (915-mm) **OR** 48-inch (1220-mm) **OR** 60-inch (1520-mm) **OR** 72-inch (1830-mm), **as directed**, minimum cover.
 - c. Install ductile-iron pressure piping according to AWWA C600 or AWWA M41.
 - d. Install ductile-iron special fittings according to AWWA C600.
 - e. Install PVC pressure piping according to AWWA M23 or to ASTM D 2774 and ASTM F 1668.
 - f. Install PVC water-service piping according to ASTM D 2774 and ASTM F 1668.
8. If required to provide protection for metal piping, install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:
 - a. Hub-and-spigot, cast-iron soil pipe.
 - b. Hubless cast-iron soil pipe and fittings.
 - c. Ductile-iron pipe and fittings.
 - d. Expansion joints and deflection fittings.
9. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

C. Pipe Joint Construction

1. Join gravity-flow, nonpressure, drainage piping according to the following:
 - a. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
 - b. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
 - c. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.



- d. Join ductile-iron, gravity sewer piping according to AWWA C600 for push-on joints.
 - e. Join ABS sewer piping according to ASTM D 2321 and ASTM D 2751 for elastomeric-seal joints.
 - f. Join PVC cellular-core sewer piping according to ASTM D 2321 and ASTM F 891 for solvent-cemented joints.
 - g. Join PVC corrugated sewer piping according to ASTM D 2321.
 - h. Join PVC profile sewer piping according to ASTM D 2321 for elastomeric-seal joints or ASTM F 794 for gasketed joints.
 - i. Join PVC Type PSM sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
 - j. Join PVC gravity sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
 - k. Join fiberglass sewer piping according to ASTM D 4161 for elastomeric-seal joints.
 - l. Join nonreinforced-concrete sewer piping according to ASTM C 14 (ASTM C 14M) and ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
 - m. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
 - n. Join dissimilar pipe materials with nonpressure-type, flexible **OR** rigid, **as directed**, couplings.
2. Join force-main, pressure piping according to the following:
 - a. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.
 - b. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
 - c. Join PVC pressure piping according to AWWA M23 for gasketed joints.
 - d. Join PVC water-service piping according to ASTM D 2855.
 - e. Join dissimilar pipe materials with pressure-type couplings.
 3. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
 - a. Use nonpressure flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
 - 1) Unshielded **OR** Shielded, **as directed**, flexible **OR** rigid, **as directed**, couplings for pipes of same or slightly different OD.
 - 2) Unshielded, increaser/reducer-pattern, flexible **OR** rigid, **as directed**, couplings for pipes with different OD.
 - 3) Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
 - b. Use pressure pipe couplings for force-main joints.
- D. Manhole Installation
1. General: Install manholes complete with appurtenances and accessories indicated.
 2. Install precast concrete manhole sections with sealants according to ASTM C 891.
 3. Install FRP manholes according to manufacturer's written instructions.
 4. Form continuous concrete channels and benches between inlets and outlet.
 5. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.
 6. Install manhole-cover inserts in frame and immediately below cover.
- E. Concrete Placement
1. Place cast-in-place concrete according to ACI 318.
- F. Backwater Valve Installation
1. Install horizontal-type backwater valves in piping manholes or pits.
 2. Install combination horizontal and manual gate valves in piping and in manholes.
 3. Install terminal-type backwater valves on end of piping and in manholes. Secure units to sidewalls.



G. Cleanout Installation

1. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
 - a. Use Light-Duty, top-loading classification cleanouts in earth **OR** unpaved foot-traffic, **as directed**, areas.
 - b. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
 - c. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
 - d. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.
2. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding grade.
3. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

H. Connections

1. Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains specified in Division 22 Section "Sanitary Waste And Vent Piping".
2. Connect force-main piping to building's sanitary force mains specified in Division 22 Section "Sanitary Waste And Vent Piping". Terminate piping where indicated.
3. Make connections to existing piping and underground manholes.
 - a. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch (150-mm) overlap with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
 - b. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
 - c. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.
 - 1) Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
 - 2) Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
 - d. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.
4. Connect to grease **OR** oil **OR** sand, **as directed**, interceptors specified in Division 22 Section "Sanitary Waste Interceptors".

I. Closing Abandoned Sanitary Sewer Systems

1. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
 - a. Close open ends of piping with at least 8-inch- (203-mm-) thick, brick masonry bulkheads.
 - b. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
2. Abandoned Manholes: Excavate around manhole as required and use either procedure below:
 - a. Remove manhole and close open ends of remaining piping.



- b. Remove top of manhole down to at least 36 inches (915 mm) below final grade. Fill to within 12 inches (300 mm) of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.
3. Backfill to grade according to Division 31 Section "Earth Moving".

J. Identification

1. Materials and their installation are specified in Division 31 Section "Earth Moving". Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
 - a. Use warning tape **OR** detectable warning tape, **as directed**, over ferrous piping.
 - b. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

K. Field Quality Control

1. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of Project.
 - a. Submit separate report for each system inspection.
 - b. Defects requiring correction include the following:
 - 1) Alignment: Less than full diameter of inside of pipe is visible between structures.
 - 2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - 3) Damage: Crushed, broken, cracked, or otherwise damaged piping.
 - 4) Infiltration: Water leakage into piping.
 - 5) Exfiltration: Water leakage from or around piping.
 - c. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 - d. Reinspect and repeat procedure until results are satisfactory.
2. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - a. Do not enclose, cover, or put into service before inspection and approval.
 - b. Test completed piping systems according to requirements of authorities having jurisdiction.
 - c. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 - d. Submit separate report for each test.
 - e. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
 - 1) Fill sewer piping with water. Test with pressure of at least 10-foot (3-m) head of water, and maintain such pressure without leakage for at least 15 minutes.
 - 2) Close openings in system and fill with water.
 - 3) Purge air and refill with water.
 - 4) Disconnect water supply.
 - 5) Test and inspect joints for leaks.

OR

Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

 - 6) Option: Test plastic gravity sewer piping according to ASTM F 1417.
 - 7) Option: Test concrete gravity sewer piping according to ASTM C 924 (ASTM C 924M).
 - f. Force Main: Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 150 psig (1035 kPa).
 - 1) Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
 - 2) PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.
 - g. Manholes: Perform hydraulic test according to ASTM C 969 (ASTM C 969M).
3. Leaks and loss in test pressure constitute defects that must be repaired.



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4. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

L. Cleaning

1. Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION 22 05 76 00



SECTION 22 05 76 00a - STORM DRAINAGE PIPING SPECIALTIES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for storm drainage piping specialties. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Roof drains.
 - b. Miscellaneous storm drainage piping specialties.
 - c. Cleanouts.
 - d. Backwater valves.
 - e. Trench drains.
 - f. Channel drainage systems.
 - g. Through-penetration firestop assemblies.
 - h. Flashing materials.

C. Submittals

1. Product Data: For each type of product indicated.

D. Quality Assurance

1. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.2 PRODUCTS

A. Metal Roof Drains

1. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
 - a. Standard: ASME A112.6.4, for general-purpose roof drains.
 - b. Body Material: Cast iron.
 - c. Dimension of Body: Nominal 14-inch (357-mm) diameter.
 - d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
 - e. Flow-Control Weirs: Not required **OR** Required, **as directed**.
 - f. Outlet: Bottom **OR** Side, **as directed**.
 - g. Extension Collars: Not required **OR** Required, **as directed**.
 - h. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - i. Expansion Joint: Not required **OR** Required, **as directed**.
 - j. Sump Receiver Plate: Not required **OR** Required, **as directed**.
 - k. Dome Material: Aluminum **OR** Cast iron **OR** PE **OR** Stainless steel, **as directed**.
 - l. Perforated Gravel Guard: Stainless steel **OR** Not required, **as directed**.
 - m. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
 - n. Water Dam: Not required **OR** 2 inches (51 mm) high, **as directed**.
2. Cast-Iron, Medium-Sump, General-Purpose Roof Drains:
 - a. Standard: ASME A112.6.4, for general-purpose roof drains.
 - b. Body Material: Cast iron.
 - c. Dimension of Body: 8- to 12-inch (203- to 305-mm) diameter.
 - d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
 - e. Flow-Control Weirs: Not required **OR** Required, **as directed**.
 - f. Outlet: Bottom **OR** Side, **as directed**.
 - g. Extension Collars: Not required **OR** Required, **as directed**.



- h. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - i. Expansion Joint: Not required **OR** Required, **as directed**.
 - j. Sump Receiver Plate: Not required **OR** Required, **as directed**.
 - k. Dome Material: Aluminum **OR** Cast iron **OR** Copper **OR** PE **OR** Stainless steel, **as directed**.
 - l. Wire Mesh: Stainless steel or brass over dome **OR** Not required, **as directed**.
 - m. Perforated Gravel Guard: Stainless steel **OR** Not required, **as directed**.
 - n. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
 - o. Water Dam: Not required **OR** 2 inches (51 mm) high, **as directed**.
3. Copper, Medium-Sump, General-Purpose Roof Drains:
- a. Standard: ASME A112.6.4, for general-purpose roof drains.
 - b. Body Material: Copper.
 - c. Dimension of Body: 8- to 12-inch (203- to 305-mm) diameter.
 - d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
 - e. Flow-Control Weirs: Not required **OR** Required, **as directed**.
 - f. Outlet: Bottom **OR** Side, **as directed**.
 - g. Extension Collars: Not required **OR** Required, **as directed**.
 - h. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - i. Expansion Joint: Not required **OR** Required, **as directed**.
 - j. Sump Receiver Plate: Not required **OR** Required, **as directed**.
 - k. Dome Material: Aluminum **OR** Cast iron **OR** Copper **OR** PE **OR** Stainless steel, **as directed**.
 - l. Wire Mesh: Stainless steel or brass over dome **OR** Not required, **as directed**.
 - m. Perforated Gravel Guard: Stainless steel **OR** Not required, **as directed**.
 - n. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
 - o. Water Dam: Not required **OR** 2 inches (51 mm) high, **as directed**.
4. Cast-Iron, Small-Sump, General-Purpose Roof Drains:
- a. Standard: ASME A112.6.4, for general-purpose roof drains.
 - b. Body Material: Cast iron.
 - c. Dimension of Body: Nominal 8-inch (203-mm) diameter.
 - d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
 - e. Outlet: Bottom **OR** Side, **as directed**.
 - f. Extension Collars: Not required **OR** Required, **as directed**.
 - g. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - h. Expansion Joint: Not required **OR** Required, **as directed**.
 - i. Sump Receiver Plate: Not required **OR** Required, **as directed**.
 - j. Dome Material: Cast iron.
 - k. Wire Mesh: Stainless steel or brass over dome **OR** Not required, **as directed**.
 - l. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
5. Copper, Small-Sump, General-Purpose Roof Drains:
- a. Standard: ASME A112.6.4, for general-purpose roof drains.
 - b. Body Material: Copper.
 - c. Dimension of Body: Nominal 8-inch (203-mm) diameter.
 - d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
 - e. Outlet: Bottom **OR** Side, **as directed**.
 - f. Extension Collars: Not required **OR** Required, **as directed**.
 - g. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - h. Expansion Joint: Not required **OR** Required, **as directed**.
 - i. Sump Receiver Plate: Not required **OR** Required, **as directed**.
 - j. Dome Material: Cast iron.
 - k. Wire Mesh: Stainless steel or brass over dome **OR** Not required, **as directed**.
 - l. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
6. Metal, Cornice and Gutter Roof Drains:
- a. Standard: ASME A112.6.4, for cornice and gutter roof drains.
 - b. Body Material: Metal.



- c. Dimension of Body: Nominal 6-inch (152-mm) diameter.
 - d. Outlet: Bottom **OR** Side **OR** 45-degree angle, **as directed**.
 - e. Dome Material: Bronze.
 - f. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
7. Metal, Parapet Roof Drains:
- a. Standard: ASME A112.6.4, for parapet roof drains.
 - b. Body Material: Cast iron.
 - c. Outlet: Back **OR** Angle, **as directed**.
 - d. Grate Material: Bronze **OR** Cast iron **OR** Nickel-bronze alloy, **as directed**.
 - e. Vandal-Proof Grate: Not required **OR** Required, **as directed**.
8. Metal, Large-Sump, Promenade Roof Drains:
- a. Standard: ASME A112.6.4, for promenade roof drains.
 - b. Body Material: Cast iron.
 - c. Dimension of Body: Nominal 14-inch (357-mm) diameter.
 - d. Dimension of Frame and Grate: Nominal 14 inches (357 mm) square.
 - e. Outlet: Bottom.
 - f. Grate Material: Bronze **OR** Cast iron **OR** Nickel-bronze alloy, **as directed**.
 - g. Vandal-Proof Grate: Not required **OR** Required, **as directed**.
 - h. Extension Collars: Not required **OR** Required, **as directed**.
 - i. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - j. Expansion Joint: Not required **OR** Required, **as directed**.
 - k. Sump Receiver Plate: Not required **OR** Required, **as directed**.
9. Metal, Medium-Sump, Promenade Roof Drains:
- a. Standard: ASME A112.6.4, for promenade roof drains.
 - b. Body Material: Cast iron.
 - c. Dimension of Body: 11- to 12-inch (280- to 305-mm) diameter.
 - d. Dimension of Frame and Grate: Nominal 12 inches (305 mm) square.
 - e. Outlet: Bottom.
 - f. Grate Material: Bronze **OR** Cast iron **OR** Nickel-bronze alloy, **as directed**.
 - g. Vandal-Proof Grate: Not required **OR** Required, **as directed**.
 - h. Extension Collars: Not required **OR** Required, **as directed**.
 - i. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - j. Expansion Joint: Not required **OR** Required, **as directed**.
 - k. Sump Receiver Plate: Not required **OR** Required, **as directed**.
10. Metal, Small-Sump, Promenade Roof Drains:
- a. Standard: ASME A112.6.4, for promenade roof drains.
 - b. Body Material: Cast iron.
 - c. Dimension of Body: Nominal 8-inch (203-mm) diameter.
 - d. Dimension of Frame and Grate: Nominal 8 inches (203 mm) square.
 - e. Outlet: Bottom.
 - f. Grate Material: Bronze **OR** Cast iron **OR** Nickel-bronze alloy, **as directed**.
 - g. Vandal-Proof Grate: Not required **OR** Required, **as directed**.
 - h. Extension Collars: Not required **OR** Required, **as directed**.
 - i. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - j. Expansion Joint: Not required **OR** Required, **as directed**.
 - k. Sump Receiver Plate: Not required **OR** Required, **as directed**.
11. Metal, Medium-Sump, Deck Roof Drains:
- a. Standard: ASME A112.6.4, for deck roof drains; ASME A112.6.3, for floor drains.
 - b. Body Material: Metal.
 - c. Flange: Anchor **OR** Anchor with weep holes **OR** Not required, **as directed**.
 - d. Clamping Device: Not required **OR** Required, **as directed**.
 - e. Integral Backwater Valve: Not required **OR** Required, **as directed**.
 - f. Outlet: Bottom **OR** End **OR** Side, **as directed**.
 - g. Grate Material: Cast iron.
 - h. Grate Finish: Painted **OR** Not required, **as directed**.



- i. Overall Dimension of Frame and Grate: Nominal 14 inches (357 mm) round **OR** square, **as directed**.
 - j. Top-Loading Classification: Extra-Heavy Duty **OR** Heavy Duty, **as directed**.
 - k. Vandal-Proof Frame and Grate: Not required **OR** Required, **as directed**.
12. Metal, Small-Sump, Deck Roof Drains:
- a. Standard: ASME A112.6.4, for deck roof drains; ASME A112.6.3, for floor drains.
 - b. Body Material: Metal.
 - c. Flange: Anchor **OR** Anchor with weep holes **OR** Not required, **as directed**.
 - d. Clamping Device: Not required **OR** Required, **as directed**.
 - e. Integral Backwater Valve: Not required **OR** Required, **as directed**.
 - f. Outlet: Bottom **OR** End **OR** Side, **as directed**.
 - g. Grate Material: Cast iron.
 - h. Grate Finish: Painted **OR** Not required, **as directed**.
 - i. Overall Dimension of Frame and Grate: Nominal 8 inches (203 mm) round **OR** square, **as directed**.
 - j. Top-Loading Classification: Extra-Heavy Duty **OR** Heavy Duty **OR** Light Duty **OR** Medium Duty, **as directed**.
 - k. Vandal-Proof Frame and Grate: Not required **OR** Required, **as directed**.
- B. Plastic Roof Drains
- 1. Plastic Roof Drains:
 - a. Standard: ASME A112.6.4, for plastic roof drains.
 - b. Body Material: ABS or PVC.
 - c. Sump Diameter: **<Insert nominal dimension>**.
 - d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
 - e. Outlet: Bottom.
 - f. Extension Collars: Not required **OR** Required, **as directed**.
 - g. Underdeck Clamp: Not required **OR** Required, **as directed**.
 - h. Expansion Joint: Not required **OR** Required, **as directed**.
 - i. Sump Receiver Plate: Not required **OR** Required, **as directed**.
 - j. Dome Material: Aluminum **OR** Cast iron **OR** PE **OR** Stainless steel, **as directed**.
 - k. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
- C. Miscellaneous Storm Drainage Piping Specialties
- 1. Downspout Adaptors:
 - a. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
 - b. Size: Inlet size to match parapet drain outlet.
 - 2. Downspout Boots:
 - a. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 (DN 100) outlet; and shop-applied bituminous coating.
 - b. Size: Inlet size to match downspout and NPS 4 (DN 100) outlet.
 - 3. Conductor Nozzles:
 - a. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
 - b. Size: Same as connected conductor.
- D. Cleanouts
- 1. Floor Cleanouts:
 - a. Standard: ASME A112.36.2M, for adjustable housing **OR** cast-iron soil pipe with cast-iron ferrule **OR** heavy-duty, adjustable housing **OR** threaded, adjustable housing, **as directed**, cleanouts.
 - b. Size: Same as connected branch.
 - c. Type: Adjustable housing **OR** Cast-iron soil pipe with cast-iron ferrule **OR** Heavy-duty, adjustable housing **OR** Threaded, adjustable housing, **as directed**.
 - d. Body or Ferrule Material: Cast iron **OR** Stainless steel, **as directed**.



- e. Clamping Device: Not required **OR** Required, **as directed**.
 - f. Outlet Connection: Inside calk **OR** Spigot **OR** Threaded, **as directed**.
 - g. Closure: Brass plug with straight threads and gasket **OR** Brass plug with tapered threads **OR** Cast-iron plug **OR** Plastic plug, **as directed**.
 - h. Adjustable Housing Material: Cast iron **OR** Plastic, **as directed**, with threads **OR** set-screws or other device, **as directed**.
 - i. Frame and Cover Material and Finish: Nickel-bronze, copper alloy **OR** Painted cast iron **OR** Polished bronze **OR** Rough bronze **OR** Stainless steel, **as directed**.
 - j. Frame and Cover Shape: Round **OR** Square, **as directed**.
 - k. Top-Loading Classification: Extra-Heavy Duty **OR** Heavy Duty **OR** Light Duty **OR** Medium Duty, **as directed**.
 - l. Riser: ASTM A 74, Extra-Heavy **OR** Service, **as directed**, class, cast-iron drainage pipe fitting and riser to cleanout.
2. Test Tees:
- a. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
 - b. Size: Same as connected drainage piping.
 - c. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
 - d. Closure Plug: Countersunk or raised head, brass.
 - e. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
3. Wall Cleanouts:
- a. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
 - b. Size: Same as connected drainage piping.
 - c. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch **OR** Hubless, cast-iron soil-pipe test tee, **as directed**, as required to match connected piping.
 - d. Closure: Countersunk **OR** Countersunk or raised-head **OR** Raised-head, **as directed**, drilled-and-threaded **OR** brass **OR** cast-iron, **as directed**, plug.
 - e. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 - f. Wall Access: Round, deep, chrome-plated bronze **OR** flat, chrome-plated brass or stainless-steel, **as directed**, cover plate with screw.
 - g. Wall Access: Round **OR** Square, **as directed**, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.
4. Plastic Floor Cleanouts:
- a. Size: Same as connected branch.
 - b. Body Material: PVC.
 - c. Closure Plug: PVC.
 - d. Riser: Drainage pipe fitting and riser to cleanout of same material as drainage piping.
- E. Backwater Valves
1. Cast-Iron, Horizontal Backwater Valves:
- a. Standard: ASME A112.14.1, for backwater valves.
 - b. Size: Same as connected piping.
 - c. Body Material: Cast iron.
 - d. Cover: Cast iron with bolted or threaded access check valve.
 - e. End Connections: Hub and spigot or hubless.
 - f. Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed **OR** open for airflow unless subject to backflow condition, **as directed**.
 - g. Extension: ASTM A 74, Service class; full-size, cast-iron soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.
2. Cast-Iron, Drain-Outlet Backwater Valves:
- a. Size: Same as floor drain outlet.
 - b. Body Material: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
 - c. Check Valve: Removable ball float.
 - d. Inlet: Threaded.



- e. Outlet: Threaded or spigot.
- 3. Plastic, Horizontal Backwater Valves:
 - a. Standard: ASME A112.14.1, for backwater valves.
 - b. Size: Same as connected piping.
 - c. Body Material: ABS **OR** PVC, **as directed**.
 - d. Cover: Same material as body with threaded access to check valve.
 - e. Check Valve: Removable swing check.
 - f. End Connections: Socket type.

F. Trench Drains

- 1. Trench Drains:
 - a. Standard: ASME A112.6.3, for trench drains.
 - b. Body Material: Cast iron.
 - c. Flange: Anchor **OR** Anchor with weep holes **OR** Not required, **as directed**.
 - d. Clamping Device: Not required **OR** Required, **as directed**.
 - e. Outlet: Bottom **OR** End **OR** Side, **as directed**.
 - f. Grate Material: Ductile iron or gray iron **OR** stainless steel, **as directed**.
 - g. Grate Finish: Painted **OR** Not required, **as directed**.
 - h. Dimensions of Frame and Grate: **<Insert dimensions>**.
 - i. Top-Loading Classification: Extra-Heavy Duty **OR** Heavy Duty **OR** Light Duty **OR** Medium Duty, **as directed**.

G. Channel Drainage Systems

- 1. Narrow, Sloped-Invert, Polymer-Concrete, Channel Drainage Systems:
 - a. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 - 1) Channel Sections: Narrow, interlocking-joint, sloped-invert, polymer-concrete modular units with end caps. Include rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated. Include extension sections necessary for required depth.
 - a) Dimensions: 4-inch (102-mm) inside width. Include number of units required to form total lengths indicated.
 - b) Frame: Galvanized steel or gray iron for grates **OR** Not required, **as directed**.
 - 2) Grates: Manufacturer's designation "heavy duty" **OR** "medium duty", **as directed**, with slots or perforations, and of width and thickness that fit recesses in channel sections.
 - a) Material: Ductile iron **OR** Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
 - b) Locking Mechanism: Manufacturer's standard device for securing grates to channel sections **OR** Not required, **as directed**.
 - 3) Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
 - 4) Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
 - 5) Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- 2. Narrow, Level-Invert, Polymer-Concrete, Channel Drainage Systems:
 - a. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 - 1) Channel Sections: Narrow, interlocking-joint, precast, polymer-concrete modular units with end caps. Include rounded bottom, with level invert and with NPS 4 (DN 100) outlets in number and locations indicated.
 - a) Dimensions: 5-inch (127-mm) inside width and 9-3/4-inch (248-mm) depth. Include number of units required to form total lengths indicated.



- b) Frame: Galvanized steel or gray iron for grates **OR** Not required, **as directed**.
 - 2) Grates: Manufacturer's designation "heavy duty" **OR** "medium duty", **as directed**, with slots or perforations, and of width and thickness that fit recesses in channel sections.
 - a) Material: Ductile iron **OR** Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
 - b) Locking Mechanism: Manufacturer's standard device for securing grates to channel sections **OR** Not required, **as directed**.
 - 3) Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
 - 4) Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
 - 5) Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
3. Wide, Level-Invert, Polymer-Concrete, Channel Drainage Systems:
- a. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 - 1) Channel Sections: Wide, interlocking-joint, precast, polymer-concrete modular units with end caps. Include flat or rounded bottom, with level invert and with outlets in number, sizes, and locations indicated.
 - a) Dimensions: 8-inch (203-mm) inside width and 13-3/4-inch (350-mm) depth. Include number of units required to form total lengths indicated.
 - b) Frame: Galvanized steel or gray iron for grates **OR** Not required, **as directed**.
 - 2) Grates: Manufacturer's designation "heavy duty" **OR** "medium duty", **as directed**, with slots or perforations, and of width and thickness that fit recesses in channel sections.
 - a) Material: Ductile iron **OR** Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
 - b) Locking Mechanism: Manufacturer's standard device for securing grates to channel sections **OR** Not required, **as directed**.
 - 3) Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
 - 4) Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
 - 5) Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- H. Through-Penetration Firestop Assemblies
- 1. Through-Penetration Firestop Assemblies:
 - a. Standard: ASTM E 814, for through-penetration firestop assemblies.
 - b. Certification and Listing: Intertek Testing Service NA for through-penetration firestop assemblies.
 - c. Size: Same as connected pipe.
 - d. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
 - e. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
 - f. Special Coating: Corrosion resistant on interior of fittings.
- I. Flashing Materials
- 1. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm thickness).



2. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.
3. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil (1.01-mm) minimum thickness.
4. Fasteners: Metal compatible with material and substrate being fastened.
5. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
6. Solder: ASTM B 32, lead-free alloy.

1.3 EXECUTION

A. Installation

1. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 7 Sections.
 - a. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 - b. Install expansion joints, if indicated, in roof drain outlets.
 - c. Position roof drains for easy access and maintenance.
2. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.
3. Install downspout boots at grade with top 6 inches (152 mm) **OR** 12 inches (305 mm) **OR** 18 inches (457 mm), **as directed**, above grade. Secure to building wall.
4. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
5. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 - a. Use cleanouts the same size as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 - b. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - c. Locate cleanouts at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
 - d. Locate cleanouts at base of each vertical soil and waste stack.
6. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
7. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
8. Install horizontal backwater valves in floor with cover flush with floor.
9. Install drain-outlet backwater valves in outlet of drains.
10. Install test tees in vertical conductors and near floor.
11. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
12. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
13. Assemble channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
14. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.
15. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

B. Connections

1. Comply with requirements for piping specified in Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Flashing Installation



1. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - a. Lead Sheets: Burn joints of 6.0-lb/sq. ft. (30-kg/sq. m) lead sheets, 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of 4.0-lb/sq. ft. (20-kg/sq. m) lead sheets, 0.0625-inch (1.6-mm) thickness or thinner.
 - b. Copper Sheets: Solder joints of copper sheets.
 2. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - a. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches (250 mm) and with skirt or flange extending at least 8 inches (200 mm) around pipe.
 - b. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
 - c. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.
 3. Set flashing on floors and roofs in solid coating of bituminous cement.
 4. Secure flashing into sleeve and specialty clamping ring or device.
 5. Fabricate and install flashing and pans, sumps, and other drainage shapes.
- D. Protection
1. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
 2. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 05 76 00a



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**SECTION 22 07 19 00 - PLUMBING INSULATION**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for plumbing insulation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Insulation Materials:
 - 1) Calcium silicate.
 - 2) Cellular glass.
 - 3) Flexible elastomeric.
 - 4) Mineral fiber.
 - 5) Phenolic.
 - 6) Polyisocyanurate.
 - 7) Polyolefin.
 - 8) Polystyrene.
 - b. Insulating cements.
 - c. Adhesives.
 - d. Mastics.
 - e. Lagging adhesives.
 - f. Sealants.
 - g. Factory-applied jackets.
 - h. Field-applied fabric-reinforcing mesh.
 - i. Field-applied cloths.
 - j. Field-applied jackets.
 - k. Tapes.
 - l. Securements.
 - m. Corner angles.

C. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:
 - a. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - b. Detail attachment and covering of heat tracing inside insulation.
 - c. Detail insulation application at pipe expansion joints for each type of insulation.
 - d. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - e. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - f. Detail application of field-applied jackets.
 - g. Detail application at linkages of control devices.
 - h. Detail field application for each equipment type.
4. Field quality-control reports.

D. Quality Assurance



1. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - a. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - b. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

E. Delivery, Storage, And Handling

1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.2 PRODUCTS

A. Insulation Materials

1. Comply with requirements in Part 1.3 schedule articles for where insulating materials shall be applied.
2. Products shall not contain asbestos, lead, mercury, or mercury compounds.
3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
6. Calcium Silicate:
 - a. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - b. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - c. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
7. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - a. Block Insulation: ASTM C 552, Type I.
 - b. Special-Shaped Insulation: ASTM C 552, Type III.
 - c. Board Insulation: ASTM C 552, Type IV.
 - d. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 - e. Preformed Pipe Insulation with Factory-Applied ASJ **OR** ASJ-SSL, **as directed**: Comply with ASTM C 552, Type II, Class 2.
 - f. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
8. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
9. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
10. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.
11. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation



- without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
12. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.
 13. Mineral-Fiber, Preformed Pipe Insulation:
 - a. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 14. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ **OR** FSK jacket, **as directed**, complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 15. Phenolic:
 - a. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 - b. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 - c. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 - d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - 1) Preformed Pipe Insulation: None **OR** ASJ, **as directed**.
 - 2) Board for Equipment Applications: None **OR** ASJ, **as directed**.
 16. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
 - a. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
 - b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E 84.
 - c. Fabricate shapes according to ASTM C 450 and ASTM C 585.
 - d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - 1) Pipe Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
 - 2) Equipment Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
 17. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
 18. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.
- B. Insulating Cements
1. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
 2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
 3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- C. Adhesives
1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
 2. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).



- a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
7. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. PVC Jacket Adhesive: Compatible with PVC jacket.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mastics

1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - a. For indoor applications, use mastics that have a VOC content of <Insert value> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - a. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - b. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - d. Color: White.
3. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
 - a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
 - b. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 - c. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - d. Color: White.
4. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
 - a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
 - b. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 - c. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - d. Color: White.
5. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - a. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 - b. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
 - c. Solids Content: 63 percent by volume and 73 percent by weight.
 - d. Color: White.

E. Lagging Adhesives



1. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
 - a. For indoor applications, use lagging adhesives that have a VOC content of <Insert value> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
 - c. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
 - d. Color: White.

- F. Sealants
 1. Joint Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Permanently flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 - d. Color: White or gray.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. FSK and Metal Jacket Flashing Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Fire- and water-resistant, flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - d. Color: Aluminum.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Fire- and water-resistant, flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - d. Color: White.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- G. Factory-Applied Jackets
 1. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 - b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 - c. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 - d. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
 - e. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
 - f. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

- H. Field-Applied Fabric-Reinforcing Mesh
 1. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.



2. Woven Glass-Fiber Fabric for Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.
 3. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment and pipe.
- I. Field-Applied Cloths
1. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
- J. Field-Applied Jackets
1. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
 2. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - a. Adhesive: As recommended by jacket material manufacturer.
 - b. Color: White **OR** Color-code jackets based on system. Color as selected by the Owner, **as directed**.
 - c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - 1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 - d. Factory-fabricated tank heads and tank side panels.
 3. Metal Jacket:
 - a. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - 1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
 - 2) Finish and thickness are indicated in field-applied jacket schedules.
 - 3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 5) Factory-Fabricated Fitting Covers:
 - a) Same material, finish, and thickness as jacket.
 - b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c) Tee covers.
 - d) Flange and union covers.
 - e) End caps.
 - f) Beveled collars.
 - g) Valve covers.
 - h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
 - b. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - 1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
 - 2) Material, finish, and thickness are indicated in field-applied jacket schedules.
 - 3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 5) Factory-Fabricated Fitting Covers:



- a) Same material, finish, and thickness as jacket.
 - b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c) Tee covers.
 - d) Flange and union covers.
 - e) End caps.
 - f) Beveled collars.
 - g) Valve covers.
 - h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
4. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

K. Tapes

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - a. Width: 3 inches (75 mm).
 - b. Thickness: 11.5 mils (0.29 mm).
 - c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - d. Elongation: 2 percent.
 - e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - f. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - a. Width: 3 inches (75 mm).
 - b. Thickness: 6.5 mils (0.16 mm).
 - c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - d. Elongation: 2 percent.
 - e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - f. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
3. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - a. Width: 2 inches (50 mm).
 - b. Thickness: 6 mils (0.15 mm).
 - c. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 - d. Elongation: 500 percent.
 - e. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
4. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - a. Width: 2 inches (50 mm).
 - b. Thickness: 3.7 mils (0.093 mm).
 - c. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 - d. Elongation: 5 percent.
 - e. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
5. PVDC Tape: White vapor-retarder PVDC tape with acrylic adhesive.
 - a. Width: 3 inches (75 mm).
 - b. Film Thickness: 4 mils (0.10 mm) **OR** 6 mils (0.15 mm), **as directed**.
 - c. Adhesive Thickness: 1.5 mils (0.04 mm).
 - d. Elongation at Break: 145 percent.
 - e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

L. Securements

1. Bands:
 - a. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.



- b. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
 - c. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
2. Insulation Pins and Hangers:
- a. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated.
 - b. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - c. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 1) Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - 2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - 3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 - d. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 1) Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - 2) Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - 3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 - e. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 1) Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - 2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - 3) Adhesive-backed base with a peel-off protective cover.
 - f. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - 1) Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 - g. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.



3. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
4. Wire: 0.080-inch (2.0-mm) nickel-copper alloy **OR** 0.062-inch (1.6-mm) soft-annealed, stainless steel **OR** 0.062-inch (1.6-mm) soft-annealed, galvanized steel, **as directed**.

M. Corner Angles

1. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
2. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.
3. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**.

1.3 EXECUTION

A. Preparation

1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
OR
Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - b. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
3. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

B. General Installation Requirements

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
4. Install insulation with longitudinal seams at top and bottom of horizontal runs.
5. Install multiple layers of insulation with longitudinal and end seams staggered.
6. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
7. Keep insulation materials dry during application and finishing.
8. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
9. Install insulation with least number of joints practical.
10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - a. Install insulation continuously through hangers and around anchor attachments.



- b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
- c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
11. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
12. Install insulation with factory-applied jackets as follows:
 - a. Draw jacket tight and smooth.
 - b. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - c. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, o.c.
 - 1) For below ambient services, apply vapor-barrier mastic over staples.
 - d. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - e. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
16. For above ambient services, do not install insulation to the following:
 - a. Vibration-control devices.
 - b. Testing agency labels and stamps.
 - c. Nameplates and data plates.
 - d. Manholes.
 - e. Handholes.
 - f. Cleanouts.

C. Penetrations

1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - a. Seal penetrations with flashing sealant.
 - b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - d. Seal jacket to roof flashing with flashing sealant.
2. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - a. Seal penetrations with flashing sealant.



- b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - c. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 - d. Seal jacket to wall flashing with flashing sealant.
 4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
 5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - a. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
 6. Insulation Installation at Floor Penetrations:
 - a. Pipe: Install insulation continuously through floor penetrations.
 - b. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping".
- D. Equipment, Tank, And Vessel Insulation Installation
1. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
 - a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of tank and vessel surfaces.
 - b. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 - c. Protect exposed corners with secured corner angles.
 - d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - 1) Do not weld anchor pins to ASME-labeled pressure vessels.
 - 2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - 3) On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
 - 4) Do not overcompress insulation during installation.
 - 5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - 6) Impale insulation over anchor pins and attach speed washers.
 - 7) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 - f. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
 - g. Stagger joints between insulation layers at least 3 inches (75 mm).
 - h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.



- i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
- j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- 2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
 - a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 - b. Seal longitudinal seams and end joints.
- 3. Insulation Installation on Pumps:
 - a. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
 - b. Fabricate boxes from galvanized steel **OR** aluminum **OR** stainless steel, **as directed**, at least 0.040 inch (1.0 mm) **OR** 0.050 inch (1.3 mm) **OR** 0.060 inch (1.6 mm), **as directed**, thick.
 - c. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

E. General Pipe Insulation Installation

- 1. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- 2. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - a. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 - b. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - c. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - d. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 - e. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 - f. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 - g. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.



- c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
 - d. Finish flange insulation same as pipe insulation.
 4. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 - b. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
 - c. Finish fittings insulation same as pipe insulation.
 5. Insulation Installation on Valves and Pipe Specialties:
 - a. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - b. Install insulation to flanges as specified for flange insulation application.
 - c. Finish valve and specialty insulation same as pipe insulation.
- G. Cellular-Glass Insulation Installation
 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
 - d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 - b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed sections of cellular-glass insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
- H. Flexible Elastomeric Insulation Installation
 1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 2. Insulation Installation on Pipe Flanges:
 - a. Install pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.



- c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install mitered sections of pipe insulation.
 - b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - b. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
 - d. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 - I. Mineral-Fiber Insulation Installation
 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - c. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
 - d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available.
 - b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available.
 - b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
 - c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - d. Install insulation to flanges as specified for flange insulation application.
 - J. Phenolic Insulation Installation
 1. General Installation Requirements:



- a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
 - b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
2. Insulation Installation on Straight Pipes and Tubes:
- a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
3. Insulation Installation on Pipe Flanges:
- a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Insulation Installation on Pipe Fittings and Elbows:
- a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
5. Insulation Installation on Valves and Pipe Specialties:
- a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
- K. Polyisocyanurate Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
- a. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
 - b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
 - c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
- a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.
3. Insulation Installation on Fittings and Elbows:
- a. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
4. Insulation Installation on Valves and Pipe Specialties:
- a. Install preformed sections of polyisocyanurate insulation to valve body.



- b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
- c. Install insulation to flanges as specified for flange insulation application.

L. Polyolefin Insulation Installation

- 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- 2. Insulation Installation on Pipe Flanges:
 - a. Install pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
 - d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install mitered sections of polyolefin pipe insulation.
 - b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install cut sections of polyolefin pipe and sheet insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
 - d. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

M. Polystyrene Insulation Installation

- 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
 - b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
 - c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
- 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.
- 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
- 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed section of polystyrene insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.



N. Field-Applied Jacket Installation

1. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - a. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 - b. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
 - c. Completely encapsulate insulation with coating, leaving no exposed insulation.
2. Where FSK jackets are indicated, install as follows:
 - a. Draw jacket material smooth and tight.
 - b. Install lap or joint strips with same material as jacket.
 - c. Secure jacket to insulation with manufacturer's recommended adhesive.
 - d. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
3. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 - a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
4. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.
5. Where PVDC jackets are indicated, install as follows:
 - a. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
 - b. Wrap factory-presizes jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
 - c. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
 - d. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
 - e. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

O. Finishes

1. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 07.
 - a. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - 1) Finish Coat Material: Interior, flat, latex-emulsion size.
2. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
3. Color: Final color as selected by the Owner. Vary first and second coats to allow visual inspection of the completed Work.
4. Do not field paint aluminum or stainless-steel jackets.



P. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Inspect field-insulated equipment, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
 - b. Inspect pipe, fittings, strainers, and valves, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
3. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

Q. Domestic Water Boiler Breeching Insulation Schedule

1. Round, exposed breeching and connector insulation shall be one of the following:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
2. Round, concealed breeching and connector insulation shall be one of the following:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
3. Rectangular, exposed breeching and connector insulation shall be one of the following:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
4. Rectangular, concealed breeching and connector insulation shall be one of the following:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.

R. Equipment Insulation Schedule

1. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
2. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
3. Heat-exchanger (water-to-water for domestic water heating service) insulation shall be one of the following:
 - a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
4. Steam-to-hot-water converter insulation shall be one of the following:
 - a. Calcium Silicate: 3 inches (75 mm) thick.



- b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
5. Domestic water pump insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1 inch (25 mm) thick.
 - d. Polyisocyanurate: 1 inch (25 mm) thick.
6. Domestic chilled-water (potable) pump insulation shall be one of the following:
- a. Cellular Glass: 3 inches (75 mm) thick.
 - b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1 inch (25 mm) thick.
 - d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.
7. Domestic hot-water pump insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1 inch (25 mm) thick.
 - d. Polyisocyanurate: 1 inch (25 mm) thick.
8. Domestic water, domestic chilled-water (potable), and domestic hot-water hydropneumatic tank insulation shall be one of the following:
- a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
9. Domestic hot-water storage tank insulation shall be one of the following, of thickness to provide an R-value of 12.5:
- a. Cellular glass.
 - b. Mineral-Fiber Board: 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-fiber pipe and tank.
 - d. Phenolic.
10. Domestic water storage tank insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
11. Domestic chilled-water (potable) storage tank insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.



- f. Polyisocyanurate: 1 inch (25 mm) thick.
- g. Polyolefin: 1 inch (25 mm) thick.
- 12. Piping system filter-housing insulation shall be one of the following:
 - a. Cellular Glass: 3 inches (75 mm) thick.
 - b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
- S. Piping Insulation Schedule, General
 - 1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
 - 2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - a. Drainage piping located in crawl spaces.
 - b. Underground piping.
 - c. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
- T. Indoor Piping Insulation Schedule
 - 1. Domestic Cold Water:
 - a. NPS 1 (DN 25) and Smaller: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - b. NPS 1-1/4 (DN 32) and Larger: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
 - 2. Domestic Hot and Recirculated Hot Water:
 - a. NPS 1-1/4 (DN 32) and Smaller: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - b. NPS 1-1/2 (DN 40) and Larger: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
 - 3. Domestic Chilled Water (Potable):
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.



- 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
4. Stormwater and Overflow:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
 5. Roof Drain and Overflow Drain Bodies:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
 6. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Flexible Elastomeric: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm) thick.
 - 3) Polyolefin: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) thick.
 7. Sanitary Waste Piping Where Heat Tracing Is Installed:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches (38 mm) thick.
 - 3) Phenolic: 1-1/2 inches (38 mm) thick.
 - 4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.
 8. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 9. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet (3 m) of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 10. Hot Service Drains:
 - a. All Pipe Sizes: Insulation shall be one of the following:



- 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
 - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch (25 mm) thick.
11. Hot Service Vents:
- a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
 - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch (25 mm) thick.
- U. Outdoor, Aboveground Piping Insulation Schedule
1. Domestic Water Piping:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Flexible Elastomeric: 2 inches (50 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 4) Phenolic: 2 inches (50 mm) thick.
 - 5) Polyisocyanurate: 2 inches (50 mm) thick.
 - 6) Polyolefin: 2 inches (50 mm) thick.
 - 7) Polystyrene: 2 inches (50 mm) thick.
 2. Domestic Hot and Recirculated Hot Water:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Flexible Elastomeric: 2 inches (50 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 4) Phenolic: 2 inches (50 mm) thick.
 - 5) Polyisocyanurate: 2 inches (50 mm) thick.
 - 6) Polyolefin: 2 inches (50 mm) thick.
 3. Sanitary Waste Piping Where Heat Tracing Is Installed:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 3) Phenolic: 2 inches (50 mm) thick.
 - 4) Polyisocyanurate: 2 inches (50 mm) thick.
 4. Hot Service Drains:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
 - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 5. Hot Service Vents:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
 - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type II: 1 inch (25 mm) thick.
- V. Outdoor, Underground Piping Insulation Schedule
1. Loose-fill insulation, for belowground piping, is specified in Division 28.
 2. Sanitary Waste Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches (50 mm) thick.
 3. Chilled Water, All Sizes: Cellular glass, 2 inches (50 mm) thick.
- W. Indoor, Field-Applied Jacket Schedule
1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 2. If more than one material is listed, selection from materials listed is Contractor's option.
 3. Equipment, Concealed:
 - a. None.



- b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
- a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
5. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
- a. None.
 - b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Piping, Concealed:
- a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Piping, Exposed:
- a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.



- c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
- X. Outdoor, Field-Applied Jacket Schedule
- 1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 - 2. If more than one material is listed, selection from materials listed is Contractor's option.
 - 3. Equipment, Concealed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
 - 4. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 - a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
 - 5. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 - a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed** with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
 - 6. Piping, Concealed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.



- d. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Piping, Exposed:
- a. PVC: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm) **OR** 40 mils (1.0 mm), **as directed**, thick.
 - b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
- Y. Underground, Field-Installed Insulation Jacket
- 1. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 22 07 19 00



Task	Specification	Specification Description
22 07 19 00	21 07 00 00	Fire-Suppression Systems Insulation



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SECTION 22 11 16 00 - DOMESTIC WATER PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for domestic water piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
 - b. Encasement for piping.
 - c. Specialty valves.
 - d. Flexible connectors.
 - e. Water meters furnished by utility company for installation by Contractor.
OR
Water meters.
 - f. Escutcheons.
 - g. Sleeves and sleeve seals.
 - h. Wall penetration systems.

C. Performance Requirements

1. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Field quality-control reports.

E. Quality Assurance

1. Piping materials shall bear label, stamp, or other markings of specified testing agency.
2. Comply with NSF 14 for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping, **as directed**.
3. Comply with NSF 61 for potable domestic water piping and components.

F. Project Conditions

1. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of water service.
 - b. Do not proceed with interruption of water service without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials



1. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Copper Tube And Fittings
1. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) water tube, drawn temper.
 - a. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
 - b. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
 - c. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
 - d. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
 - e. Copper Pressure-Seal-Joint Fittings:
 - 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
 - 2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.
 - f. Copper Push-on-Joint Fittings:
 - 1) Description: Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.
 - g. Copper-Tube Extruded-Tee Connections:
 - 1) Description: Tee formed in copper tube according to ASTM F 2014.
 - h. Grooved-Joint Copper-Tube Appurtenances:
 - 1) Copper Grooved-End Fittings: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.
 - 2) Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.
 2. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) and ASTM B 88, Type L (ASTM B 88M, Type B) water tube, annealed temper.
 - a. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
 - b. Copper Pressure-Seal-Joint Fittings:
 - 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
 - 2) NPS 3 and NPS 4 (DN 80 and DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.
- C. Ductile-Iron Pipe And Fittings
1. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - a. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.
 - b. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153, ductile iron.
 - 1) Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
 2. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - a. Standard-Pattern, Push-on-Joint Fittings: AWWA C110, ductile or gray iron.
 - 1) Gaskets: AWWA C111, rubber.
 - b. Compact-Pattern, Push-on-Joint Fittings: AWWA C153, ductile iron.
 - 1) Gaskets: AWWA C111, rubber.
 3. Plain-End, Ductile-Iron Pipe: AWWA C151.
 - a. Grooved-Joint, Ductile-Iron-Pipe Appurtenances:
 - 1) Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.



- 2) Grooved-End, Ductile-Iron-Pipe Couplings: AWWA C606 for ductile-iron-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.
- D. Galvanized-Steel Pipe And Fittings
1. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B, Standard Weight. Include ends matching joining method.
 - a. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Standard Weight, seamless steel pipe with threaded ends.
 - b. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
 - c. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
 - d. Flanges: ASME B16.1, Class 125, cast iron.
 - e. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:
 - 1) Galvanized, Grooved-End Fittings for Galvanized-Steel Piping: ASTM A 47/A 47M, malleable-iron casting; ASTM A 106/A 106M, steel pipe; or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
 - 2) Grooved-End-Pipe Couplings for Galvanized-Steel Piping: AWWA C606 for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.
- E. CPVC Piping
1. CPVC Pipe: ASTM F 441/F 441M, Schedule 40 and Schedule 80.
 - a. CPVC Socket Fittings: ASTM F 438 for Schedule 40 and ASTM F 439 for Schedule 80.
 - b. CPVC Threaded Fittings: ASTM F 437, Schedule 80.
 2. CPVC Piping System: ASTM D 2846/D 2846M, SDR 11, pipe and socket fittings.
 3. CPVC Tubing System: ASTM D 2846/D 2846M, SDR 11, tube and socket fittings.
- F. PEX Tube And Fittings
1. PEX Distribution System: ASTM F 877, SDR 9 tubing.
 - a. Fittings for PEX Tube: ASTM F 1807, metal-insert type with copper or stainless-steel crimp rings and matching PEX tube dimensions.
 - b. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F 877; with plastic or corrosion-resistant-metal valve for each outlet.
- G. PVC Pipe And Fittings
1. PVC Pipe: ASTM D 1785, Schedule 40 and Schedule 80.
 - a. PVC Socket Fittings: ASTM D 2466 for Schedule 40 and ASTM D 2467 for Schedule 80.
 - b. PVC Schedule 80 Threaded Fittings: ASTM D 2464.
- H. Piping Joining Materials
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.
 2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
 3. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
 4. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
 5. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
 - a. Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 6. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.



- a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- I. Encasement For Piping
1. Standard: ASTM A 674 or AWWA C105.
 2. Form: Sheet **OR** Tube, **as directed**.
 3. Material: LLDPE film of 0.008-inch (0.20-mm) **OR** LLDPE film of 0.008-inch (0.20-mm) minimum thickness or high-density, cross-laminated PE film of 0.004-inch (0.10-mm) **OR** High-density, cross-laminated PE film of 0.004-inch (0.10-mm), **as directed**, minimum thickness.
 4. Color: Black **OR** Natural, **as directed**.
- J. Specialty Valves
1. Comply with requirements in Division 22 Section "General-duty Valves For Plumbing Piping" for general-duty metal valves.
 2. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.
 3. CPVC Union Ball Valves:
 - a. Description:
 - 1) Standard: MSS SP-122.
 - 2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 3) Body Material: CPVC.
 - 4) Body Design: Union type.
 - 5) End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket **OR** threaded, **as directed**.
 - 6) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket **OR** threaded **OR** flanged, **as directed**.
 - 7) Ball: CPVC; full port.
 - 8) Seals: PTFE or EPDM-rubber O-rings.
 - 9) Handle: Tee shaped.
 4. PVC Union Ball Valves:
 - a. Description:
 - 1) Standard: MSS SP-122.
 - 2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 3) Body Material: PVC.
 - 4) Body Design: Union type.
 - 5) End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket **OR** threaded, **as directed**.
 - 6) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket **OR** threaded **OR** flanged, **as directed**.
 - 7) Ball: PVC; full port.
 - 8) Seals: PTFE or EPDM-rubber O-rings.
 - 9) Handle: Tee shaped.
 5. CPVC Non-Union Ball Valves:
 - a. Description:
 - 1) Standard: MSS SP-122.
 - 2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 3) Body Material: CPVC.
 - 4) Body Design: Non-union type.



- 5) End Connections: Socket or threaded.
 - 6) Ball: CPVC; full or reduced port.
 - 7) Seals: PTFE or EPDM-rubber O-rings.
 - 8) Handle: Tee shaped.
6. PVC Non-Union Ball Valves:
- a. Description:
 - 1) Standard: MSS SP-122.
 - 2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 3) Body Material: PVC.
 - 4) Body Design: Non-union type.
 - 5) End Connections: Socket or threaded.
 - 6) Ball: PVC; full or reduced port.
 - 7) Seals: PTFE or EPDM-rubber O-rings.
 - 8) Handle: Tee shaped.
7. CPVC Butterfly Valves:
- a. Description:
 - 1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 2) Body Material: CPVC.
 - 3) Body Design: Lug or wafer type.
 - 4) Seat: EPDM rubber.
 - 5) Seals: PTFE or EPDM-rubber O-rings.
 - 6) Disc: CPVC.
 - 7) Stem: Stainless steel.
 - 8) Handle: Lever.
8. PVC Butterfly Valves:
- a. Description:
 - 1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 2) Body Material: PVC.
 - 3) Body Design: Lug or wafer type.
 - 4) Seat: EPDM rubber.
 - 5) Seals: PTFE or EPDM-rubber O-rings.
 - 6) Disc: PVC.
 - 7) Stem: Stainless steel.
 - 8) Handle: Lever.
9. CPVC Ball Check Valves:
- a. Description:
 - 1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 2) Body Material: CPVC.
 - 3) Body Design: Union-type ball check.
 - 4) End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket **OR** threaded, **as directed**.
 - 5) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket **OR** threaded **OR** flanged, **as directed**.
 - 6) Ball: CPVC.
 - 7) Seals: EPDM- or FKM-rubber O-rings.
10. PVC Ball Check Valves:
- a. Description:
 - 1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 2) Body Material: PVC.
 - 3) Body Design: Union-type ball check.



- 4) End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket **OR** threaded, **as directed**.
 - 5) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket **OR** threaded **OR** flanged, **as directed**.
 - 6) Ball: PVC.
 - 7) Seals: EPDM- or FKM-rubber O-rings.
11. CPVC Gate Valves:
- a. Description:
 - 1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 2) Body Material: CPVC.
 - 3) Body Design: Nonrising stem.
 - 4) End Connections for Valves NPS 2 (DN 50) and Smaller: Socket **OR** Threaded, **as directed**.
 - 5) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket **OR** Threaded **OR** Flanged, **as directed**.
 - 6) Gate and Stem: Plastic.
 - 7) Seals: EPDM rubber.
 - 8) Handle: Wheel.
12. PVC Gate Valves:
- a. Description:
 - 1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
 - 2) Body Material: PVC.
 - 3) Body Design: Nonrising stem.
 - 4) End Connections for Valves NPS 2 (DN 50) and Smaller: Socket **OR** Threaded, **as directed**.
 - 5) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket **OR** Threaded **OR** Flanged, **as directed**.
 - 6) Gate and Stem: Plastic.
 - 7) Seals: EPDM rubber.
 - 8) Handle: Wheel.
- K. Transition Fittings
1. General Requirements:
 - a. Same size as pipes to be joined.
 - b. Pressure rating at least equal to pipes to be joined.
 - c. End connections compatible with pipes to be joined.
 2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
 3. Sleeve-Type Transition Coupling: AWWA C219.
 4. Plastic-to-Metal Transition Fittings:
 - a. Description: CPVC **OR** PVC, **as directed**, one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket threaded, **as directed**, end.
 5. Plastic-to-Metal Transition Unions:
 - a. Description: CPVC **OR** PVC, **as directed**, four-part union. Include brass or stainless-steel, **as directed**, threaded end, solvent-cement-joint or threaded, **as directed**, plastic end, rubber O-ring, and union nut.
- L. Dielectric Fittings
1. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
 2. Dielectric Unions:



- a. Description:
 - 1) Pressure Rating: 150 psig (1035 kPa) **OR** 250 psig (1725 kPa), **as directed**, at 180 deg F (82 deg C).
 - 2) End Connections: Solder-joint copper alloy and threaded ferrous.
 3. Dielectric Flanges:
 - a. Description:
 - 1) Factory-fabricated, bolted, companion-flange assembly.
 - 2) Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
 - 3) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
 4. Dielectric-Flange Kits:
 - a. Description:
 - 1) Nonconducting materials for field assembly of companion flanges.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Gasket: Neoprene or phenolic.
 - 4) Bolt Sleeves: Phenolic or polyethylene.
 - 5) Washers: Phenolic with steel backing washers.
 5. Dielectric Couplings:
 - a. Description:
 - 1) Galvanized-steel coupling.
 - 2) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - 3) End Connections: Female threaded.
 - 4) Lining: Inert and noncorrosive, thermoplastic.
 6. Dielectric Nipples:
 - a. Description:
 - 1) Electroplated steel nipple complying with ASTM F 1545.
 - 2) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - 3) End Connections: Male threaded or grooved.
 - 4) Lining: Inert and noncorrosive, propylene.
- M. Flexible Connectors
1. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - a. Working-Pressure Rating: Minimum 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**.
 - b. End Connections NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
 - c. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.
 2. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
 - a. Working-Pressure Rating: Minimum 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**.
 - b. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
 - c. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.
- N. Water Meters
1. Displacement-Type Water Meters:
 - a. Description:
 - 1) Standard: AWWA C700.
 - 2) Pressure Rating: 150-psig (1035-kPa) working pressure.
 - 3) Body Design: Nutating disc; totalization meter.
 - 4) Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility.
 - 5) Case: Bronze.
 - 6) End Connections: Threaded.
 2. Turbine-Type Water Meters:



- a. Description:
 - 1) Standard: AWWA C701.
 - 2) Pressure Rating: 150-psig (1035-kPa) working pressure.
 - 3) Body Design: Turbine; totalization meter.
 - 4) Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
 - 5) Case: Bronze.
 - 6) End Connections for Meters NPS 2 (DN 50) and Smaller: Threaded.
 - 7) End Connections for Meters NPS 2-1/2 (DN 65) and Larger: Flanged.
3. Compound-Type Water Meters:
 - a. Description:
 - 1) Standard: AWWA C702.
 - 2) Pressure Rating: 150-psig (1035-kPa) working pressure.
 - 3) Body Design: With integral mainline and bypass meters; totalization meter.
 - 4) Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
 - 5) Case: Bronze.
 - 6) Pipe Connections: Flanged.
4. Fire-Service-Type Water Meters:
 - a. Description:
 - 1) Standard: AWWA C703 and UL listing.
 - 2) Pressure Rating: 175-psig (1200-kPa) working pressure.
 - 3) Body Design:
 - a) Proportional, Detector-Type Water Meters: With meter on bypass.
 - i. Bypass Meter: AWWA C701, turbine **OR** AWWA C702, compound, **as directed**, type with bronze case; size not less than one-half nominal size of main-line meter.
 - b) Turbine-Type Water Meters: With strainer, and with meter on bypass.
 - i. Strainer: Full size, matching water meter.
 - ii. Bypass Meter: AWWA C701, turbine type with bronze case; not less than NPS 2 (DN 50).
 - 4) Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
 - 5) Case: Bronze.
 - 6) Pipe Connections for Meters NPS 2 (DN 50) and Smaller: Threaded.
 - 7) Pipe Connections for Meters NPS 2-1/2 (DN 65) and Larger: Flanged.
5. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.
OR
Remote Registration System: Encoder type complying with AWWA C707; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

O. Escutcheons

1. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
2. One Piece, Cast Brass: Polished, chrome-plated **OR** rough-brass, **as directed**, finish with setscrews.
3. One Piece, Deep Pattern: Deep-drawn, box-shaped brass with chrome-plated finish.
4. One Piece, Stamped Steel: Chrome-plated finish with setscrew **OR** spring clips, **as directed**.
5. Split Casting, Cast Brass: Polished, chrome-plated **OR** rough-brass, **as directed**, finish with concealed hinge and setscrew.
6. Split Plate, Stamped Steel: Chrome-plated finish with concealed **OR** exposed-rivet, **as directed**, hinge, setscrew **OR** spring clips, **as directed**.
7. One-Piece Floor Plates: Cast-iron flange with holes for fasteners, **as directed**.



8. Split-Casting Floor Plates: Cast brass with concealed hinge.

P. Sleeves

1. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
4. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
5. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
6. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.
7. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with setscrews.

Q. Sleeve Seals

1. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM-rubber **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
 - c. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

R. Wall Penetration Systems

1. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.
 - a. Carrier-Pipe Deflection: Up to 5 percent without leakage.
 - b. Housing: Ductile-iron casting with hub, waterstop, anchor ring, and locking devices. Include gland, bolts, and nuts.
 - c. Housing-to-Sleeve Gasket: EPDM rubber **OR** NBR, **as directed**.
 - d. Housing-to-Carrier-Pipe Gasket: AWWA C111, EPDM rubber **OR** NBR, **as directed**.
 - e. Pipe Sleeve: AWWA C151, ductile-iron pipe **OR** ASTM A 53/A 53M, Schedule 40, zinc-coated steel pipe, **as directed**.

S. Grout

1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink; recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Earthwork

1. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."



3. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
4. Install underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105.
5. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters And Gages For Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.
6. Install shutoff valve immediately upstream of each dielectric fitting.
7. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.
8. Install domestic water piping level with 0.25 percent slope downward toward drain **OR** without pitch, **as directed**, and plumb.
9. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
10. Install seismic restraints on piping. Comply with requirements in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
11. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
12. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
13. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
14. Install piping adjacent to equipment and specialties to allow service and maintenance.
15. Install piping to permit valve servicing.
16. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.
17. Install piping free of sags and bends.
18. Install fittings for changes in direction and branch connections.
19. Install PEX piping with loop at each change of direction of more than 90 degrees.
20. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
21. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters And Gages For Plumbing Piping" for pressure gages.
22. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.
23. Install thermometers on inlet **OR** inlet and outlet, **as directed**, piping from each water heater. Comply with requirements in Division 22 Section "Meters And Gages For Plumbing Piping" for thermometers.

C. Joint Construction

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
4. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Braze Joints" Chapter.



5. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
 6. Pressure-Sealed Joints: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.
 7. Copper-Tubing, Push-on Joints: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.
 8. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
 9. Copper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints.
 10. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.
 11. Steel-Piping Grooved Joints: Cut **OR** Roll, **as directed**, groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
 12. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
 13. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
 - b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - c. PVC Piping: Join according to ASTM D 2855.
 14. PEX Piping Joints: Join according to ASTM F 1807.
 15. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.
- D. Valve Installation
1. General-Duty Valves: Comply with requirements in Division 22 Section "General-duty Valves For Plumbing Piping" for valve installations.
 2. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.
 3. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties".
 - a. Hose-End Drain Valves: At low points in water mains, risers, and branches.
 - b. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.
 4. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 (DN 50) and smaller and butterfly valves for piping NPS 2-1/2 (DN 65) and larger. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.
 5. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for calibrated balancing valves.
- E. Transition Fitting Installation
1. Install transition couplings at joints of dissimilar piping.
 2. Transition Fittings in Underground Domestic Water Piping:



- a. NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
 - b. NPS 2 (DN 50) and Larger: Sleeve-type coupling.
3. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings **OR** unions, **as directed**.
- F. Dielectric Fitting Installation
1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 2. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric couplings **OR** nipples **OR** unions, **as directed**.
 3. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges **OR** flange kits **OR** nipples, **as directed**.
 4. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.
- G. Flexible Connector Installation
1. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump, **as directed**.
 2. Install bronze-hose flexible connectors in copper domestic water tubing.
 3. Install stainless-steel-hose flexible connectors in steel domestic water piping.
- H. Water Meter Installation
1. Rough-in domestic water piping for water meter installation, and install water meters, **as directed**, according to utility company's requirements.
 2. Water meters will be furnished and installed by utility company.
OR
Install water meters according to AWWA M6 and utility company's requirements.
 3. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
OR
Install turbine-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
OR
Install compound-type water meters with shutoff valves on water-meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.
OR
Install fire-service water meters with shutoff valves on water-meter inlet and outlet and on full-size valved bypass around meter. Support meter, valves, and piping on brick or concrete piers.
 4. Install remote registration system according to standards of utility company and of authorities having jurisdiction.
- I. Hanger And Support Installation
1. Comply with requirements in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
 2. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support products and installation.
 - a. Vertical Piping: MSS Type 8 or 42, clamps.
 - b. Individual, Straight, Horizontal Piping Runs:
 - 1) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - 2) Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - 3) Longer Than 100 Feet (30 m) If Indicated: MSS Type 49, spring cushion rolls.
 - c. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - d. Base of Vertical Piping: MSS Type 52, spring hangers.
 3. Support vertical piping and tubing at base and at each floor.



4. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
5. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
 - e. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
 - f. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
 - g. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
6. Install supports for vertical copper tubing every 10 feet (3 m).
7. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - d. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
 - e. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
 - f. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
 - g. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
 - h. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.
8. Install supports for vertical steel piping every 15 feet (4.5 m).
9. Install vinyl-coated hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1 (DN 25) and Smaller: 36 inches (900 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
 - d. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
 - e. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
 - f. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
10. Install supports for vertical CPVC piping every 60 inches (1500 mm) for NPS 1 (DN 25) and smaller, and every 72 inches (1800 mm) for NPS 1-1/4 (DN 32) and larger.
11. Install vinyl-coated hangers for PEX piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1 (DN 25) and Smaller: 32 inches (815 mm) with 3/8-inch (10-mm) rod.
12. Install hangers for vertical PEX piping every 48 inches (1200 mm).
13. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 2 (DN 50) and Smaller: 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
 - c. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
 - d. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
 - e. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
14. Install supports for vertical PVC piping every 48 inches (1200 mm).
15. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

J. Connections

1. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment and machines to allow service and maintenance.



3. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
4. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
 - a. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
 - b. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 - c. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 Section(s) "Plumbing Fixtures" OR "Healthcare Plumbing Fixtures" OR "Emergency Plumbing Fixtures" OR "Security Plumbing Fixtures", **as directed**, for connection sizes.
 - d. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

K. Escutcheon Installation

1. Install escutcheons for penetrations of walls, ceilings, and floors.
2. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.
 - d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
 - e. Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
 - f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
3. Escutcheons for Existing Piping:
 - a. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
 - b. Insulated Piping: Split plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
 - e. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
 - f. Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
 - g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

L. Sleeve Installation



1. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
2. Sleeves are not required for core-drilled holes.
3. Permanent sleeves are not required for holes formed by removable PE sleeves.
4. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
5. Install sleeves in new partitions, slabs, and walls as they are built.
6. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
7. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
8. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals **OR** wall penetration systems, **as directed**, specified in this Section.
9. Seal space outside of sleeves in concrete slabs and walls with grout.
10. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
11. Install sleeve materials according to the following applications:
 - a. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE **OR** Molded PVC **OR** Steel pipe, **as directed**.
 - b. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe **OR** Stack sleeve fittings, **as directed**.
 - 1) Extend sleeves 2 inches (50 mm) above finished floor level.
 - 2) For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
 - c. Sleeves for Piping Passing through Gypsum-Board Partitions:
 - 1) PVC pipe **OR** Steel pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Galvanized-steel sheet sleeves for pipes NPS 6 (DN 150) and larger.
 - 3) Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
 - d. Sleeves for Piping Passing through Concrete Roof Slabs: Molded PE **OR** Molded PVC **OR** Steel pipe, **as directed**.
 - e. Sleeves for Piping Passing through Exterior Concrete Walls:
 - 1) Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Cast-iron wall pipe sleeves for pipes NPS 6 (DN 150) and larger.
 - 3) Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
 - 4) Do not use sleeves when wall penetration systems are used.
 - f. Sleeves for Piping Passing through Interior Concrete Walls:
 - 1) PVC pipe **OR** Steel pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
 - 2) Galvanized-steel sheet sleeves for pipes NPS 6 (DN 150) and larger.
12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

M. Sleeve Seal Installation

1. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
2. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe



and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

N. Wall Penetration System Installation

1. Install wall penetration systems in new, exterior concrete walls.
2. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

O. Identification

1. Identify system components. Comply with requirements in Division 22 Section "Identification For Plumbing Piping And Equipment" for identification materials and installation.
2. Label pressure piping with system operating pressure.

P. Field Quality Control

1. Perform tests and inspections.
2. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2) Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
3. Piping Tests:
 - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
 - c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - e. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
 - f. Prepare reports for tests and for corrective action required.
4. Domestic water piping will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

Q. Adjusting

1. Perform the following adjustments before operation:
 - a. Close drain valves, hydrants, and hose bibbs.
 - b. Open shutoff valves to fully open position.
 - c. Open throttling valves to proper setting.
 - d. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.



- 1) Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
- 2) Adjust calibrated balancing valves to flows indicated.
- e. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
- f. Remove and clean strainer screens. Close drain valves and replace drain plugs.
- g. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
- h. Check plumbing specialties and verify proper settings, adjustments, and operation.

R. Cleaning

1. Clean and disinfect potable and non-potable, **as directed**, domestic water piping as follows:
 - a. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - b. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - 1) Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - 2) Fill and isolate system according to either of the following:
 - a) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
 - b) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.
 - 3) Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - 4) Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
2. Clean non-potable domestic water piping as follows:
 - a. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - b. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
 - 1) Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - 2) Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
3. Prepare and submit reports of purging and disinfecting activities.
4. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

S. Piping Schedule

1. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
2. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
3. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
4. Under-building-slab, domestic water, building service piping, NPS 3 (DN 80) and smaller, shall be one of the following:
 - a. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; wrought-copper solder-joint fittings; and brazed **OR** copper pressure-seal fittings; and pressure-sealed, **as directed**, joints.
 - b. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
5. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 (DN 100 to DN 200) and larger, shall be one of the following:



- a. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; wrought-copper solder-joint fittings; and brazed joints.
 - b. Mechanical-joint, ductile-iron pipe; standard-pattern **OR** compact-pattern, **as directed**, mechanical-joint fittings; and mechanical joints.
 - c. Push-on-joint, ductile-iron pipe; standard-pattern **OR** compact-pattern, **as directed**, push-on-joint fittings; and gasketed joints.
 - d. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
 - e. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
6. Under-building slab, combined domestic water, building-service, and fire-service-main piping, NPS 6 to NPS 12 (DN 150 to DN 300), shall be one of the following:
 - a. Mechanical-joint, ductile-iron pipe; standard-pattern **OR** compact-pattern, **as directed**, mechanical-joint fittings; and mechanical joints.
 - b. Push-on-joint, ductile-iron pipe; standard-pattern **OR** compact-pattern, **as directed**, push-on-joint fittings; and gasketed joints.
 - c. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
 7. Under-building-slab, domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:
 - a. Hard **OR** Soft, **as directed**, copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper solder-joint fittings; and brazed **OR** copper pressure-seal-joint fittings; and pressure-sealed, **as directed**, joints.
 - b. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
 8. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:
 - a. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
 - b. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; cast-copper **OR** wrought-copper, **as directed**, solder-joint fittings; and brazed **OR** soldered, **as directed**, joints.
 - c. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; copper pressure-seal-joint fittings; and pressure-sealed joints.
 - d. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B) **OR**, **as directed**; copper push-on-joint fittings; and push-on joints.
 - e. CPVC, Schedule 40 pipe; CPVC, Schedule 40 **OR** Schedule 80 pipe; CPVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
 - f. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
 - g. CPVC Tubing System: CPVC tube; CPVC socket fittings; and solvent-cemented joints. NPS 1-1/2 (DN 40) and NPS 2 (DN 50) CPVC pipe with CPVC socket fittings may be used instead of tubing.
 - h. PEX Tube, NPS 1 (DN 25) and smaller; fittings for PEX tube; and crimped joints.
 - i. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
 9. Aboveground domestic water piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
 - a. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; cast-copper **OR** wrought-copper, **as directed**, solder-joint fittings; and brazed **OR** soldered, **as directed**, joints.
 - b. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; copper pressure-seal-joint fittings; and pressure-sealed joints.
 - c. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; grooved-joint copper-tube appurtenances; and grooved joints.



- d. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
 - e. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
 - f. CPVC, Schedule 40 pipe; CPVC, Schedule 40 **OR** Schedule 80 pipe; CPVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
 - g. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
 - h. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
10. Aboveground domestic water piping, NPS 5 to NPS 8 (DN 125 to DN 200), shall be one of the following:
- a. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; cast-copper **OR** wrought-copper, **as directed**, solder-joint fittings; and brazed **OR** soldered, **as directed**, joints.
 - b. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; grooved-joint copper-tube appurtenances; and grooved joints.
 - c. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
 - d. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
 - e. CPVC, Schedule 40 pipe; CPVC, Schedule 40 **OR** Schedule 80 pipe; CPVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
 - f. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
 - g. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
11. Aboveground, combined domestic-water-service and fire-service-main piping, NPS 6 to NPS 12 (DN 150 to DN300), shall be one of the following:
- a. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
 - b. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
 - c. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
- T. Valve Schedule
1. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - a. Shutoff Duty: Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
 - b. Throttling Duty: Use ball or globe valves for piping NPS 2 (DN 50) and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
 - c. Hot-Water Circulation Piping, Balancing Duty: Calibrated **OR** Memory-stop, **as directed**, balancing valves.
 - d. Drain Duty: Hose-end drain valves.
 2. Use check valves to maintain correct direction of domestic water flow to and from equipment.
 3. Iron grooved-end valves may be used with grooved-end piping.
 4. CPVC and PVC valves matching piping materials may be used.

END OF SECTION 22 11 16 00



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**SECTION 22 11 16 00a - SANITARY WASTE AND VENT PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for sanitary waste and vent piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes:
 - a. Pipe, tube, and fittings.
 - b. Special pipe fittings.
 - c. Encasement for underground metal piping.

C. Performance Requirements

1. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
 - a. Soil, Waste, and Vent Piping: 10-foot head of water (30 kPa).
 - b. Sanitary Sewer, Force-Main Piping: 50 psig (345 kPa) **OR** 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
2. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of earthquake motions determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings: For solvent Drainage System: Include plans, elevations, sections, and details.
4. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.
5. Field quality-control inspection and test reports.

E. Quality Assurance

1. Piping materials shall bear label, stamp, or other markings of specified testing agency.
2. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

F. Project Conditions

1. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of sanitary waste service.



- b. Do not proceed with interruption of sanitary waste service without the Owner written permission.

1.2 PRODUCTS

A. Piping Materials

1. Comply with requirements in "Piping Applications" Article for applications of pipe, tube, fitting, and joining methods for specific services, service locations, and pipe sizes.

B. Hub-And-Spigot, Cast-Iron Soil Pipe And Fittings

1. Pipe and Fittings: ASTM A 74, Service and Extra-Heavy class(es).
2. Gaskets: ASTM C 564, rubber.
3. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

C. Hubless, Cast-Iron Soil Pipe And Fittings

1. Pipe and Fittings: ASTM A 888 or CISPI 301.
2. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.
3. CISPI, Hubless-Piping Couplings:
 - a. Standards: ASTM C 1277 and CISPI 310
 - b. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
4. Heavy-Duty, Hubless-Piping Couplings:
 - a. Standards: ASTM C 1277 and ASTM C 1540.
 - b. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
5. Cast-Iron, Hubless-Piping Couplings:
 - a. Standard: ASTM C 1277.
 - b. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

D. Galvanized-Steel Pipe And Fittings

1. Galvanized Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight. Include ends matching joining method.
2. Galvanized-Cast-Iron Drainage Fittings: ASME B16.12, galvanized.
3. Steel Pipe Pressure Fittings:
 - a. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
 - b. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 - c. Galvanized-Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, **as directed**, standard pattern.
4. Cast-Iron Flanges: ASME B16.1, Class 125.
 - a. Flange Gasket Materials: ASME ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - b. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
5. Grooved-Joint Systems:
 - a. Galvanized, Grooved-End Fittings for Galvanized-Steel Piping: ASTM A 536 ductile-iron castings, ASTM A 47/A 47M malleable-iron castings, ASTM A 234/A 234M forged steel fittings, or ASTM A 106/A 106M steel pipes with dimensions matching ASTM A 53/A 53M steel pipe, and complying with AWWA C606 for grooved ends.
 - b. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber gasket suitable for hot and cold water; and bolts and nuts.



- E. Stainless-Steel Pipe And Fittings
1. Pipe and Fittings: ASME A112.3.1, drainage pattern with socket and spigot ends.
 2. Internal Sealing Rings: Elastomeric gasket shaped to fit socket groove.
 - a. Material: EPDM, unless NBR is indicated.
- F. Ductile-Iron Pipe And Fittings
1. Ductile-Iron, Mechanical-Joint Piping:
 - a. Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - b. Ductile-Iron Fittings: AWWA C110/A21.10, mechanical-joint, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
 - c. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
 2. Ductile-Iron, Push-on-Joint Piping:
 - a. Ductile-Iron Pipe: AWWA C151/A21.51, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - b. Ductile-Iron Fittings: AWWA C110/A21.10, push-on-joint ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
 - c. Gaskets: AWWA C111/A21.11, rubber.
 3. Ductile-Iron, Grooved-Joint Piping:
 - a. Ductile-Iron Pipe: AWWA C151/A21.51 with round-cut-grooved ends according to AWWA C606.
 - b. Ductile-Iron-Pipe Appurtenances:
 - 1) Grooved-End, Ductile-Iron Fittings: ASTM A 536 ductile-iron castings with dimensions matching AWWA C110/A 21.10 ductile-iron pipe or AWWA C153/A 21.53 ductile-iron fittings and complying with AWWA C606 for grooved ends.
 - 2) Grooved Mechanical Couplings for Ductile-Iron Pipe: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber center-leg gasket suitable for hot and cold water; and bolts and nuts.
- G. Copper Tube And Fittings
1. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
 2. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
 3. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.
 4. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.
 5. Copper Pressure Fittings:
 - a. ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - b. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to metal seating surfaces, and solder-joint or threaded ends
 6. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
 - a. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - b. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
 7. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux
- H. ABS Pipe And Fittings
1. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.
 2. Cellular-Core ABS Pipe: ASTM F 628, Schedule 40.
 3. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.
 4. Solvent Cement ASTM D 2235:
 - a. Use ABS solvent cement that has a VOC content of 325 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).



- I. PVC Pipe And Fittings
1. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
 2. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
 3. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
 4. Adhesive Primer: ASTM F 656.
 - a. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 5. Solvent Cement: ASTM D 2564.
 - a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- J. Specialty Pipe Fittings
1. Transition Couplings:
 - a. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
 - b. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
 - c. Unshielded, Nonpressure Transition Couplings:
 - 1) Standard: ASTM C 1173.
 - 2) Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 3) Sleeve Materials:
 - a) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - b) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - c) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
 - d. Shielded Nonpressure Transition Couplings:
 - 1) ASTM C 1460.
 - 2) Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - e. Pressure Transition Pipe Couplings:
 - 1) AWWA C219.
 - 2) Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 - 3) Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
 - 4) Gasket Material: Natural or synthetic rubber.
 - 5) Metal Component Finish: Corrosion-resistant coating or material.
 2. Dielectric Fittings:
 - a. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
 - b. Dielectric Unions:
 - 1) Description:
 - a) Standard: ASSE 1079.
 - b) Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) **OR** 150 psig (1035 kPa) **OR** 250 psig (1725 kPa), **as directed**.
 - c) End Connections: Solder-joint copper alloy and threaded ferrous.
 - c. Dielectric Flanges:
 - 1) Description:
 - a) Standard: ASSE 1079.



- b) Factory-fabricated, bolted, companion-flange assembly.
 - c) Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) **OR** 150 psig (1035 kPa) **OR** 175 psig (1200 kPa) **OR** 300 psig (2070 kPa), **as directed**.
 - d) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
 - d. Dielectric-Flange Insulating Kits:
 - 1) Description:
 - a) Nonconducting materials for field assembly of companion flanges.
 - b) Pressure Rating: 150 psig (1035 kPa).
 - c) Gasket: Neoprene or phenolic.
 - d) Bolt Sleeves: Phenolic or polyethylene.
 - e) Washers: Phenolic with steel backing washers.
 - e. Dielectric Nipples
 - 1) Description:
 - a) Electroplated steel nipple complying with ASTM F 1545.
 - b) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - c) End Connections: Male threaded or grooved.
 - d) Lining: Inert and noncorrosive, propylene.
- K. Encasement For Underground Metal Piping
- 1. Standard: ASTM A 674 or AWWA C105/A 21.5
 - 2. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) **OR** high density, cross-laminated polyethylene film of 0.004-inch (0.10-mm), **as directed**, minimum thickness.
 - 3. Form: Sheet **OR** Tube, **as directed**.
 - 4. Color: Black **OR** Natural, **as directed**.

1.3 EXECUTION

- A. Earth Moving
- 1. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
- B. Piping Installation
- 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
 - 2. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
 - 3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
 - 4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 - 5. Install piping to permit valve servicing.
 - 6. Install piping at indicated slopes.
 - 7. Install piping free of sags and bends.
 - 8. Install fittings for changes in direction and branch connections.
 - 9. Install piping to allow application of insulation.
 - 10. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
 - 11. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with



- common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
12. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
 13. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
 - a. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent **OR** 2 percent, as directed downward in direction of flow for piping NPS 4 (DN 100) and larger.
 - b. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
 - c. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
 14. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - a. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.
 15. Install steel piping according to applicable plumbing code.
 16. Install stainless-steel piping according to ASME A112.3.1 and applicable plumbing code.
 17. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
 18. Install aboveground ABS piping according to ASTM D 2661.
 19. Install aboveground PVC piping according to ASTM D 2665.
 20. Install underground ABS and PVC piping according to ASTM D 2321.
 21. Install engineered soil and waste drainage and vent piping systems as follows:
 - a. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
 - b. Solvent Drainage System: Comply with ASSE 1043 and solvent fitting manufacturer's written installation instructions.
 - c. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.
 22. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside building between wall and floor penetrations and connection to sanitary sewer piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
 - a. Install encasement on piping according to ASTM A 674 or AWWA C105/A 21.5.
 23. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
 - a. Install encasement on piping according to ASTM A 674 or AWWA C105/A 21.5.
 24. Install force mains at elevations indicated.
 25. Plumbing Specialties:
 - a. Install backwater valves in sanitary waste gravity-flow piping. Comply with requirements for backwater valves specified in Division 22 Section "Sanitary Waste Piping Specialties".
 - b. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties".
 - c. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Sanitary Waste Piping Specialties".
 26. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
 27. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Common Work Results For Plumbing".
 28. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Common Work Results For Plumbing".



29. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Common Work Results For Plumbing".

C. Joint Construction

1. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.
3. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
4. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
5. Join stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.
6. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
7. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
8. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
9. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - c. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

D. Specialty Pipe Fitting Installation

1. Transition Couplings:
 - a. Install transition couplings at joints of piping with small differences in OD's.
 - b. In Drainage Piping: Unshielded **OR** Shielded, **as directed**, nonpressure transition couplings.
 - c. In Aboveground Force Main Piping: Fitting-type transition couplings.
 - d. In Underground Force Main Piping:
 - 1) NPS 1-1/2 (DN 40) and Smaller: Fitting-type transition couplings.
 - 2) NPS 2 (DN 50) and Larger: Pressure transition couplings.
2. Dielectric Fittings:
 - a. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - b. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples **OR** unions, **as directed**.
 - c. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges **OR** flange kits **OR** nipples, **as directed**.
 - d. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

E. Valve Installation

1. General valve installation requirements are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
2. Shutoff Valves:
 - a. Install shutoff valve on each sewage pump discharge.



- b. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
- c. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.
- 3. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
- 4. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
 - a. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
 - b. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
 - c. Install backwater valves in accessible locations.
 - d. Backwater valve are specified in Division 22 Section "Sanitary Waste Piping Specialties".

F. Hanger And Support Installation

1. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
2. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment".
 - a. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - b. Install stainless-steel **OR** fiberglass pipe hangers, **as directed** for horizontal piping in corrosive environments.
 - c. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - d. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 - e. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - f. Install individual, straight, horizontal piping runs according to the following:
 - 1) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - 2) Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - 3) Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.
 - g. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - h. Base of Vertical Piping: MSS Type 52, spring hangers.
3. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting[, **valve,**] and coupling.
4. Support vertical piping and tubing at base and at each floor.
5. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
6. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
 - c. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
 - d. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
 - e. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
 - f. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
7. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
8. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - d. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
 - e. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
 - f. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
 - g. NPS 6 and NPS 8 (DN 150 and DN 200): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
 - h. NPS 10 to NPS 12 (DN 250 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.



9. Install supports for vertical steel piping every 15 feet (4.5 m).
10. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 2 (DN 50): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3 (DN 80): 96 inches (2400 mm) with 1/2-inch (13-mm) rod.
 - c. NPS 4 (DN 100): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
 - d. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
11. Install supports for vertical stainless-steel piping every 10 feet (3 m).
12. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
 - d. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
 - e. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
 - f. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
13. Install supports for vertical copper tubing every 10 feet (3 m).
14. Install hangers for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
 - c. NPS 4 and 5 (DN 100 and 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
 - d. NPS 6 and NPS 8 (DN 150 and DN 200): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
 - e. NPS 10 to NPS 12 (DN 250 to DN 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
15. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).
16. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

G. Connections

1. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
3. Connect drainage and vent piping to the following:
 - a. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
 - b. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - c. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
 - d. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - e. Install horizontal backwater valves with cleanout cover flush with floor **OR** in pit with pit cover flush with floor, **as directed**.
 - f. Comply with requirements for backwater valves, cleanouts and drains specified in Division 22 Section "Facility Storm Drainage Piping".
 - g. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.
4. Connect force-main piping to the following:
 - a. Sanitary Sewer: To exterior force main or sanitary manhole.
 - b. Sewage Pumps: To sewage pump discharge.
5. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
6. Make connections according to the following unless otherwise indicated:



- a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
- b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

H. Identification

1. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 22 Section "Identification For Plumbing Piping And Equipment".

I. Field Quality Control

1. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
2. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
3. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
4. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - a. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - b. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - c. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 - d. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa). Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
 - e. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - f. Prepare reports for tests and required corrective action.
5. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - a. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - b. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - c. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - d. Prepare reports for tests and required corrective action.



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- J. Cleaning and Protection
1. Clean interior of piping. Remove dirt and debris as work progresses.
 2. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
 3. Place plugs in ends of uncompleted piping at end of day and when work stops.
 4. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION 22 11 16 00a



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SECTION 22 11 16 00b - STORM DRAINAGE PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for storm drainage piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes:
 - a. Pipe, tube, and fittings.
 - b. Special pipe fittings.
 - c. Encasement for underground metal piping.

C. Performance Requirements

1. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
 - a. Storm Drainage Piping: 10-foot head of water (30 kPa).
 - b. Storm Drainage, Force-Main Piping: 50 psig (345 kPa) **OR** 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
2. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings: For controlled-flow **OR** siphonic roof drainage system, as directed by the Owner. Include calculations, plans, and details. Controlled-Flow Storm Drainage System: Include calculations, plans, and details.
4. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Field quality-control inspection and test reports.

E. Quality Assurance

1. Piping materials shall bear label, stamp, or other markings of specified testing agency.
2. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

F. Project Conditions

1. Interruption of Existing Storm-Drainage Service: Do not interrupt service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of storm-drainage service.



- b. Do not proceed with interruption of storm-drainage service without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials

1. Refer to Part 1.3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining methods for specific services, service locations, and pipe sizes.

B. Hub-And-Spigot, Cast-Iron Soil Pipe And Fittings

1. Pipe and Fittings: ASTM A 74, Service and Extra-Heavy class(es).
2. Gaskets: ASTM C 564, rubber.
3. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

C. Hubless Cast-Iron Soil Pipe And Fittings

1. Pipe and Fittings: ASTM A 888 or CISPI 301.
2. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
 - b. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
 - c. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.
3. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Galvanized-Steel Pipe And Fittings

1. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.
2. Drainage Fittings: ASME B16.12, galvanized, **as directed**, threaded, cast-iron drainage pattern.
3. Pressure Fittings:
 - a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
 - b. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 - c. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, **as directed**, standard pattern.
 - d. Cast-Iron Flanges: ASME B16.1, Class 125.
 - e. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized, **as directed**.
4. Grooved-Joint Systems:
 - a. Grooved-End, Steel-Piping Fittings: ASTM A 47/A 47M, galvanized, **as directed**, malleable-iron casting; ASTM A 106, galvanized-steel pipe; or ASTM A 536, galvanized, **as directed**, ductile-iron casting; with dimensions matching steel pipe.
 - b. Grooved-End, Steel-Piping Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

E. Ductile-Iron, Pipe and Fittings

1. Ductile-Iron, Mechanical-Joint Piping
 - a. Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
 - b. Ductile-Iron Fittings: AWWA C110/A21.10, mechanical-joint ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.



- c. Glands, Gaskets, and Bolts: AWWA C111/A121.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
 2. Ductile-Iron, Push-on-Joint,
 - a. Ductile-Iron Pipe: AWWA C151/A21.51, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
 - b. Ductile-Iron Fittings: AWWA C110/A21.10, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
 - c. Gaskets: AWWA C111/A21.11, rubber.
 3. Ductile Iron, Grooved-Joint Piping:
 - a. Ductile-Iron Pipe: AWWA C151/A21.51 with round-cut-grooved ends according to AWWA C606.
 - b. Ductile-Iron-Pipe Appurtenances:
 - 1) Grooved-End, Ductile-Iron Fittings: ASTM A 536, ductile-iron castings with dimensions matching pipe. AWWA C110/A21.10 ductile-iron pipe or AWWA C153/A21.53 ductile-iron fittings and complying with AWWA C606 for grooved ends.
 - 2) Grooved Mechanical Couplings for Ductile-Iron Pipe: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys, EPDM-rubber center-leg gasket suitable for hot and cold water, and bolts and nuts.
- F. Copper Tube And Fittings
1. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
 2. Copper Drainage Fittings: ASME B16.23, cast-copper or ASME B16.29, wrought-copper, solder-joint fittings.
 3. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.
 4. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.
 5. Copper Pressure Fittings:
 - a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - b. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
 6. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
 - a. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - b. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
 7. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.
- G. ABS Pipe And Fittings
1. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.
 2. Cellular-Core ABS Pipe: ASTM F 628, Schedule 40.
 3. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.
 4. Solvent Cement: ASTM D 2235
 - a. Use ABS solvent cement that has a VOC content of 325 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- H. PVC Pipe And Fittings
1. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
 2. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
 3. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
 4. Adhesive Primer: ASTM F 656.
 - a. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 5. Solvent Cement: ASTM D 2564.



- a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

I. Specialty Pipe Fittings

1. Transition Couplings:

- a. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
- b. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
- c. Unshielded, Nonpressure Transition Couplings:
 - 1) Standard: ASTM C 1173.
 - 2) Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 3) Sleeve Materials:
 - a) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - b) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - c) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- d. Shielded, Nonpressure Transition Couplings:
 - 1) Standard: ASTM C 1460.
 - 2) Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
- e. Pressure Transition Couplings:
 - f. Standard: AWWA C219.
 - g. Description: Metal, sleeve-type couplings same size as, with pressure rating at least equal to and ends compatible with, pipes to be joined.
 - h. Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
 - i. Gasket Material: Natural or synthetic rubber.
 - j. Metal Component Finish: Corrosion-resistant coating or material.

2. Dielectric Fittings:

- a. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- b. Dielectric Unions:
 - 1) Description:
 - a) Standard: ASSE 1079.
 - b) Pressure Rating: **150 psig (1035 kPa) OR 250 psig (1725 kPa)** at 180 deg F (82 deg C), **as directed**.
 - c) End Connections: Solder-joint copper alloy and threaded ferrous.
- c. Dielectric Flanges:
 - 1) Description:
 - a) Standard: ASSE 1079.
 - b) Factory-fabricated, bolted, companion-flange assembly.
 - c) Pressure Rating: **150 psig (1035 kPa) OR 175 psig (1200 kPa)** minimum **OR 300 psig (2070 kPa), as directed**.
 - d) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- d. Dielectric-Flange Insulating Kits:
 - 1) Description:
 - a) Nonconducting materials for field assembly of companion flanges.



- b) Pressure Rating: **150 psig (1035 kPa)**
- c) Gasket: Neoprene or phenolic.
- d) Bolt Sleeves: Phenolic or polyethylene.
- e) Washers: Phenolic with steel-backing washers.
- e. Dielectric Nipples:
 - 1) Description:
 - a) Electroplated steel nipple complying with ASTM F 1545.
 - b) Pressure Rating: **300 psig (2070 kPa) at 225 deg F (107 deg C).**
 - c) End Connections: Male threaded or grooved.
 - d) Lining: Inert and noncorrosive, propylene.

J. Encasement For Underground Metal Piping

- 1. Description: ASTM A 674 or AWWA C105
- 2. Material: High-density, crosslaminated PE film of 0.004-inch (0.10-mm) **OR** LLDPE film of 0.008-inch (0.20-mm), **as directed**, minimum thickness.
- 3. Form: Sheet **OR** Tube, **as directed**.
- 4. Color: Black **OR** Natural, **as directed**.

1.3 EXECUTION

A. Earth Moving

- 1. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Piping Installation

- 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- 2. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- 3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- 4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- 5. Install piping to permit valve servicing.
- 6. Install piping at indicated slopes.
- 7. Install piping free of sags and bends.
- 8. Install fittings for changes in direction and branch connections.
- 9. Install piping to allow application of insulation.
- 10. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
- 11. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- 12. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- 13. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
 - a. Building Storm Drain: 1 percent **OR** 2 percent, **as directed**, downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent **OR** 2 percent, **as directed**, downward in direction of flow for piping NPS 4 (DN 100) and larger.



- b. Horizontal Storm-Drainage Piping: **2 percent** downward in direction of flow.
- 14. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - a. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
- 15. Install steel piping according to applicable plumbing code.
- 16. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- 17. Install aboveground ABS piping according to ASTM D 2661.
- 18. Install aboveground PVC piping according to ASTM D 2665.
- 19. Install underground ABS and PVC piping according to ASTM D 2321.
- 20. Install engineered controlled-flow **OR** siphonic, **as directed**, drain specialties and storm drainage piping in locations indicated.
- 21. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside building between wall and floor penetrations and connection to storm sewer piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
 - a. Install encasement on piping according to ASTM A 674 or AWWA C105.
- 22. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
 - a. Install encasement on piping according to ASTM A 674 or AWWA C105.
- 23. Install force mains at elevations indicated.
- 24. Plumbing Specialties:
 - a. Install backwater valves in storm drainage gravity-flow piping. Comply with requirements for backwater valves specified in Division 33 Section "Storm Utility Drainage Piping".
 - b. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Division 33 Section "Storm Utility Drainage Piping".
 - c. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Division 33 Section "Storm Utility Drainage Piping".
- 25. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- 26. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Common Work Results For Plumbing".
- 27. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Common Work Results For Plumbing".
- 28. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Common Work Results For Plumbing".

C. Joint Construction

- 1. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results For Plumbing".
- 2. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- 3. Hub-and-Spigot, Cast-Iron Soil Piping Calked Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
- 4. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
- 5. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.



6. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
 7. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fittings. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
 8. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
 9. Plastic, Nonpressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - c. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.
- D. Specialty Pipe Fitting Installation
1. Transition Couplings:
 - a. Install transition couplings at joints of piping with small differences in OD's.
 - b. In Drainage Piping: Unshielded **OR** Shielded, **as directed** nonpressure transition couplings.
 - c. In Aboveground Force-Main Piping: Fitting-type transition couplings.
 - d. In Underground Force-Main Piping:
 - 1) NPS 1-1/2 (DN 40) and Smaller: Fitting-type transition couplings.
 - 2) NPS 2 (DN 50) and Larger: Pressure transition couplings.
 2. Dielectric Fittings:
 - a. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - b. Dielectric Fittings for **NPS 2 (DN 50)** and Smaller: Use dielectric nipples **OR** unions, **as directed**.
 - c. Dielectric Fittings for **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Use dielectric flanges **OR** flange kits **OR** nipples, **as directed**.
 - d. Dielectric Fittings for **NPS 5 (DN 125)** and Larger: Use dielectric flange kits.
- E. Valve Installation
1. General valve installation requirements are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
 2. Shutoff Valves: Install shutoff valve on each sump pump discharge.
 - a. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
 - b. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.
 3. Check Valves: Install swing check valve, between pump and shutoff valve, on each sump pump discharge.
 4. Backwater Valves: Install backwater valves in piping subject to backflow.
 - a. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
 - b. Install backwater valves in accessible locations.
 - c. Comply with requirements for backwater valve specified in Division 22 Section "Storm Drainage Piping Specialties".
- F. Hanger And Support Installation
1. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
 2. Comply with requirements for pipe hangers and supports and installation specified in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment".
 - a. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - b. Install stainless-steel **OR** fiberglass pipe hangers, **as directed**, for horizontal piping in corrosive environments.
 - c. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.



- d. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
- e. Vertical Piping: MSS Type 8 or Type 42, clamps.
- f. Individual, Straight, Horizontal Piping Runs:
 - 1) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - 2) Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - 3) Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.
- g. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
- h. Base of Vertical Piping: MSS Type 52, spring hangers.
3. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.
4. Support vertical piping and tubing at base and at each floor.
5. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
6. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
 - c. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
 - d. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
 - e. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
 - f. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
7. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
8. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - d. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
 - e. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
 - f. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
 - g. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
 - h. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.
9. Install supports for vertical steel piping every 15 feet (4.5 m).
10. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
 - d. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
 - e. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
 - f. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
11. Install supports for vertical copper tubing every 10 feet (3 m).
12. Install hangers for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
 - c. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
 - d. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
 - e. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
13. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).



14. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

G. Connections

1. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
3. Connect storm drainage piping to roof drains and storm drainage specialties.
 - a. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
 - b. Install horizontal backwater valves with cleanout cover flush with floor **OR** in pit with pit cover flush with floor, **as directed**.
 - c. Comply with requirements for backwater valves, cleanouts and drains specified in Division 22 Section "Storm Drainage Piping Specialties".
4. Connect force-main piping to the following:
 - a. Storm Sewer: To exterior force main or storm manhole.
 - b. Sump Pumps: To sump pump discharge.
5. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
6. Make connections according to the following unless otherwise indicated:
 - a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

H. Identification

1. Identify exposed storm drainage piping. Comply with requirements for identification specified in Division 22 Section "Identification For Plumbing Piping And Equipment".

I. Field Quality Control

1. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
2. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
3. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
4. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - a. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - b. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - c. Test Procedure: Test storm drainage piping, except outside leaders, **as directed**, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 - d. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - e. Prepare reports for tests and required corrective action.



5. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - a. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - b. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - c. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - d. Prepare reports for tests and required corrective action.

J. Cleaning

1. Clean interior of piping. Remove dirt and debris as work progresses.
2. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
3. Place plugs in ends of uncompleted piping at end of day and when work stops.

K. Piping Schedule

1. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
2. Aboveground storm drainage piping NPS 6 (DN 150) and smaller shall be any of the following:
 - a. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - b. Hubless, cast-iron soil pipe and fittings; **CISPI, heavy-duty**, hubless-piping couplings; and coupled joints.
 - c. Galvanized-steel pipe, drainage fittings, and threaded joints.
 - d. Copper tube and fittings in first subparagraph below are only available in NPS 1-1/4 to NPS 8 (DN 32 to DN 200).
 - e. Copper DWV tube, copper drainage fittings, and soldered joints.
 - f. Solid-wall **OR** Cellular-core ABS pipe, **as directed**, ABS socket fittings, and solvent-cemented joints.
 - g. Solid-wall **OR** Cellular-core PVC pipe, **as directed**, PVC socket fittings, and solvent-cemented joints.
 - h. Dissimilar Pipe-Material Couplings: Unshielded **OR** Shielded, **as directed**, nonpressure transition couplings.
3. Aboveground, storm drainage piping NPS 8 (DN 200) and larger shall be any of the following:
 - a. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - b. Hubless, cast-iron soil pipe and fittings; **CISPI, heavy-duty**, hubless-piping couplings; and coupled joints.
 - c. Galvanized-steel pipe, drainage fittings, and threaded joints.
 - d. Copper DWV tube, copper drainage fittings, and soldered joints.
 - e. Solid-wall **OR** Cellular-core PVC pipe, **as directed**, PVC socket fittings, and solvent-cemented joints.
 - f. Dissimilar Pipe-Material Couplings: Unshielded **OR** Shielded, **as directed**, nonpressure transition couplings.
4. Underground storm drainage piping **NPS 6 (DN 150) and smaller** shall be **any of** the following:
 - a. Extra Heavy **OR** Service class, **as directed**, cast-iron soil pipe and fittings; gaskets; and gasketed **OR** calking materials; and calked joints, **as directed**.
 - b. Hubless, cast-iron soil pipe and fittings; **CISPI, heavy-duty, cast-iron**, hubless-piping couplings; and coupled joints.
 - c. Solid-wall **OR** Cellular-core ABS pipe, **as directed**, ABS socket fittings, and solvent-cemented joints.
 - d. **Solid-wall OR Cellular-core** PVC pipe, **as directed**, PVC socket fittings, and solvent-cemented joints.



- e. Dissimilar Pipe-Material Couplings: Unshielded **OR** Shielded, **as directed**, nonpressure transition couplings.
5. Underground, storm drainage piping **NPS 8 (DN 200) and larger** shall be **any of** the following:
 - a. Extra Heavy **OR** Service class, **as directed**, cast-iron soil pipe and fittings; gaskets; and gasketed **OR** calking materials; and calked joints **as directed**.
 - b. Hubless, cast-iron soil pipe and fittings; **CISPI, heavy-duty, cast-iron**, hubless-piping couplings; and coupled joints.
 - c. **Solid-wall OR Cellular-core** PVC pipe, **as directed**, PVC socket fittings, and solvent-cemented joints.
 - d. Cellular-core, sewer and drain series, PVC pipe; PVC socket fittings; and solvent-cemented joints.
 - e. Dissimilar Pipe-Material Couplings: **Unshielded OR Shielded, as directed**, nonpressure transition couplings.
6. Aboveground storm drainage force mains **NPS 1-1/2 and NPS 2 (DN 40 and DN 50)** shall be **any of** the following:
 - a. Hard copper tube, copper pressure fittings, and soldered joints.
 - b. Galvanized-steel pipe, pressure fittings, and threaded joints.
7. Aboveground storm drainage force mains **NPS 2-1/2 to NPS 6 (DN 65 to DN 150)** shall be any of the following:
 - a. Hard copper tube, copper pressure fittings, and soldered joints.
 - b. Galvanized-steel pipe, pressure fittings, and threaded joints.
 - c. Grooved-end, galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
 - d. Fitting-type transition couplings if dissimilar pipe materials.
8. Underground storm drainage force mains NPS 4 (DN 100) and smaller shall be any of the following:
 - a. Hard **OR** Soft, **as directed** copper tube; **wrought-copper** pressure fittings; and soldered joints.
 - b. Ductile-iron, mechanical-joint piping and mechanical joints.
 - c. Ductile-iron, push-on-joint piping and push-on joints.
 - d. Ductile-iron, grooved-joint piping and grooved joints.
 - e. Fitting-type transition coupling for piping smaller than NPS 1-1/2 (DN 40) and pressure transition coupling for NPS 1-1/2 (DN 40) and larger if dissimilar pipe materials.
9. Underground storm drainage force mains NPS 5 (DN 125) and larger shall be any of the following:
 - a. Hard copper tube; **wrought-copper** pressure fittings; and soldered joints.
 - b. Ductile-iron, mechanical-joint piping and mechanical joints.
 - c. Ductile-iron, push-on-joint piping and push-on joints.
 - d. Ductile-iron, grooved-joint piping and grooved joints.
 - e. Pressure transition couplings if dissimilar pipe materials.

END OF SECTION 22 11 16 00b



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SECTION 22 11 16 00c - HYDRONIC PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for hydronic piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - a. Hot-water heating piping.
 - b. Chilled-water piping.
 - c. Dual-temperature heating and cooling water piping.
 - d. Condenser-water piping.
 - e. Glycol cooling-water piping.
 - f. Makeup-water piping.
 - g. Condensate-drain piping.
 - h. Blowdown-drain piping.
 - i. Air-vent piping.
 - j. Safety-valve-inlet and -outlet piping.

C. Definitions

1. PTFE: Polytetrafluoroethylene.
2. RTRF: Reinforced thermosetting resin (fiberglass) fittings.
3. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

D. Performance Requirements

1. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 - a. Hot-Water Heating Piping: **psig (kPa)**, as directed by the Owner at 200 deg F (93 deg C).
 - b. Chilled-Water Piping: **psig (kPa)**, as directed by the Owner at 200 deg F (93 deg C).
 - c. Dual-Temperature Heating and Cooling Water Piping: **psig (kPa)**, ethylene at 200 deg F (93 deg C).
 - d. Condenser-Water Piping: **psig (kPa)**, as directed by the Owner at 150 deg F (66 deg C).
 - e. Glycol Cooling-Water Piping: **psig (kPa)**, as directed by the Owner at 150 deg F (66 deg C).
 - f. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C).
 - g. Condensate-Drain Piping: 150 deg F (66 deg C).
 - h. Blowdown-Drain Piping: 200 deg F (93 deg C).
 - i. Air-Vent Piping: 200 deg F (93 deg C).
 - j. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

E. Submittals

1. Product Data: For each type of the following:
 - a. Plastic pipe and fittings with solvent cement.
 - b. RTRP and RTRF with adhesive.
 - c. Pressure-seal fittings.
 - d. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - e. Air control devices.



- f. Chemical treatment.
- g. Hydronic specialties.
- 2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
- 3. Shop Drawings: Detail, at 1/4 (1:50) scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
- 4. Welding certificates.
- 5. Qualification Data: For Installer.
- 6. Field quality-control test reports.
- 7. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.
- 8. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

F. Quality Assurance

- 1. Installer Qualifications:
 - a. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
 - b. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
- 2. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- 3. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- 4. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.2 PRODUCTS

A. Copper Tube And Fittings

- 1. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M, Type C), **as directed**.
- 2. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).
- 3. DWV Copper Tubing: ASTM B 306, Type DWV.
- 4. Wrought-Copper Fittings: ASME B16.22.
 - a. Grooved-End Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze casting.
 - b. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated, **as directed**, EPDM gasket rated for minimum 230 deg F (110 deg C) for use with housing, and steel bolts and nuts.
- 5. Copper or Bronze Pressure-Seal Fittings:
 - a. Housing: Copper.
 - b. O-Rings and Pipe Stops: EPDM.



- c. Tools: Manufacturer's special tools.
 - d. Minimum 200-psig (1379-kPa) working-pressure rating at 250 deg F (121 deg C).
 6. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
 7. Wrought-Copper Unions: ASME B16.22.
- B. Steel Pipe And Fittings
1. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 1.3 "Piping Applications" Article.
 2. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 1.3 "Piping Applications" Article.
 3. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 1.3 "Piping Applications" Article.
 4. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 1.3 "Piping Applications" Article.
 5. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 1.3 "Piping Applications" Article.
 6. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
 7. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Butt welding.
 - c. Facings: Raised face.
 8. Grooved Mechanical-Joint Fittings and Couplings:
 - a. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - b. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 9. Steel Pressure-Seal Fittings:
 - a. Housing: Steel.
 - b. O-Rings and Pipe Stop: EPDM.
 - c. Tools: Manufacturer's special tool.
 - d. Minimum 300-psig (2070-kPa) working-pressure rating at 230 deg F (110 deg C).
 10. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.
- C. Plastic Pipe And Fittings
1. CPVC Plastic Pipe: ASTM F 441/F 441M, Schedules 40 and 80, plain ends as indicated in Part 1.3 "Piping Applications" Article.
 2. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
 3. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends as indicated in Part 1.3 "Piping Applications" Article.
 4. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.
- D. Fiberglass Pipe And Fittings
1. RTRP: ASTM D 2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.
 2. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.
 3. Flanges: ASTM D 4024. Full-face gaskets suitable for the service, minimum 1/8-inch (3.2-mm) thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.



E. Joining Materials

1. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - a. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - 1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - 2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
3. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
4. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
5. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
6. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
7. Solvent Cements for Joining Plastic Piping:
 - a. CPVC Piping: ASTM F 493.
 - 1) Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 1) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.
 - a. Use fiberglass adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

F. Transition Fittings

1. Plastic-to-Metal Transition Fittings:
 - a. CPVC **OR** PVC, **as directed**, one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.
2. Plastic-to-Metal Transition Unions:
 - a. MSS SP-107, CPVC **OR** PVC, **as directed**, union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

G. Dielectric Fittings

1. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions:
 - a. Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
4. Dielectric Flanges:
 - a. Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
5. Dielectric-Flange Kits:
 - a. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.



- b. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.
- 6. Dielectric Couplings:
 - a. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
- 7. Dielectric Nipples:
 - a. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

H. Valves

- 1. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 22 Section(s) "General-duty Valves For Plumbing Piping" OR Division 23 Section(s) "General-duty Valves For Hvac Piping".
- 2. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation And Control For Hvac".
- 3. Plastic Ball Valves:
 - a. Body: One-, two-, or three-piece CPVC or PVC to match piping.
 - b. Ball: Full-port CPVC or PVC to match piping.
 - c. Seats: PTFE.
 - d. Seals: EPDM.
 - e. End Connections: Socket, union, or flanged.
 - f. Handle Style: Tee shape.
 - g. CWP Rating: Equal to piping service.
 - h. Maximum Operating Temperature: Equal to piping service.
 - i. Comply with MSS SP-122.
- 4. Plastic Butterfly Valves:
 - a. Body: PVC or CPVC to match piping wafer type for installation between flanges.
 - b. Disc: EPDM-coated steel.
 - c. Seats: PTFE.
 - d. Handle Style: Locking lever.
 - e. CWP Rating: Equal to piping service.
 - f. Maximum Operating Temperature: Equal to piping service.
- 5. Plastic Check Valves:
 - a. Body: One-, two-, or three-piece PVC or CPVC to match piping.
 - b. Ends: Socket or flanged.
 - c. Seats: PTFE.
 - d. Check Style: Swing or ball type.
 - e. CWP Rating: Equal to piping service.
 - f. Maximum Operating Temperature: Equal to piping service.
- 6. Bronze, Calibrated-Orifice, Balancing Valves:
 - a. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 - b. Ball: Brass or stainless steel.
 - c. Plug: Resin.
 - d. Seat: PTFE.
 - e. End Connections: Threaded or socket.
 - f. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 - g. Handle Style: Lever, with memory stop to retain set position.
 - h. CWP Rating: Minimum 125 psig (860 kPa).
 - i. Maximum Operating Temperature: 250 deg F (121 deg C).
- 7. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
 - a. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 - b. Ball: Brass or stainless steel.
 - c. Stem Seals: EPDM O-rings.
 - d. Disc: Glass and carbon-filled PTFE.
 - e. Seat: PTFE.



- f. End Connections: Flanged or grooved.
- g. Pressure Gage Connections: Integral seals for portable differential pressure meter.
- h. Handle Style: Lever, with memory stop to retain set position.
- i. CWP Rating: Minimum 125 psig (860 kPa).
- j. Maximum Operating Temperature: 250 deg F (121 deg C).
- 8. Diaphragm-Operated, Pressure-Reducing Valves:
 - a. Body: Bronze or brass.
 - b. Disc: Glass and carbon-filled PTFE.
 - c. Seat: Brass.
 - d. Stem Seals: EPDM O-rings.
 - e. Diaphragm: EPT.
 - f. Low inlet-pressure check valve.
 - g. Inlet Strainer: removable without system shutdown.
 - h. Valve Seat and Stem: Noncorrosive.
 - i. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- 9. Diaphragm-Operated Safety Valves:
 - a. Body: Bronze or brass.
 - b. Disc: Glass and carbon-filled PTFE.
 - c. Seat: Brass.
 - d. Stem Seals: EPDM O-rings.
 - e. Diaphragm: EPT.
 - f. Wetted, Internal Work Parts: Brass and rubber.
 - g. Inlet Strainer: removable without system shutdown.
 - h. Valve Seat and Stem: Noncorrosive.
 - i. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- 10. Automatic Flow-Control Valves:
 - a. Body: Brass or ferrous metal.
 - b. Piston and Spring Assembly: Stainless steel **OR** Corrosion resistant, **as directed**, tamper proof, self cleaning, and removable.
 - c. Combination Assemblies: Include bronze or brass-alloy ball valve.
 - d. Identification Tag: Marked with zone identification, valve number, and flow rate.
 - e. Size: Same as pipe in which installed.
 - f. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
 - g. Minimum CWP Rating: 175 psig (1207 kPa) **OR** 300 psig (2070 kPa), **as directed**.
 - h. Maximum Operating Temperature: 200 deg F (93 deg C) **OR** 250 deg F (121 deg C), **as directed**.
- I. Air Control Devices
 - 1. Manual Air Vents:
 - a. Body: Bronze.
 - b. Internal Parts: Nonferrous.
 - c. Operator: Screwdriver or thumbscrew.
 - d. Inlet Connection: NPS 1/2 (DN 15).
 - e. Discharge Connection: NPS 1/8 (DN 6).
 - f. CWP Rating: 150 psig (1035 kPa).
 - g. Maximum Operating Temperature: 225 deg F (107 deg C).
 - 2. Automatic Air Vents:
 - a. Body: Bronze or cast iron.
 - b. Internal Parts: Nonferrous.
 - c. Operator: Noncorrosive metal float.
 - d. Inlet Connection: NPS 1/2 (DN 15).



- e. Discharge Connection: NPS 1/4 (DN 8).
- f. CWP Rating: 150 psig (1035 kPa).
- g. Maximum Operating Temperature: 240 deg F (116 deg C).
3. Expansion Tanks:
 - a. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. (379-L) unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig (860-kPa) working pressure and 250 deg F (121 deg C) maximum operating temperature.
 - c. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig (860-kPa) working pressure and 240 deg F (116 deg C) maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
 - d. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- (20-mm-) diameter gage glass, and slotted-metal glass guard.
4. Diaphragm-Type **OR** Bladder-Type, **as directed**, Expansion Tanks:
 - a. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Diaphragm **OR** Bladder, **as directed**: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 - c. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
5. Tangential-Type Air Separators:
 - a. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
 - b. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
 - c. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
 - d. Blowdown Connection: Threaded.
 - e. Size: Match system flow capacity.
6. In-Line Air Separators:
 - a. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
 - b. Maximum Working Pressure: Up to 175 psig (1207 kPa).
 - c. Maximum Operating Temperature: Up to 300 deg F (149 deg C).
7. Air Purgers:
 - a. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
 - b. Maximum Working Pressure: 150 psig (1035 kPa).
 - c. Maximum Operating Temperature: 250 deg F (121 deg C).
- J. Chemical Treatment
 1. Bypass Chemical Feeder: Welded steel construction; 125-psig (860-kPa) working pressure; 5-gal. (19-L) capacity; with fill funnel and inlet, outlet, and drain valves.
 - a. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.
 2. Ethylene and Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions.
- K. Hydronic Piping Specialties
 1. Y-Pattern Strainers:



- a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 125 psig (860 kPa).
2. Basket Strainers:
- a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 125 psig (860 kPa).
3. T-Pattern Strainers:
- a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
 - b. End Connections: Grooved ends.
 - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
 - d. CWP Rating: 750 psig (5170 kPa).
4. Stainless-Steel Bellow, Flexible Connectors:
- a. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
 - b. End Connections: Threaded or flanged to match equipment connected.
 - c. Performance: Capable of 3/4-inch (20-mm) misalignment.
 - d. CWP Rating: 150 psig (1035 kPa).
 - e. Maximum Operating Temperature: 250 deg F (121 deg C).
5. Spherical, Rubber, Flexible Connectors:
- a. Body: Fiber-reinforced rubber body.
 - b. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
 - c. Performance: Capable of misalignment.
 - d. CWP Rating: 150 psig (1035 kPa).
 - e. Maximum Operating Temperature: 250 deg F (121 deg C).
6. Expansion fittings are specified in Division 22 Section(s) "Expansion Fittings And Loops For Plumbing Piping" OR Division 23 Section(s) "Expansion Fittings And Loops For Hvac Piping".

1.3 EXECUTION

1. Hot-water heating piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
 - a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.
 - b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
 - c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
2. Hot-water heating piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
 - a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
 - b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - c. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.



- d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
- e. RTRP and RTRF with adhesive or flanged joints.
3. Hot-water heating piping installed belowground and within slabs shall be either of the following:
 - a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
4. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
 - a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.
 - b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
 - c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
5. Chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
 - a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
 - b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - c. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
 - e. RTRP and RTRF with adhesive or flanged joints.
6. Chilled-water piping installed belowground and within slabs shall be either of the following:
 - a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
7. Dual-temperature heating and cooling water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
 - a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.
 - b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
 - c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
8. Dual-temperature heating and cooling water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
 - a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
 - b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - c. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
 - e. RTRP and RTRF with adhesive or flanged joints.
9. Dual-temperature heating and cooling water piping installed belowground and within slabs shall be either of the following:
 - a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
10. Condenser-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
 - a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.



- b. Schedule 80 **OR** 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
 - c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
11. Condenser-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
- a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
 - b. Schedule 80 **OR** 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - c. Schedule 80 **OR** 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
 - e. RTRP and RTRF with adhesive or flanged joints.
12. Condenser-water piping installed belowground and within slabs shall be either of the following:
- a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
13. Glycol cooling-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
- a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.
 - b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
 - c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
14. Glycol cooling-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
- a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
 - b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - c. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 - d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
 - e. RTRP and RTRF with adhesive or flanged joints.
15. Glycol cooling-water piping installed belowground and within slabs shall be either of the following:
- a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
16. Makeup-water piping installed aboveground shall be either of the following:
- a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
 - b. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings, and solvent-welded joints.
17. Makeup-Water Piping Installed Belowground and within Slabs: Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
18. Condensate-Drain Piping: Type M (C) **OR** DWV, **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints, **as directed**.
- OR**
- Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.



19. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
 20. Air-Vent Piping:
 - a. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
 - b. Outlet: Type K (A), annealed-temper copper tubing with soldered or flared joints.
 21. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
- B. Valve Applications
1. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.
 2. Install throttling-duty **OR** calibrated-orifice, balancing, **as directed**, valves at each branch connection to return main.
 3. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
 4. Install check valves at each pump discharge and elsewhere as required to control flow direction.
 5. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
 6. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.
- C. Piping Installations
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
 2. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
 3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
 4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 5. Install piping to permit valve servicing.
 6. Install piping at indicated slopes.
 7. Install piping free of sags and bends.
 8. Install fittings for changes in direction and branch connections.
 9. Install piping to allow application of insulation.
 10. Select system components with pressure rating equal to or greater than system operating pressure.
 11. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
 12. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
 13. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
 14. Reduce pipe sizes using eccentric reducer fitting installed with level side down.
 15. Install branch connections to mains using mechanically formed, **as directed**, tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
 16. Install valves according to Division 22 Section(s) "General-duty Valves For Plumbing Piping" OR Division 23 Section(s) "General-duty Valves For Hvac Piping".
 17. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.



18. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
19. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).
20. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 22 Section(s) "Expansion Fittings And Loops For Plumbing Piping" OR Division 23 Section(s) "Expansion Fittings And Loops For Hvac Piping".
21. Identify piping as specified in Division 22 Section(s) "Identification For Plumbing Piping And Equipment" OR Division 23 Section(s) "Identification For Hvac Piping And Equipment".

D. Hangers And Supports

1. Hanger, support, and anchor devices are specified in Division 22 Section(s) "Hangers And Supports For Plumbing Piping And Equipment" OR Division 23 Section(s) "Hangers And Supports For Hvac Piping And Equipment". Comply with the following requirements for maximum spacing of supports.
2. Seismic restraints are specified in Division 21 Section(s) "Vibration And Seismic Controls For Fire-suppression Piping And Equipment" OR Division 22 Section(s) "Vibration And Seismic Controls For Plumbing Piping And Equipment" OR Division 23 Section(s) "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install the following pipe attachments:
 - a. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
 - b. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
 - c. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
 - d. Spring hangers to support vertical runs.
 - e. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - f. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
4. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 - a. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 - b. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
 - e. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
 - f. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 1/2 inch (12 mm).
 - g. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (12 mm).
 - h. NPS 3-1/2 (DN 90): Maximum span, 13 feet (4 m); minimum rod size, 1/2 inch (12 mm).
 - i. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 5/8 inch (16 mm).
 - j. NPS 5 (DN 125): Maximum span, 16 feet (4.9 m); minimum rod size, 5/8 inch (16 mm).
 - k. NPS 6 (DN 150): Maximum span, 17 feet (5.2 m); minimum rod size, 3/4 inch (20 mm).
 - l. NPS 8 (DN 200): Maximum span, 19 feet (5.8 m); minimum rod size, 3/4 inch (20 mm).
 - m. NPS 10 (DN 250): Maximum span, 22 feet (6.7 m); minimum rod size, 7/8 inch (20 mm).
 - n. NPS 12 (DN 300): Maximum span, 23 feet (7 m); minimum rod size, 7/8 inch (20 mm).
 - o. NPS 14 (DN 350): Maximum span, 25 feet (7.6 m); minimum rod size, 1 inch (24 mm).
 - p. NPS 16 (DN 400): Maximum span, 27 feet (8.2 m); minimum rod size, 1 inch (24 mm).
 - q. NPS 18 (DN 450): Maximum span, 28 feet (8.5 m); minimum rod size, 1 inch (24 mm).
 - r. NPS 20 (DN 500): Maximum span, 30 feet (9.1 m); minimum rod size, 1-1/4 inches (30 mm).
5. Install hangers for drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
 - a. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 3/8 inch (10 mm).



- b. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 - e. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 - f. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 1/2 inch (12 mm).
 - g. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (12 mm).
6. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
 7. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
 8. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.
- E. Pipe Joint Construction
1. Join pipe and fittings according to the following requirements and Division 21 specifying piping systems.
 2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
 5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
 6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
 7. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1.1 "Quality Assurance" Article.
 8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
 9. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - c. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
 - d. PVC Nonpressure Piping: Join according to ASTM D 2855.
 10. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
 11. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
 12. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
 13. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.
- F. Hydronic Specialties Installation



1. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
OR
Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.
 2. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
 3. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.
OR
Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
 4. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches (1200 mm) above the floor. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 (DN 20) pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.
 5. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
 - a. Install tank fittings that are shipped loose.
 - b. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.
- OR**
Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

G. Terminal Equipment Connections

1. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
2. Install control valves in accessible locations close to connected equipment.
3. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
4. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 22 Section(s) "Meters And Gages For Plumbing Piping" OR Division 23 Section(s) "Meters And Gages For Hvac Piping".

H. Chemical Treatment

1. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
 - a. pH: 9.0 to 10.5.
 - b. "P" Alkalinity: 100 to 500 ppm.
 - c. Boron: 100 to 200 ppm.
 - d. Chemical Oxygen Demand: Maximum 100 ppm. Modify this value if closed system contains glycol.
 - e. Corrosion Inhibitor:
 - 1) Sodium Nitrate: 1000 to 1500 ppm.
 - 2) Molybdate: 200 to 300 ppm.
 - 3) Chromate: 200 to 300 ppm.
 - 4) Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
 - 5) Chromate Plus Molybdate: 50 to 100 ppm each.
 - f. Soluble Copper: Maximum 0.20 ppm.
 - g. Tolyriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
 - h. Total Suspended Solids: Maximum 10 ppm.



- i. Ammonia: Maximum 20 ppm.
 - j. Free Caustic Alkalinity: Maximum 20 ppm.
 - k. Microbiological Limits:
 - 1) Total Aerobic Plate Count: Maximum 1000 organisms/ml.
 - 2) Total Anaerobic Plate Count: Maximum 100 organisms/ml.
 - 3) Nitrate Reducers: 100 organisms/ml.
 - 4) Sulfate Reducers: Maximum 0 organisms/ml.
 - 5) Iron Bacteria: Maximum 0 organisms/ml.
 2. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
 3. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.
 4. Fill systems indicated to have antifreeze or glycol solutions with the following concentrations:
 - a. Hot-Water Heating Piping: Minimum percent ethylene, as directed by the Owner **OR** propylene, **as directed**, glycol.
 - b. Chilled-Water Piping: Minimum percent ethylene, as directed by the Owner **OR** propylene, **as directed**, glycol.
 - c. Dual-Temperature Heating and Cooling Water Piping: Minimum percent, as directed by the Owner ethylene **OR** propylene, **as directed**, glycol.
 - d. Glycol Cooling-Water Piping: Minimum percent ethylene, as directed by the Owner. **OR** propylene, **as directed**, glycol.
- I. Field Quality Control
1. Prepare hydronic piping according to ASME B31.9 and as follows:
 - a. Leave joints, including welds, uninsulated and exposed for examination during test.
 - b. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - c. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - d. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - e. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
 2. Perform the following tests on hydronic piping:
 - a. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - b. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 - c. Isolate expansion tanks and determine that hydronic system is full of water.
 - d. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 - e. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 - f. Prepare written report of testing.
 3. Perform the following before operating the system:
 - a. Open manual valves fully.
 - b. Inspect pumps for proper rotation.
 - c. Set makeup pressure-reducing valves for required system pressure.
 - d. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).



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- e. Set temperature controls so all coils are calling for full flow.
 - f. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 - g. Verify lubrication of motors and bearings.

END OF SECTION 22 11 16 00c

**SECTION 22 11 16 00d - STEAM AND CONDENSATE PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for steam and condensate piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following for LP and HP steam and condensate piping:
 - a. Pipe and fittings.
 - b. Strainers.
 - c. Flash tanks.
 - d. Safety valves.
 - e. Pressure-reducing valves.
 - f. Steam traps.
 - g. Thermostatic air vents and vacuum breakers.
 - h. Steam and condensate meters.

C. Definitions

1. HP Systems: High-pressure piping operating at more than 15 psig (104 kPa) as required by ASME B31.1.
2. LP Systems: Low-pressure piping operating at 15 psig (104 kPa) or less as required by ASME B31.9.
3. RTRF: Reinforced thermosetting resin (fiberglass) fittings.
4. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

D. Performance Requirements

1. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures:
 - a. HP Steam Piping: <Insert psig (kPa).>
 - b. LP Steam Piping: <Insert psig (kPa).>
 - c. Condensate Piping: <Insert psig (kPa)> at 250 deg F (121 deg C).
 - d. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C).
 - e. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
 - f. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
 - g. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

E. Submittals

1. Product Data: For each type of the following:
 - a. RTRP and RTRF with adhesive.
 - b. Pressure-reducing and safety valve.
 - c. Steam trap.
 - d. Air vent and vacuum breaker.
 - e. Flash tank.
 - f. Meter.
2. Shop Drawings: Detail, 1/4 inch equals 1 foot (1:50) scale, flash tank assemblies and fabrication of pipe anchors, hangers, pipe, multiple pipes, alignment guides, and expansion joints and loops and their attachment to the building structure. Detail locations of anchors, alignment guides, and expansion joints and loops.



3. Welding certificates.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

F. Quality Assurance

1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code - Steel."
2. Pipe Welding: Qualify processes and operators according to the following:
 - a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
3. ASME Compliance: Comply with ASME B31.1, "Power Piping" **AND/OR** ASME B31.9, "Building Services Piping", **as directed**, for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.2 PRODUCTS

A. Copper Tube And Fittings

1. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M, Type C), **as directed**.
2. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).
3. Wrought-Copper Fittings and Unions: ASME B16.22.

B. Steel Pipe And Fittings

1. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, Type, Grade, and Schedule as indicated in Part 3 piping applications articles.
2. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in Part 3 piping applications articles.
3. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in Part 3 piping applications articles.
4. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 piping applications articles.
5. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in Part 3 piping applications articles; raised ground face, and bolt holes spot faced.
6. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
7. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Butt welding.
 - c. Facings: Raised face.
8. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.
9. Stainless-Steel Bellows, Flexible Connectors:
 - a. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
 - b. End Connections: Threaded or flanged to match equipment connected.
 - c. Performance: Capable of 3/4-inch (20-mm) misalignment.
 - d. CWP Rating: 150-psig (1035-kPa).
 - e. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Fiberglass Pipe And Fittings



1. RTRP: ASTM D 2996 filament-wound pipe with tapered bell and spigot ends for adhesive joints.
2. RTRF: Compression or spray-up/contact molded fittings of same material, pressure class, and joining method as pipe.
3. Flanges: ASTM D 4024 full-face gaskets suitable for the service, minimum 1/8 inch (3.2 mm) thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.
4. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

D. Joining Materials

1. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - a. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - 1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - 2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
3. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
4. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BA9-1, silver alloy for joining copper with bronze or steel.
5. Welding Filler Metals: Comply with AWS D10.12 (AWS D10.12M) for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
6. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

E. Dielectric Fittings

1. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions:
 - a. Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
4. Dielectric Flanges:
 - a. Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
5. Dielectric-Flange Kits:
 - a. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - b. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

F. Valves

1. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-duty Valves For Hvac Piping".
2. Stop-Check Valves:
 - a. Body and Bonnet: Malleable iron.
 - b. End Connections: Flanged.
 - c. Disc: Cylindrical with removable liner and machined seat.
 - d. Stem: Brass alloy.
 - e. Operator: Outside screw and yoke with cast-iron handwheel.
 - f. Packing: Polytetrafluoroethylene-impregnated packing with two-piece packing gland assembly.
 - g. Pressure Class: 250.

G. Strainers

1. Y-Pattern Strainers:



- a. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
 - d. Tapped blowoff plug.
 - e. CWP Rating: 250-psig (1725-kPa) working steam pressure.
2. Basket Strainers:
- a. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 250-psig (1725-kPa) working steam pressure.
- H. Flash Tanks
1. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code, for 150-psig (1035-kPa) rating; and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.
- I. Safety Valves
1. Bronze **OR** Brass, **as directed**, Safety Valves:
 - a. Disc Material: Forged copper alloy.
 - b. End Connections: Threaded inlet and outlet.
 - c. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
 - d. Pressure Class: 250.
 - e. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
 - f. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
 2. Cast-Iron Safety Valves:
 - a. Disc Material: Forged copper alloy with bronze nozzle.
 - b. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
 - c. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
 - d. Pressure Class: 250.
 - e. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
 - f. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
 - g. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
- J. Pressure-Reducing Valves
1. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.
 2. Description: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff.
 3. Body: Cast iron.
 4. End Connections: Threaded connections for valves NPS 2 (DN 50) and smaller and flanged connections for valves NPS 2-1/2 (DN 65) and larger.
 5. Trim: Hardened stainless steel.
 6. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.
 7. Gaskets: Non-asbestos materials.



K. Steam Traps

1. Thermostatic Traps:
 - a. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
 - b. Trap Type: Balanced-pressure.
 - c. Bellows: Stainless steel or monel.
 - d. Head and Seat: Replaceable, hardened stainless steel.
 - e. Pressure Class: 125.
2. Thermodynamic Traps:
 - a. Body: Stainless steel with screw-in cap.
 - b. End Connections: Threaded.
 - c. Disc and Seat: Stainless steel.
 - d. Maximum Operating Pressure: 600 psig (4140 kPa).
3. Float and Thermostatic Traps:
 - a. Body and Bolted Cap: ASTM A 126, cast iron.
 - b. End Connections: Threaded.
 - c. Float Mechanism: Replaceable, stainless steel.
 - d. Head and Seat: Hardened stainless steel.
 - e. Trap Type: Balanced pressure.
 - f. Thermostatic Bellows: Stainless steel or monel.
 - g. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.
 - h. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
 - i. Maximum Operating Pressure: 125 psig (860 kPa).
4. Inverted Bucket Traps:
 - a. Body and Cap: Cast iron.
 - b. End Connections: Threaded.
 - c. Head and Seat: Stainless steel.
 - d. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
 - e. Bucket: Brass or stainless steel.
 - f. Strainer: Integral stainless-steel inlet strainer within the trap body.
 - g. Air Vent: Stainless-steel thermostatic vent.
 - h. Pressure Rating: 250 psig (1725 kPa).

L. Thermostatic Air Vents And Vacuum Breakers

1. Thermostatic Air Vents:
 - a. Body: Cast iron, bronze or stainless steel.
 - b. End Connections: Threaded.
 - c. Float, Valve, and Seat: Stainless steel.
 - d. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
 - e. Pressure Rating: 125 psig (861 kPa) **OR** 300 psig (2068 kPa), **as directed**.
 - f. Maximum Temperature Rating: 350 deg F (177 deg C).
2. Vacuum Breakers:
 - a. Body: Cast iron, bronze, or stainless steel.
 - b. End Connections: Threaded.
 - c. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
 - d. O-ring Seal: EPR.
 - e. Pressure Rating: 125 psig (861 kPa) **OR** 300 psig (2068 kPa), **as directed**.
 - f. Maximum Temperature Rating: 350 deg F (177 deg C).

M. Steam Meters

1. Meters shall have a microprocessor to display totalizer flow, flow rate, temperature, pressure, time, and date; alarms for high and low flow rate and temperature.
 - a. Computer shall have 4 to 20-mA or 2 to 10 volt output for temperature, pressure, and contact closure for flow increments.
 - b. Independent timers to store four peak flow rates and total flow.



- c. Interface compatible with central workstation described in Division 23 Section "Instrumentation And Control For Hvac".
 - d. Microprocessor Enclosure: NEMA 250, Type 4.
2. Sensor:
- a. Venturi, of stainless-steel **OR** carbon-steel, **as directed**, construction, for insertion in pipeline between flanges. At least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.
 - b. Vortex type with stainless-steel wetted parts and wafer **OR** flange, **as directed**, connections; and with a piezoelectric sensor removable and serviceable without shutting down the process. At least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.
 - c. Spring-loaded, variable-area flowmeter type; density compensated with stainless-steel wetted parts and wafer **OR** flange, **as directed**, connections. At least 10:1 turndown with plus or minus 2 percent accuracy over full-flow range.

N. Condensate Meters

- 1. Body: Cast iron, bronze, or brass.
- 2. Turbine: Copper, brass, or stainless steel.
- 3. Connections: Threaded for NPS 2 (DN 50) and smaller and flanged for NPS 2-1/2 (DN 65).
- 4. Totalizer: Meters shall have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.
 - a. Computer shall have 4- to 20-mA or 2- to 10-volt output for temperature, pressure, and contact closure for flow increments.
 - b. Independent timers to store four peak flow rates and total flow.
 - c. Interface compatible with central workstation specified in Division 23 Section "Instrumentation And Control For Hvac".
 - d. Microprocessor Enclosure: NEMA 250, Type 4.
- 5. Pressure Rating: Atmospheric.
- 6. Maximum Temperature Rating: 250 deg F (121 deg C).

1.3 EXECUTION

A. LP Steam Piping Applications

- 1. LP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40 **OR** 80, **as directed**, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- 2. LP Steam Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 40 **OR** 80, **as directed**, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- 3. LP Steam Piping, NPS 14 through NPS 18 (DN 350 through DN 450): Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- 4. LP Steam Piping, NPS 20 (DN 500) and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- 5. Condensate piping above grade, NPS 2 (DN 50) and smaller, shall be either of the following, **as directed**:
 - a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
- 6. Condensate piping above grade, NPS 2-1/2 (DN 65) and larger, shall be either of the following, **as directed**:
 - a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
- 7. Condensate piping below grade, NPS 2 (DN 50) and smaller, shall be either of the following, **as directed**:



- a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
 8. Condensate piping below grade, NPS 2-1/2 (DN 65) and larger, shall be either of the following, **as directed**:
 - a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
- B. HP Steam Piping Applications
 1. HP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40 **OR** 80, **as directed**, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
 2. HP Steam Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 40 **OR** 80, **as directed**, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
 3. HP Steam Piping, NPS 14 through NPS 18 (DN 350 through DN 450): Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
 4. HP Steam Piping, NPS 20 (DN 500) and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
 5. Condensate piping above grade, NPS 2 (DN 50) and smaller, shall be either of the following, **as directed**:
 - a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
 6. Condensate piping above grade, NPS 2-1/2 (DN 65) and larger, shall be either of the following, **as directed**:
 - a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
 7. Condensate piping below grade, NPS 2 (DN 50) and smaller, shall be either of the following, **as directed**:
 - a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
 8. Condensate piping below grade, NPS 2-1/2 (DN 65) and larger, shall be either of the following, **as directed**:
 - a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
 - b. RTRP and RTRF with adhesive or flanged joints.
- C. Ancillary Piping Applications
 1. Makeup-water piping installed above grade shall be either of the following, **as directed**:
 - a. Drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
 - b. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings, and solvent welded joints.
 2. Makeup-Water Piping Installed below Grade and within Slabs: Annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
 3. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
 4. Air-Vent Piping:
 - a. Inlet: Same as service where installed.
 - b. Outlet: Type K (A) annealed-temper copper tubing with soldered or flared joints.
 5. Vacuum-Breaker Piping: Outlet, same as service where installed.
 6. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.
- D. Valve Applications



1. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.
2. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

E. Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Use indicated piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
5. Install piping to permit valve servicing.
6. Install piping free of sags and bends.
7. Install fittings for changes in direction and branch connections.
8. Install piping to allow application of insulation.
9. Select system components with pressure rating equal to or greater than system operating pressure.
10. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
11. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full port-ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
12. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.
13. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.
14. Reduce pipe sizes using eccentric reducer fitting installed with level side down.
15. Install branch connections to mains using mechanically formed, **as directed**, tee fittings in main pipe, with the branch connected to top of main pipe.
16. Install valves according to Division 23 Section "General-duty Valves For Hvac Piping".
17. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
18. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
19. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).
20. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings And Loops For Hvac Piping".
21. Identify piping as specified in Division 23 Section "Identification For Hvac Piping And Equipment".
22. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
 - a. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet (90 m).
 - b. Size drip legs same size as main. In steam mains NPS 6 (DN 150) and larger, drip leg size can be reduced, but to no less than NPS 4 (DN 100).
23. Flash Tank:



- a. Pitch condensate piping down toward flash tank.
 - b. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
 - c. Install thermostatic air vent at tank top.
 - d. Install safety valve at tank top.
 - e. Install full-port ball valve, and swing check valve on condensate outlet.
 - f. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for three times the calculated heat load.
 - g. Install pressure gage on low-pressure steam outlet according to Division 23 Section "Meters And Gages For Hvac Piping".
- F. Steam-Trap Installation
1. Install steam traps in accessible locations as close as possible to connected equipment.
 2. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.
- G. Pressure-Reducing Valve Installation
1. Install pressure-reducing valves in accessible location for maintenance and inspection.
 2. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.
 3. Install gate valves on both sides of pressure-reducing valves.
 4. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections respectively.
 5. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Division 23 Section "Meters And Gages For Hvac Piping".
 6. Install strainers upstream for pressure-reducing valve.
 7. Install safety valve downstream from pressure-reducing valve station.
- H. Steam Or Condensate Meter Installation
1. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's instructions.
 2. Provide data acquisition wiring. Refer to Division 23 Section "Instrumentation And Control For Hvac".
- I. Safety Valve Installation
1. Install safety valves according to ASME B31.1, "Power Piping" **OR** ASME B31.9, "Building Services Piping," **as directed**
 2. Pipe safety-valve discharge without valves to atmosphere outside the building.
 3. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.
 4. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2 (DN 65).
- J. Hangers And Supports
1. Install hangers and supports according to Division 23 Section "Hangers And Supports For Hvac Piping And Equipment". Comply with requirements below for maximum spacing.
 2. Seismic restraints are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 3. Install the following pipe attachments:
 - a. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
 - b. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
 - c. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
 - d. Spring hangers to support vertical runs.
 4. Install hangers with the following maximum spacing and minimum rod sizes:
 - a. NPS 3/4 (DN 20): Maximum span, 9 feet (2.7 m); minimum rod size, 1/4 inch (6.4 mm).



- b. NPS 1 (DN 25): Maximum span, 9 feet (2.7 m); minimum rod size, 1/4 inch (6.4 mm).
 - c. NPS 1-1/2 (DN 40): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 2 (DN 50): Maximum span, 13 feet (4 m); minimum rod size, 3/8 inch (10 mm).
 - e. NPS 2-1/2 (DN 65): Maximum span, 14 feet (4.3 m); minimum rod size, 3/8 inch (10 mm).
 - f. NPS 3 (DN 80): Maximum span, 15 feet (4.6 m); minimum rod size, 3/8 inch (10 mm).
 - g. NPS 4 (DN 100): Maximum span, 17 feet (5.2 m); minimum rod size, 1/2 inch (13 mm).
 - h. NPS 6 (DN 150): Maximum span, 21 feet (6.4 m); minimum rod size, 1/2 inch (13 mm).
 - i. NPS 8 (DN 200): Maximum span, 24 feet (7.3 m); minimum rod size, 5/8 inch (16 mm).
 - j. NPS 10 (DN 250): Maximum span, 26 feet (8 m); minimum rod size, 3/4 inch (19 mm).
 - k. NPS 12 (DN 300): Maximum span, 30 feet (9.1 m); minimum rod size, 7/8 inch (22 mm).
 - l. NPS 14 (DN 350): Maximum span, 32 feet (9.8 m); minimum rod size, 1 inch (25 mm).
 - m. NPS 16 (DN 400): Maximum span, 35 feet (10.7 m); minimum rod size, 1 inch (25 mm).
 - n. NPS 18 (DN 450): Maximum span, 37 feet (11.3 m); minimum rod size, 1-1/4 inches (32 mm).
 - o. NPS 20 (DN 500): Maximum span, 39 feet (11.9 m); minimum rod size, 1-1/4 inches (32 mm).
5. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
 - a. NPS 1/2 (DN 15): Maximum span, 4 feet (1.2 m); minimum rod size, 1/4 inch (6.4 mm).
 - b. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
 - c. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
 - d. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 - e. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 - f. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
 - g. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
 6. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.
 7. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

K. Pipe Joint Construction

1. Join pipe and fittings according to the following requirements and Division 21 specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube ends. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Welded Joints: Construct joints according to AWS D10.12 (AWS D10.12M), using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

L. Terminal Equipment Connections



1. Size for supply and return piping connections shall be the same as or larger than equipment connections.
2. Install traps and control valves in accessible locations close to connected equipment.
3. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
4. Install vacuum breakers downstream from control valve, close to coil inlet connection.
5. Install a drip leg at coil outlet.

M. Field Quality Control

1. Prepare steam and condensate piping according to ASME B31.1, "Power Piping" **AND/OR** ASME B31.9, "Building Services Piping," **as directed**, and as follows:
 - a. Leave joints, including welds, uninsulated and exposed for examination during test.
 - b. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - c. Flush system with clean water. Clean strainers.
 - d. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
2. Perform the following tests on steam and condensate piping:
 - a. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - b. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
 - c. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
3. Prepare written report of testing.

END OF SECTION 22 11 16 00d



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**SECTION 22 11 16 00e - REFRIGERANT PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for refrigerant piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes refrigerant piping used for air-conditioning applications.

C. Performance Requirements

1. Line Test Pressure for Refrigerant R-134a:
 - a. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).
 - b. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).
 - c. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).
2. Line Test Pressure for Refrigerant R-407C:
 - a. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
 - b. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
 - c. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).
3. Line Test Pressure for Refrigerant R-410A:
 - a. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
 - b. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
 - c. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

D. Submittals

1. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
 - a. Thermostatic expansion valves.
 - b. Solenoid valves.
 - c. Hot-gas bypass valves.
 - d. Filter dryers.
 - e. Strainers.
 - f. Pressure-regulating valves.
2. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
 - a. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).
 - b. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Welding certificates.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

E. Quality Assurance

1. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."



2. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
3. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

F. Product Storage And Handling

1. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.2 PRODUCTS

A. Copper Tube And Fittings

1. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B) **OR** ASTM B 280, Type ACR, **as directed**.
2. Wrought-Copper Fittings: ASME B16.22.
3. Wrought-Copper Unions: ASME B16.22.
4. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
5. Brazing Filler Metals: AWS A5.8.
6. Flexible Connectors:
 - a. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - b. End Connections: Socket ends.
 - c. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
 - d. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
 - e. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Steel Pipe And Fittings

1. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.
2. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.
3. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.
4. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
5. Flanged Unions:
 - a. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 (DN 25 to DN 40) and ductile iron for NPS 2 to NPS 3 (DN 50 to DN 80). Apply rust-resistant finish at factory.
 - b. Gasket: Fiber asbestos free.
 - c. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
 - d. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
 - e. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
 - f. Pressure Rating: Factory test at minimum 400 psig (2760 kPa).
 - g. Maximum Operating Temperature: 330 deg F (165 deg C).
6. Flexible Connectors:
 - a. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
 - b. End Connections:
 - 1) NPS 2 (DN 50) and Smaller: With threaded-end connections.
 - 2) NPS 2-1/2 (DN 65) and Larger: With flanged-end connections.
 - c. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
 - d. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).



- e. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Valves And Specialties

1. Diaphragm Packless Valves:
 - a. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - b. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - c. Operator: Rising stem and hand wheel.
 - d. Seat: Nylon.
 - e. End Connections: Socket, union, or flanged.
 - f. Working Pressure Rating: 500 psig (3450 kPa).
 - g. Maximum Operating Temperature: 275 deg F (135 deg C).
2. Packed-Angle Valves:
 - a. Body and Bonnet: Forged brass or cast bronze.
 - b. Packing: Molded stem, back seating, and replaceable under pressure.
 - c. Operator: Rising stem.
 - d. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
 - e. Seal Cap: Forged-brass or valox hex cap.
 - f. End Connections: Socket, union, threaded, or flanged.
 - g. Working Pressure Rating: 500 psig (3450 kPa).
 - h. Maximum Operating Temperature: 275 deg F (135 deg C).
3. Check Valves:
 - a. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
 - b. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
 - c. Piston: Removable polytetrafluoroethylene seat.
 - d. Closing Spring: Stainless steel.
 - e. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
 - f. End Connections: Socket, union, threaded, or flanged.
 - g. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
 - h. Working Pressure Rating: 500 psig (3450 kPa).
 - i. Maximum Operating Temperature: 275 deg F (135 deg C).
4. Service Valves:
 - a. Body: Forged brass with brass cap including key end to remove core.
 - b. Core: Removable ball-type check valve with stainless-steel spring.
 - c. Seat: Polytetrafluoroethylene.
 - d. End Connections: Copper spring.
 - e. Working Pressure Rating: 500 psig (3450 kPa).
5. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
 - a. Body and Bonnet: Plated steel.
 - b. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 - c. Seat: Polytetrafluoroethylene.
 - d. End Connections: Threaded.
 - e. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24 **OR** 115 **OR** 208, **as directed**, -V ac coil.
 - f. Working Pressure Rating: 400 psig (2760 kPa).
 - g. Maximum Operating Temperature: 240 deg F (116 deg C).
 - h. Manual operator.
6. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
 - a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 - b. Piston, Closing Spring, and Seat Insert: Stainless steel.
 - c. Seat Disc: Polytetrafluoroethylene.
 - d. End Connections: Threaded.
 - e. Working Pressure Rating: 400 psig (2760 kPa).
 - f. Maximum Operating Temperature: 240 deg F (116 deg C).
7. Thermostatic Expansion Valves: Comply with ARI 750.



- a. Body, Bonnet, and Seal Cap: Forged brass or steel.
 - b. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 - c. Packing and Gaskets: Non-asbestos.
 - d. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 - e. Suction Temperature: 40 deg F (4.4 deg C).
 - f. Superheat: Adjustable **OR** Nonadjustable, **as directed**.
 - g. Reverse-flow option (for heat-pump applications).
 - h. End Connections: Socket, flare, or threaded union.
 - i. Working Pressure Rating: 700 psig (4820 kPa) **OR** 450 psig (3100 kPa), **as directed**.
8. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
- a. Body, Bonnet, and Seal Cap: Ductile iron or steel.
 - b. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 - c. Packing and Gaskets: Non-asbestos.
 - d. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 - e. Seat: Polytetrafluoroethylene.
 - f. Equalizer: Internal **OR** External, **as directed**.
 - g. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24 **OR** 115 **OR** 208, **as directed**, -V ac coil.
 - h. End Connections: Socket.
 - i. Set Pressure: as directed by the Owner.
 - j. Throttling Range: Maximum 5 psig (34 kPa).
 - k. Working Pressure Rating: 500 psig (3450 kPa).
 - l. Maximum Operating Temperature: 240 deg F (116 deg C).
9. Straight-Type Strainers:
- a. Body: Welded steel with corrosion-resistant coating.
 - b. Screen: 100-mesh stainless steel.
 - c. End Connections: Socket or flare.
 - d. Working Pressure Rating: 500 psig (3450 kPa).
 - e. Maximum Operating Temperature: 275 deg F (135 deg C).
10. Angle-Type Strainers:
- a. Body: Forged brass or cast bronze.
 - b. Drain Plug: Brass hex plug.
 - c. Screen: 100-mesh monel.
 - d. End Connections: Socket or flare.
 - e. Working Pressure Rating: 500 psig (3450 kPa).
 - f. Maximum Operating Temperature: 275 deg F (135 deg C).
11. Moisture/Liquid Indicators:
- a. Body: Forged brass.
 - b. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 - c. Indicator: Color coded to show moisture content in ppm.
 - d. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 - e. End Connections: Socket or flare.
 - f. Working Pressure Rating: 500 psig (3450 kPa).
 - g. Maximum Operating Temperature: 240 deg F (116 deg C).
12. Replaceable-Core Filter Dryers: Comply with ARI 730.
- a. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 - b. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 - c. Desiccant Media: Activated alumina **OR** charcoal, **as directed**.
 - d. Designed for reverse flow (for heat-pump applications).
 - e. End Connections: Socket.
 - f. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
 - g. Maximum Pressure Loss: 2 psig (14 kPa).



- h. Rated Flow: as directed by the Owner.
 - i. Working Pressure Rating: 500 psig (3450 kPa).
 - j. Maximum Operating Temperature: 240 deg F (116 deg C).
 - 13. Permanent Filter Dryers: Comply with ARI 730.
 - a. Body and Cover: Painted-steel shell.
 - b. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 - c. Desiccant Media: Activated alumina **OR** charcoal, **as directed**.
 - d. Designed for reverse flow (for heat-pump applications).
 - e. End Connections: Socket.
 - f. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
 - g. Maximum Pressure Loss: 2 psig (14 kPa).
 - h. Rated Flow: as directed by the Owner.
 - i. Working Pressure Rating: 500 psig (3450 kPa).
 - j. Maximum Operating Temperature: 240 deg F (116 deg C).
 - 14. Mufflers:
 - a. Body: Welded steel with corrosion-resistant coating.
 - b. End Connections: Socket or flare.
 - c. Working Pressure Rating: 500 psig (3450 kPa).
 - d. Maximum Operating Temperature: 275 deg F (135 deg C).
 - 15. Receivers: Comply with ARI 495.
 - a. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
 - b. Comply with UL 207; listed and labeled by an NRTL.
 - c. Body: Welded steel with corrosion-resistant coating.
 - d. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
 - e. End Connections: Socket or threaded.
 - f. Working Pressure Rating: 500 psig (3450 kPa).
 - g. Maximum Operating Temperature: 275 deg F (135 deg C).
 - 16. Liquid Accumulators: Comply with ARI 495.
 - a. Body: Welded steel with corrosion-resistant coating.
 - b. End Connections: Socket or threaded.
 - c. Working Pressure Rating: 500 psig (3450 kPa).
 - d. Maximum Operating Temperature: 275 deg F (135 deg C).
- D. Refrigerants
- 1. ASHRAE 34, R-134a: Tetrafluoroethane.
 - 2. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
 - 3. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

1.3 EXECUTION

- A. Piping Applications For Refrigerant R-134a
- 1. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
OR
Suction Lines NPS 4 (DN 100) and Smaller **OR** NPS 2 to NPS 4 (DN 50 to DN 100), **as directed**, for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
 - 2. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
OR



Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**:

- a. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
 - OR**
 - NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
 - b. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
3. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

OR

Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

OR

Safety-Relief-Valve Discharge Piping:

- a. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- OR**
- NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- b. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

B. Piping Applications For Refrigerant R-407c

1. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings
- OR**
- Suction Lines NPS 4 (DN 100) and Smaller **OR** NPS 2 to NPS 4 (DN 50 to DN 100), **as directed**, for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
2. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- OR**
- Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.
- OR**
- Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**:
- a. NPS 1 (DN 25) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- OR**
- NPS 1 (DN 25) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- b. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- c. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.
3. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

**OR**

Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

OR

Safety-Relief-Valve Discharge Piping:

- a. NPS 1 (DN 25) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered joints.

OR

NPS 1 (DN 25) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

- b. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- c. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

C. Piping Applications For Refrigerant R-410a

1. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Suction Lines NPS 3-1/2 (DN 90) and Smaller **OR** NPS 2 to NPS 3-1/2 (DN 50 to DN 90), **as directed**, for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Suction Lines NPS 4 (DN 100) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

2. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** L (B), **as directed**, annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed** Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**:

- a. NPS 5/8 (DN 18) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- b. NPS 3/4 to NPS 1 (DN 20 to DN 25) and Smaller: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
- c. NPS 1-1/4 (DN 32) and Smaller: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
- d. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

OR



- Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**, NPS 2 to NPS 4 (DN 50 to DN 100): Schedule 40, black-steel and wrought-steel fittings with welded joints.
3. Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** L (B), **as directed**, annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
OR
 Safety-Relief-Valve Discharge Piping: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
OR
 Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
OR
 Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.
OR
 Safety-Relief-Valve Discharge Piping:
 - a. NPS 5/8 (DN 18) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
 - b. NPS 3/4 to NPS 1 (DN 20 to DN 25) and Smaller: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
 - c. NPS 1-1/4 (DN 32) and Smaller: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
 - d. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.**OR**
 Safety-Relief-Valve Discharge Piping NPS 2 to NPS 4 (DN 50 to DN 100): Schedule 40, black-steel and wrought-steel fittings with welded joints.
- D. Valve And Specialty Applications
1. Install diaphragm packless **OR** packed-angle, **as directed**, valves in suction and discharge lines of compressor.
 2. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
 3. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
 4. Except as otherwise indicated, install diaphragm packless **OR** packed-angle, **as directed**, valves on inlet and outlet side of filter dryers.
 5. Install a full-sized, three-valve bypass around filter dryers.
 6. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
 7. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - a. Install valve so diaphragm case is warmer than bulb.
 - b. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - c. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
 8. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
 9. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
 10. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - a. Solenoid valves.
 - b. Thermostatic expansion valves.



- c. Hot-gas bypass valves.
 - d. Compressor.
11. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor, **as directed**.
 12. Install receivers sized to accommodate pump-down charge.
 13. Install flexible connectors at compressors.
- E. Piping Installation
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
 2. Install refrigerant piping according to ASHRAE 15.
 3. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
 4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
 5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 6. Install piping adjacent to machines to allow service and maintenance.
 7. Install piping free of sags and bends.
 8. Install fittings for changes in direction and branch connections.
 9. Select system components with pressure rating equal to or greater than system operating pressure.
 10. Refer to Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls" for solenoid valve controllers, control wiring, and sequence of operation.
 11. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
 12. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors And Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
 13. Install refrigerant piping in protective conduit where installed belowground.
 14. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
 15. Slope refrigerant piping as follows:
 - a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - b. Install horizontal suction lines with a uniform slope downward to compressor.
 - c. Install traps and double risers to entrain oil in vertical runs.
 - d. Liquid lines may be installed level.
 16. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
 17. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
 - a. Shot blast the interior of piping.
 - b. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 - c. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 - d. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 - e. Finally, draw a clean, dry, lintless cloth through the tube or pipe.



- f. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.
- 18. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- 19. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping".
- 20. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- 21. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- 22. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.
- 23. Identify refrigerant piping and valves according to Division 23 Section "Identification For Hvac Piping And Equipment".

F. Pipe Joint Construction

- 1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- 3. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- 4. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- 5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - a. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - b. Use Type BA9, cadmium-free silver alloy for joining copper with bronze or steel.
- 6. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- 7. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
- 8. Welded Joints: Construct joints according to AWS D10.12/D10.12M.
- 9. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Hangers And Supports

- 1. Hanger, support, and anchor products are specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
- 2. Install the following pipe attachments:
 - a. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
 - b. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
 - c. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
 - d. Spring hangers to support vertical runs.
 - e. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- 3. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - a. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
 - b. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
 - c. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).



- d. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
 - e. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
 - f. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
 - g. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
 - h. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
 - i. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).
 4. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 - a. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
 - b. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (9.5 mm).
 - c. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (9.5 mm).
 - d. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).
 5. Support multifloor vertical runs at least at each floor.
- H. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 2. Tests and Inspections:
 - a. Comply with ASME B31.5, Chapter VI.
 - b. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - c. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - 1) Fill system with nitrogen to the required test pressure.
 - 2) System shall maintain test pressure at the manifold gage throughout duration of test.
 - 3) Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - 4) Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- I. System Charging
1. Charge system using the following procedures:
 - a. Install core in filter dryers after leak test but before evacuation.
 - b. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
 - c. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
 - d. Charge system with a new filter-dryer core in charging line.
- J. Adjusting
1. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
 2. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
 3. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
 4. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - a. Open shutoff valves in condenser water circuit.
 - b. Verify that compressor oil level is correct.
 - c. Open compressor suction and discharge valves.
 - d. Open refrigerant valves except bypass valves that are used for other purposes.
 - e. Check open compressor-motor alignment and verify lubrication for motors and bearings.
 5. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.



END OF SECTION 22 11 16 00e



SECTION 22 11 16 00f - GENERAL-SERVICE COMPRESSED-AIR PIPING

1.1 GENERAL

A. Description Of Work:

1. This specification covers the furnishing and installation of materials for general-service compressed-air piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes piping and related specialties for general-service compressed-air systems operating at 200 psig (1380 kPa) or less.

C. Definitions

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CR: Chlorosulfonated polyethylene synthetic rubber.
3. EPDM: Ethylene-propylene-diene terpolymer rubber.
4. HDPE: High-density polyethylene plastic.
5. NBR: Acrylonitrile-butadiene rubber.
6. PE: Polyethylene plastic.
7. PVC: Polyvinyl chloride plastic.
8. High-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures between 150 and 200 psig (1035 and 1380 kPa).
9. Low-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig (1035 kPa) or less.

D. Performance Requirements

1. Seismic Performance: Compressed-air piping and support and installation shall withstand effects of seismic events determined according to SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

E. Submittals

1. Product Data: For the following:
 - a. Plastic pipes, fittings, and valves.
 - b. Dielectric fittings.
 - c. Flexible pipe connectors.
 - d. Safety valves.
 - e. Pressure regulators. Include rated capacities and operating characteristics.
 - f. Automatic drain valves.
 - g. Filters. Include rated capacities and operating characteristics.
 - h. Lubricators. Include rated capacities and operating characteristics.
 - i. Quick couplings.
 - j. Hose assemblies.
2. Brazing **OR** Welding, **as directed**, certificates.
3. Field quality-control test reports.
4. Operation and maintenance data.

F. Quality Assurance

1. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or to AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
2. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.



3. ASME Compliance:
 - a. Comply with ASME B31.1, "Power Piping," for high-pressure compressed-air piping.
 - b. Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

G. Project Conditions

1. Interruption of Existing Compressed-Air Service: Do not interrupt compressed-air service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary compressed-air service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of compressed-air service.
 - b. Do not proceed with interruption of compressed-air service without the Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. Schedule 40, Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B, black or hot-dip zinc coated with ends threaded according to ASME B1.20.1.
 - a. Steel Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized seamless steel pipe. Include ends matching joining method.
 - b. Malleable-Iron Fittings: ASME B16.3, Class 150 or 300, threaded.
 - c. Malleable-Iron Unions: ASME B16.39, Class 150 or 300, threaded.
 - d. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel, threaded.
 - e. Wrought-Steel Butt-Welding Fittings: ASME B16.9, Schedule 40.
 - f. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel.
 - g. Grooved-End Fittings and Couplings:
 - 1) Grooved-End Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron casting; with grooves according to AWWA C606 and dimensions matching steel pipe.
 - 2) Couplings: AWWA C606 or UL 213, for steel-pipe dimensions and rated for 300-psig (2070-kPa) minimum working pressure. Include ferrous housing sections, gasket suitable for compressed air, and bolts and nuts. Provide EDPM gaskets for oil-free compressed air. Provide NBR gaskets if compressed air contains oil or oil vapor.
2. Schedule 5, Steel Pipe: ASTM A 135, carbon steel with plain ends and zinc-plated finish.
 - a. Pressure-Seal Fittings: Listed and labeled by a qualified testing agency and FMG-approved, carbon-steel, pressure-seal housing with O-ring end seals suitable for compressed-air piping and rated for 300-psig (2070-kPa) minimum working pressure. Provide EDPM seals for oil-free compressed air. Provide NBR seals if compressed air contains oil or oil vapor.
3. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B) and ASTM B 88, Type M (ASTM B 88M, Type C) seamless, drawn-temper, water tube.
 - a. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
 - b. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.
 - c. Copper Unions: ASME B16.22 or MSS SP-123.
 - d. Press-Type Fittings, NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - e. Press-Type Fittings, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
 - f. Extruded-Tee Outlets: Procedure for making branch outlets in copper tube according to ASTM F 2014.



- g. Grooved-End Fittings and Couplings:
 - 1) Grooved-End Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze castings.
 - 2) Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, gasket suitable for compressed air, and bolts and nuts. Provide EDPM gasket for oil-free compressed air. Provide NBR gasket if compressed air contains oil or oil vapor.
 4. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
 5. PVC Pipe: ASTM D 1785, Schedule 40.
 - a. PVC Fittings: ASTM D 2466, Schedule 40, socket type.
 6. Blue ABS Piping System: Made of ASTM D 3965, ABS-resin modified to provide shatter-resistant pipe for compressed-air service. Pipe and fittings are light blue and sizes are in millimeters.
 - a. Transition Fittings, 20 to 63 mm: Composite union with ABS socket end, CR O-ring, and malleable-iron union nut and threaded end; with construction similar to MSS SP-107, transition union.
 - b. Transition Fittings, 90 to 110 mm: Flange assembly with ABS flange, CR gasket, and metal flange of material matching piping to be connected.
 - c. Valves, 20 to 63 mm: ABS union ball valve with socket ends.
 - d. Valves, 90 to 110 mm: ABS butterfly valve with lever handle.
 7. Green ABS Piping System: Made of ASTM D 3965, ABS-resin modified to provide shatter-resistant pipe for compressed-air service. Pipe and fittings are dark green with SDR of 9.0 and same OD as ASTM A 53/A 53M, steel pipe.
 - a. Transition Fittings, NPS 1/2 to NPS 2 (DN 15 to DN 50): Composite union with ABS socket end, CR O-ring, ABS union nut, and brass solder-joint end; with construction similar to MSS SP-107, transition union.
 - b. Transition Fittings, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): ABS flange, CR gasket, and metal flange of material matching piping to be connected.
 - c. Valves, NPS 1/2 to NPS 2 (DN 15 to DN 50): Union ball valve with socket ends.
 - d. Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Union ball valve with flanged ends. Include safety exhaust feature in Part 3 "Valve Applications" Article if required.
 8. HDPE Piping System: Made of ASTM D 1248, HDPE resin to provide shatter-resistant pipe for compressed-air service. Pipe and fittings are dark blue with pipe dimensions about the same OD as ASTM D 3035, PE pipe.
 - a. Transition Fittings, NPS 1/2 to NPS 2 (DN 15 to DN 50): HDPE adapter with one socket end and one end with threaded brass insert.
 - b. Transition Fittings, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): HDPE flange, CR gasket, and metal flange of material matching piping to be connected.
 - c. Valves, NPS 1/2 to NPS 3 (DN 15 to DN 80): HDPE union ball valve with socket ends.
- B. Joining Materials
1. Pipe-Flange Gasket Materials: Suitable for compressed-air piping system contents.
 - a. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - 1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - 2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
 3. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
 4. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
 5. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.
 6. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
 7. Solvent Cements for Joining Plastic Piping:



- a. ABS Piping: ASTM D 2235.
 - b. PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.
- C. Valves
1. Metal Ball, Butterfly, Check, Gate, and Globe Valves: Comply with requirements in Division 22 Section "General-duty Valves For Plumbing Piping".
- D. Dielectric Fittings
1. General Requirements for Dielectric Fittings: Combination fitting of copper alloy and ferrous materials with insulating material; suitable for system fluid, pressure, and temperature. Include threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
 2. Dielectric Unions: Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
 3. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
 4. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - a. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.
- E. Flexible Pipe Connectors
1. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - a. Working-Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
 - b. End Connections, NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
 - c. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.
 2. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
 - a. Working-Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
 - b. End Connections, NPS 2 (DN 50) and Smaller: Threaded steel pipe nipple.
 - c. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.
- F. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
 2. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.
- G. Escutcheons
1. General Requirements: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
 3. One-Piece, Cast-Brass Escutcheons: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.



6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Escutcheons: Cast iron.
8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

H. Specialties

1. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.
 - a. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.
2. Air-Main Pressure Regulators: Bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250-psig (1725-kPa) inlet pressure, unless otherwise indicated.
 - a. Type: Pilot operated.
3. Air-Line Pressure Regulators: Diaphragm **OR** Pilot, **as directed**, operated, bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig (1380-kPa) minimum inlet pressure, unless otherwise indicated.

OR

Air-Line Pressure Regulators: Diaphragm operated, aluminum alloy or plastic body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig (1380-kPa) minimum inlet pressure, unless otherwise indicated.
4. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket if wall mounting is indicated, **as directed**.
5. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded. Include mounting bracket if wall mounting is indicated, **as directed**.
6. Mechanical Filters: Two-stage, mechanical-separation-type, air-line filters. Equip with deflector plates, resin-impregnated-ribbon-type filters with edge filtration, and drain cock. Include mounting bracket if wall mounting is indicated, **as directed**.
7. Air-Line Lubricators: With drip chamber and sight dome for observing oil drop entering air stream; with oil-feed adjustment screw and quick-release collar for easy bowl removal. Include mounting bracket if wall mounting is indicated, **as directed**.
 - a. Provide with automatic feed device for supplying oil to lubricator.

I. Quick Couplings

1. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.
2. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.
 - a. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
 - b. Plug End: Flow-sensor-bleeder, check-valve **OR** Straight-through, **as directed**, type with barbed outlet for attaching hose.
3. Valveless Quick Couplings: Straight-through brass body with stainless-steel or nickel-plated-steel operating parts.
 - a. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.
 - b. Plug End: With barbed outlet for attaching hose.

J. Hose Assemblies

1. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300-psig (2070-kPa) minimum working pressure, unless otherwise indicated.



- a. Hose: Reinforced single **OR** double, **as directed**,-wire-braid, CR-covered hose for compressed-air service.
- b. Hose Clamps: Stainless-steel clamps or bands.
- c. Hose Couplings: Two-piece, straight-through, threaded brass or stainless-steel O-ring or gasket-seal swivel coupling with barbed ends for connecting two sections of hose.
- d. Hose Splicers: One-piece, straight-through brass or stainless-steel fitting with barbed ends for connecting two sections of hose.

K. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Piping Applications

1. Compressed-Air Piping between Air Compressors and Receivers: Use one of the following piping materials for each size range:
 - a. NPS 2 (DN 50) and Smaller: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - b. NPS 2 (DN 50) and Smaller: Schedule 5, galvanized-steel pipe; pressure-seal fittings; and pressure-sealed joints.
 - c. NPS 2 (DN 50) and Smaller: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
 - d. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed joints.
 - e. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - f. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; grooved-end fittings; couplings; and grooved joints.
 - g. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
 - h. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed joints.
 - i. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
 - j. NPS 5 (DN 125) and Larger: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - k. NPS 5 (DN 125) and Larger: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; grooved-end fittings; couplings; and grooved joints.
 - l. NPS 5 (DN 125) and Larger: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
 - m. NPS 5 (DN 125) and Larger: Grooved-end, Type K or L (ASTM B 88M Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
2. Low-Pressure Compressed-Air Distribution Piping: Use one of the following piping materials for each size range:
 - a. NPS 2 (DN 50) and Smaller: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - b. NPS 2 (DN 50) and Smaller: Schedule 5, galvanized-steel pipe; pressure-seal fittings; and pressure-sealed joints.
 - c. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.



- d. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; press-type fittings; and pressure-sealed joints.
 - e. NPS 2 (DN 50) and Smaller: 63-mm and smaller, blue ABS pipe and fittings; transition fittings; valves; and solvent-cemented joints.
 - f. NPS 2 (DN 50) and Smaller: Green ABS pipe and fittings, transition fittings, and valves; and solvent-cemented joints.
 - g. NPS 2 (DN 50) and Smaller: HDPE pipe, fittings, and valves; and heat-fusion joints.
 - h. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black **OR** galvanized, **as directed**, -steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - i. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black **OR** galvanized, **as directed**, -steel pipe; grooved-end fittings; couplings; and grooved joints.
 - j. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
 - k. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
 - l. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; press-type fittings; and pressure-sealed joints.
 - m. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 90- and 110-mm, blue ABS pipe and fittings; transition fittings; and solvent-cemented joints. Include butterfly valves and flanged joints.
 - n. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): NPS 3 and NPS 4 (DN 80 and DN 100), green ABS pipe and fittings; transition fittings; and solvent-cemented joints. Include ball valves and flanged joints.
 - o. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): NPS 3 and NPS 4 (DN 80 and DN 100), HDPE pipe and fittings; valves; and heat-fusion joints.
 - p. NPS 5 and NPS 6 (DN 125 and DN 150): Schedule 40, black **OR** galvanized, **as directed**, -steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - q. NPS 5 (DN 125) and Larger: Schedule 40, black **OR** galvanized, **as directed**, -steel pipe; grooved-end fittings; couplings; and grooved joints.
 - r. NPS 5 to NPS 8 (DN 125 to DN 200): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
3. High-Pressure Compressed-Air Distribution Piping: Use one of the following piping materials for each size range:
- a. NPS 2 (DN 50) and Smaller: Schedule 40, black **OR** galvanized, **as directed**, -steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - b. NPS 2 (DN 50) and Smaller: Schedule 5, galvanized-steel pipe; pressure-seal fittings; and pressure-sealed joints.
 - c. NPS 2 (DN 50) and Smaller: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
 - d. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
 - e. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Schedule 40, black **OR** galvanized, **as directed**, -steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - f. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Schedule 40, black **OR** galvanized, **as directed**, -steel pipe; grooved-end fittings; couplings; and grooved joints.
 - g. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
 - h. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
 - i. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed joints.
 - j. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
 - k. NPS 8 (DN 200) and Larger: Schedule 40, black **OR** galvanized, **as directed**, -steel pipe; grooved-end fittings; couplings; and grooved joints.
 - l. NPS 8 (DN 200) and Larger: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.



- m. NPS 8 (DN 200): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
- 4. Drain Piping: Use one of the following piping materials:
 - a. NPS 2 (DN 50) and Smaller: Type M (Type C) copper tube; wrought-copper fittings; and brazed or soldered joints.
 - b. NPS 2 (DN 50) and Smaller: PVC pipe and fittings; and solvent-cemented joints.

B. Valve Applications

- 1. General-Duty Valves: Comply with requirements in Division 22 Section "General-duty Valves For Plumbing Piping" for metal general-duty valves. Use metal valves, unless otherwise indicated.
 - a. Metal General-Duty Valves: Use valve types specified in "Valve Applications" Article in Division 22 Section "General-duty Valves For Plumbing Piping" according to the following:
 - 1) Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.
 - 2) High-Pressure Compressed Air: Valve types specified for medium-pressure compressed air.
 - 3) Equipment Isolation NPS 2 (DN 50) and Smaller: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.
 - 4) Grooved-end valves may be used with grooved-end piping and grooved joints.
 - b. Plastic General-Duty Valves: Provide valves, made by piping manufacturer, that are compatible with piping. Do not use plastic valves between air compressors and receivers.
 - 1) Blue ABS Piping System: Ball and butterfly valves.
 - 2) Green ABS Piping System: Ball valves.
 - 3) HDPE Piping System: Ball valves.

C. Piping Installation

- 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- 2. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.
- 3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.
- 4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.
- 5. Install piping adjacent to equipment and machines to allow service and maintenance.
- 6. Install air and drain piping with 1 percent slope downward in direction of flow.
- 7. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.
- 8. Equipment and Specialty Flanged Connections:
 - a. Use steel companion flange with gasket for connection to steel pipe.
 - b. Use cast-copper-alloy companion flange with gasket and brazed **OR** soldered, **as directed**, joint for connection to copper tube. Do not use soldered joints for connection to air compressors or to equipment or machines producing shock or vibration.
- 9. Flanged joints may be used instead of specified joint for any piping or tubing system.
- 10. Extended-tee outlets with brazed branch connection may be used for copper tubing, within extruded-tee connection diameter to run tube diameter ratio for tube type, according to Extruded Tee Connections Sizes and Wall Thickness for Copper Tube (Inches) Table in ASTM F 2014.
- 11. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
- 12. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.



13. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section "Meters And Gages For Plumbing Piping".
14. Install piping to permit valve servicing.
15. Install piping free of sags and bends.
16. Install fittings for changes in direction and branch connections.
17. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".

D. Joint Construction

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
4. Welded Joints for Steel Piping: Join according to AWS D10.12/D10.12M.
5. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
6. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Join according to ASTM B 828 or CDA's "Copper Tube Handbook."
7. Extruded-Tee Outlets for Copper Tubing: Form branches according to ASTM F 2014, with tools recommended by procedure manufacturer, and using operators qualified according to Part 1 "Quality Assurance" Article.
8. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
9. Grooved Joints: Assemble couplings with housing, gasket, lubricant, and bolts. Join according to AWWA C606 for grooved joints. Do not apply lubricant to prelubricated gaskets.
10. Heat-Fusion Joints for PE Piping: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657 for socket-fusion joints.
11. Pressure-Sealed Joints: Join with tools recommended by fitting manufacturer, using operators qualified according to Part 1 "Quality Assurance" Article.
12. Solvent-Cemented Joints for ABS Piping: Clean and dry joining surfaces. Join according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. Join according to ASME B31.9 for solvent-cemented joints and to ASTM D 2235 Appendix.
13. Solvent-Cemented Joints for PVC Piping: Clean and dry joining surfaces. Join according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. Apply primer and join according to ASME B31.9 for solvent-cemented joints and to ASTM D 2672.
14. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

E. Valve Installation

1. General-Duty Valves: Comply with requirements in Division 22 Section "General-duty Valves For Plumbing Piping".
2. Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.
3. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.
4. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.



- F. Dielectric Fitting Installation
1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 2. NPS 2 (DN 50) and Smaller: Use dielectric unions.
 3. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
 4. NPS 5 (DN 125) and Larger: Use dielectric flange kits.
- G. Flexible Pipe Connector Installation
1. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter, **as directed**, of each air compressor.
 2. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.
 3. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.
- H. Specialty Installation
1. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.
 2. Install air-main pressure regulators in compressed-air piping at or near air compressors.
 3. Install air-line pressure regulators in branch piping to equipment and tools, **as directed**.
 4. Install automatic drain valves on aftercoolers, receivers, and dryers. Discharge condensate onto nearest floor drain.
 5. Install coalescing filters in compressed-air piping at or near air compressors and upstream from mechanical filters. Mount on wall at locations indicated, **as directed**.
 6. Install mechanical filters in compressed-air piping at or near air compressors and downstream from coalescing filters. Mount on wall at locations indicated, **as directed**.
 7. Install air-line lubricators in branch piping to machine tools. Mount on wall at locations indicated, **as directed**.
 8. Install quick couplings at piping terminals for hose connections.
 9. Install hose assemblies at hose connections.
- I. Connections
1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment and machine.
 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment and machine.
- J. Sleeve Installation
1. Sleeves are not required for core-drilled holes.
 2. Permanent sleeves are not required for holes formed by removable PE sleeves.
 3. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe **OR** galvanized-steel sheet **OR** stack sleeve fittings **OR** PVC pipe, **as directed**.
OR
Install sleeves for pipes passing through concrete and masonry walls, gypsum board partitions, and concrete floor and roof slabs.
 - a. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
 - b. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 4. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 5. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
 - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to



- 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
- 1) Seal space outside of sleeve fittings with grout.
6. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
- K. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - 2) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
 - 3) Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split-casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.
 - 4) Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
 - 5) Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
 - 6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
 - b. Existing Piping:
 - 1) Chrome-Plated Piping: Split-casting, cast brass with chrome-plated finish.
 - 2) Insulated Piping: Split-plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - 3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
 - 4) Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
 - 5) Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
 - 6) Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
 - 7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.
- L. Hanger And Support Installation
1. Comply with requirements in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
 2. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices.
 3. Vertical Piping: MSS Type 8 or 42, clamps.
 4. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) or Less: MSS Type 1, adjustable, steel clevis hangers.



- b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.
7. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
8. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
9. Install hangers for Schedule 40, steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1/4 to NPS 1/2 (DN 8 to DN 15): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3/4 to NPS 1-1/4 (DN 20 to DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 1-1/2 (DN 40): 12 feet (3.7 m) with 3/8-inch (10-mm) rod.
 - d. NPS 2 (DN 50): 13 feet (4 m) with 3/8-inch (10-mm) rod.
 - e. NPS 2-1/2 (DN 65): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
 - f. NPS 3 (DN 80): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
 - g. NPS 3-1/2 (DN 90): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
 - h. NPS 4 (DN 100): 17 feet (5.2 m) with 5/8-inch (16-mm) rod.
 - i. NPS 5 (DN 125): 19 feet (5.8 m) with 5/8-inch (16-mm) rod.
 - j. NPS 6 (DN 150): 21 feet (6.4 m) with 3/4-inch (19-mm) rod.
 - k. NPS 8 (DN 200): 24 feet (7.3 m) with 3/4-inch (19-mm) rod.
 - l. NPS 10 (DN 250): 26 feet (7.9 m) with 7/8-inch (22-mm) rod.
 - m. NPS 12 (DN 300): 30 feet (9.1 m) with 7/8-inch (22-mm) rod.
10. Install supports for vertical, Schedule 40, steel piping every 15 feet (4.6 m).
11. Install hangers for Schedule 5, steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1/2 (DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - e. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - f. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
12. Install supports for vertical, Schedule 5, steel piping every 10 feet (3 m).
13. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - e. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - f. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - g. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
 - h. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
 - i. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
 - j. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
 - k. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
 - l. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.
 - m. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
 - n. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.
14. Install supports for vertical copper tubing every 10 feet (3 m).
15. Install vinyl-coated hangers for ABS piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. All Sizes: Install continuous support for piping with compressed air at normal operating temperature above 100 deg F (38 deg C).
 - b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 30 inches (760 mm) with 3/8-inch (10-mm) rod.



- c. NPS 3/4 (DN 20): 38 inches (975 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 1 (DN 25): 40 inches (1015 mm) with 3/8-inch (10-mm) rod.
 - e. NPS 1-1/4 (DN 32): 45 inches (1140 mm) with 3/8-inch (10-mm) rod.
 - f. NPS 1-1/2 (DN 40): 52 inches (1330 mm) with 3/8-inch (10-mm) rod.
 - g. NPS 2 (DN 50): 58 inches (1470 mm) with 3/8-inch (10-mm) rod.
 - h. NPS 3 (DN 80): 68 inches (1730 mm) with 1/2-inch (13-mm) rod.
 - i. NPS 4 (DN 100): 76 inches (1900 mm) with 1/2-inch (13-mm) rod.
16. Install supports for vertical ABS piping every 48 inches (1220 mm).
 17. Install vinyl-coated hangers for HDPE piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. All Sizes: Install continuous support for piping with compressed air at normal operating temperature above 100 deg F (38 deg C).
 - b. NPS 1/2 (DN 15): 30 inches (760 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 3/4 (DN 20): 35 inches (890 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 1 (DN 25): 40 inches (1015 mm) with 3/8-inch (10-mm) rod.
 - e. NPS 1-1/4 (DN 32): 43 inches (1090 mm) with 3/8-inch (10-mm) rod.
 - f. NPS 1-1/2 (DN 40): 49 inches (1245 mm) with 3/8-inch (10-mm) rod.
 - g. NPS 2 (DN 50): 55 inches (1400 mm) with 3/8-inch (10-mm) rod.
 - h. NPS 3 and NPS 4 (DN 80 and DN 100): 96 inches (2440 mm) with 1/2-inch (13-mm) rod.
 18. Install supports for vertical HDPE piping every 48 inches (1220 mm).
- M. Labeling And Identification
1. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification For Plumbing Piping And Equipment".
- N. Field Quality Control
1. Perform field tests and inspections.
 2. Tests and Inspections:
 - a. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - b. Piping Leak Tests for ABS Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen, at temperature of 110 deg F (43 deg C) or less, to pressure of 40 psig (275 kPa) above system operating pressure, but not less than 80 psig (550 kPa) **OR** 100 psig (690 kPa), **as directed**, or more than 120 psig (825 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - c. Piping Leak Tests for HDPE Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen, at temperature of 100 deg F (38 deg C) or less, to pressure of 40 psig (275 kPa) above system operating pressure, but not less than 100 psig (690 kPa) **OR** 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, or more than 180 psig (1240 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - d. Repair leaks and retest until no leaks exist.
 - e. Inspect filters, lubricators, and pressure regulators for proper operation.
 3. Prepare test reports.

END OF SECTION 22 11 16 00f



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**SECTION 22 11 16 00g - COMPRESSED-AIR PIPING FOR LABORATORY AND HEALTHCARE FACILITIES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for compressed-air piping for laboratory and healthcare facilities. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Compressed-air piping and specialties for nonmedical laboratory facilities, designated "laboratory air," operating at 50 psig (345 kPa) **OR** 100 psig (690 kPa) **OR** 125 psig (860 kPa), **as directed**.
 - b. Medical air piping and specialties, designated "medical air," operating at 50 to 55 psig (345 to 380 kPa).
 - c. Dental air piping and specialties, designated "dental air," operating at 80 to 100 psig (550 to 690 kPa).
 - d. Gas-powered-tool air piping and specialties, designated "instrument air," operating at 175 psig (1200 kPa).
 - e. Healthcare laboratory air piping and specialties, designated "medical laboratory air," operating at 100 psig (690 kPa).

C. Definitions

1. D.I.S.S.: Diameter-index safety system.
2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
3. Medical Compressed-Air Piping Systems: Include medical air, dental air, instrument air, and medical laboratory air piping systems.

D. Submittals

1. Product Data: For the following:
 - a. Compressed-air tubes and fittings.
 - b. Compressed-air valves and valve boxes.
 - c. Medical compressed-air service connections.
 - d. Medical compressed-air pressure control panels.
 - e. Medical compressed-air manifolds.
 - f. Medical compressed-air alarm system components.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Piping Material Certification: Signed by Installer certifying that medical compressed-air piping materials comply with NFPA 99 requirements.
4. Brazing certificates.
5. Field quality-control test reports.
6. Operation and maintenance data.

E. Quality Assurance

1. Installer Qualifications:
 - a. Medical Compressed-Air Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.
 - b. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.



2. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization **OR** is an NRTL, **as directed**, and that is acceptable to authorities having jurisdiction.
 - a. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.
3. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections provided for in Division 22 Section "Gas Piping For Laboratory And Healthcare Facilities".
4. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
6. ASME Compliance:
 - a. Comply with ASME B31.1, "Power Piping," for laboratory compressed-air piping operating at more than 150 psig (1035 kPa).
 - b. Comply with ASME B31.9, "Building Services Piping," for laboratory compressed-air piping operating at 150 psig (1035 kPa) or less.
7. Comply with NFPA 99, "Health Care Facilities," for medical compressed-air system materials and installation in healthcare facilities.

F. Project Conditions

1. Interruption of Existing Laboratory and Medical Compressed-Air Service(s): Do not interrupt laboratory or medical compressed-air service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of laboratory and medical compressed-air service(s).
 - b. Do not proceed with interruption of laboratory and medical compressed-air service(s) without the Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. Copper Medical Gas Tube: ASTM B 819, Type K **OR** Type L, **as directed**, seamless, drawn temper, that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and in blue for Type L tube.
 - a. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
 - b. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
 - c. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
 - d. Press-Type Fittings:
 - 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
2. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.



3. Copper Water Tube: ASTM B 88, Type M (ASTM B 88M, Type C), seamless, drawn temper.
 - a. Copper Fittings: ASME B16.18, cast-copper or ASME B16.22, wrought-copper, solder-joint pressure type.
 - b. Press-Type Fittings:
 - 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
 4. PVC Pipe: ASTM D 1785, Schedule 40.
 - a. PVC Fittings: ASTM D 2466, Schedule 40, socket type.
- B. Joining Materials
1. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
 2. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
 3. Threaded-Joint Tape: PTFE.
 4. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.
- C. Valves
1. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
 2. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Ball: Full-port, chrome-plated brass.
 - c. Seats: PTFE or TFE.
 - d. Handle: Lever type with locking device, **as directed**.
 - e. Stem: Blowout proof with PTFE or TFE seal.
 - f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
 3. Check Valves: In-line pattern, bronze.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Operation: Spring loaded.
 - c. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
 4. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Ball: Full-port, chrome-plated brass.
 - c. Seats: PTFE or TFE.
 - d. Handle: Lever type with locking device, **as directed**.
 - e. Stem: Blowout proof with PTFE or TFE seal.
 - f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
 - g. Pressure Gage: Manufacturer installed on one copper-tube extension.
 5. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.
 - a. Interior Finish: Factory-applied white enamel.
 - b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Satin-chrome finish steel **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
 - c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.
- OR**
- Zone Valve Boxes: Formed or extruded aluminum with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.



- a. Interior Finish: Factory-applied white enamel.
 - b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
 - c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.
6. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.
 7. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated relieving type; manual pressure-setting adjustment; rated for 250-psig (1725-kPa) minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10-psig (5.0 kPa for each 100-kPa) inlet pressure.
 8. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket where wall mounting is indicated, **as directed**.
- D. Medical Compressed-Air Service Connections
1. Connection Devices: For specific medical compressed-air pressure and service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.
 - a. Roughing-in Assembly:
 - 1) Steel outlet box for recessed mounting and concealed piping.
 - 2) Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
 - 3) Double seals that will prevent air leakage.
 - 4) ASTM B 819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.
 - b. Finishing Assembly:
 - 1) Brass housing with primary check valve.
 - 2) Double seals that will prevent air leakage.
 - 3) Cover plate with gas-service label.
 - c. Quick-Coupler Service Connections: Pressure outlet with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.
 - d. D.I.S.S. Service Connections: Pressure outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
 - 1) Medical Air Service Connections: CGA V-5, D.I.S.S. No. 1160.
 - 2) Instrument Air Service Connections: CGA V-5, D.I.S.S. No. 1160.
 - e. Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish **OR** metal, with chrome-plated finish **OR** anodized aluminum, **as directed**, and permanent, color-coded, identifying label matching corresponding service.
- E. Medical Compressed-Air Pressure Control Panels
1. Description: Steel box and support brackets for recessed roughing in with stainless-steel or anodized-aluminum cover plate with printed operating instructions. Include manifold assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.
 - a. Minimum Working Pressure: 200 psig (1380 kPa).
 - b. Line-Pressure Control Regulator: Self-relieving diaphragm type with precision manual adjustment.
 - c. Pressure Gages: 0- to 300-psig (0- to 2070-kPa) range.



- d. Service Connection: CGA V-5, D.I.S.S. No. 1160, instrument air outlet.
- e. Before final assembly, provide temporary dust shield and U-tube for testing.
- f. Label cover plate "Air Pressure Control."

F. Medical Compressed-Air Manifolds

1. General Requirements for Medical Compressed-Air Manifolds: Comply with NFPA 99, Ch. 5, "Manifolds for Gas Cylinders without Reserve Supply."
2. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.
3. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure. Include cylinder bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
4. Compressed-Air Cylinders: Will be furnished by the Owner **OR** Number and type of compressed-air cylinders required for complete manifold systems, **as directed**.
5. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.
6. Mounting: Wall with mounting brackets for manifold control cabinet and headers **OR** Floor with support legs for manifold control cabinet, **as directed**.
7. Label manifold control unit with permanent label identifying compressed air and system operating pressure.
8. Medical Air Manifolds: For 4 cylinders and 1250-cu. ft./h (9.85-L/s) **OR** 8 cylinders and 2500-cu. ft./h (19.7-L/s), **as directed**, capacity at 55-psig (380-kPa) line pressure.
9. Instrument Air Manifolds: For 8 cylinders and 2000-cu. ft./h (15.7-L/s) **OR** 12 cylinders and 3000-cu. ft./h (23.6-L/s), **as directed**, capacity at 200-psig (1380-kPa) minimum line pressure.

G. Medical Compressed-Air-Piping Alarm Systems

1. Panels for medical compressed-air piping systems may be combined in single panels with medical vacuum and medical gas piping systems.
2. Components: Designed for continuous service and to operate on power supplied from 120 **OR** 240 **OR** 277, **as directed**, -V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.
3. Dew Point Monitors: Continuous line monitoring, having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and visual and cancelable audio signal for dryer site and master alarm panels. Alarm signals when pressure dew point rises above 39 deg F (4 deg C) at 55 psig (380 kPa).
 - a. Operation: Chilled-mirror method **OR** Chilled-mirror method or hygrometer moisture analyzer with sensor probe **OR** Hygrometer moisture analyzer with sensor probe, **as directed**.
4. Pressure Switches or Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.
 - a. Low-Pressure Operating Range: 0- to 100-psig (0- to 690-kPa).
 - b. High-Pressure Operating Range: Up to 250-psig (1725-kPa).
5. Carbon Monoxide Monitors: Panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Alarm signals when carbon monoxide level rises above 10 ppm.
6. General Requirements for Medical Compressed-Air Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.
 - a. Mounting: Exposed, surface **OR** Recessed, **as directed**, installation.
 - b. Enclosures: Fabricated from minimum 0.047-inch- (1.2-mm-) thick steel or minimum 0.05-inch- (1.27-mm-) thick aluminum, with knockouts for electrical and piping connections.
7. Master Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.



- a. Include alarm signals when the following conditions exist:
 - 1) Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 39 deg F (4 deg C) at 55 psig (380 kPa), carbon monoxide level rises above 10 ppm, and high water level is reached in receiver for liquid-ring, medical air compressor systems.
 - 2) Dental Air: Pressure drops below 65 psig (450 kPa) or rises above 110 psig (760 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 50 deg F (10 deg C) at 125 psig (860 kPa), and carbon monoxide level rises above 10 ppm.
 - 3) Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa).
 - 4) Medical Laboratory Air: Pressure drops below 90 psig (630 kPa) or rises above 110 psig (760 kPa).
 8. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
 - 2) Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa).
 9. Area Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
 - a. Include alarm signals when the following condition exists:
 - 1) Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
 10. Dental-Area Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Dental Air: Pressure drops below 65 psig (450 kPa) or rises above 110 psig (760 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 50 deg F (10 deg C) at 125 psig (860 kPa), and carbon monoxide level rises above 10 ppm.
 - 2) Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa).
 11. Medical Laboratory Area Alarm Panels: Separate trouble alarm signals, pressure gages,; and indicators for medical compressed-air piping systems.
 - a. Include alarm signals when the following condition exists:
 - 1) Medical Laboratory Air: Pressure drops below 90 psig (630 kPa) or rises above 110 psig (760 kPa).
- H. Computer Interface Cabinet
1. Description: Wall-mounting, welded-steel control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical compressed-air- piping-system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing 20, **as directed**, alarm signals.
- I. Compressed-Air-Cylinder Storage Racks
1. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.
 2. Freestanding Storage Racks: Fabricate racks as indicated or provide equivalent manufactured storage racks.



- J. Flexible Pipe Connectors
1. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - a. Working-Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
 - b. End Connections: Threaded copper pipe or plain-end copper tube.
- K. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
 2. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.
- L. Escutcheons
1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
 3. One-Piece, Cast-Brass Escutcheons: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 7. One-Piece, Floor-Plate Escutcheons: Cast iron.
 8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.
- M. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.
- N. Nitrogen
1. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

1.3 EXECUTION

- A. Piping Applications
1. Connect new tubing to existing tubing with memory-metal couplings.
 2. Laboratory Air Piping: Use one of the following piping materials for each size range:
 - a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
 - b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas tube; press-type fittings; and pressure-sealed joints.
 - c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
 3. Medical Air Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.



4. Dental Air Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
5. Instrument Air Piping:
 - a. NPS 3 (DN 80) and Smaller: Use Type K **OR** Type L, **as directed**, copper medical gas tube; wrought-copper fittings; and brazed joints.
 - b. NPS 3-1/2 (DN 90) and Larger: Use Type K, copper medical gas tube; wrought-copper fittings; and brazed joints.
6. Medical Laboratory Air Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
7. Drain Piping: Use one of the following piping materials:
 - a. Copper water tube, cast- or wrought-copper fittings, and soldered **OR** press-type fittings, and pressure-sealed, **as directed**, joints.
 - b. PVC pipe, PVC fittings, and solvent-cemented joints.

B. Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Comply with ASSE Standard #6010 for installation of compressed-air piping.
3. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
6. Install piping adjacent to equipment and specialties to allow service and maintenance.
7. Install air and drain piping with 1 percent slope downward in direction of flow.
8. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.
9. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
10. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.
11. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section "Meters And Gages For Plumbing Piping".
12. Install piping to permit valve servicing.
13. Install piping free of sags and bends.
14. Install fittings for changes in direction and branch connections.
15. Install medical compressed-air piping to medical compressed-air service connections specified in this Section, to medical compressed-air service connections in equipment specified in Division 22 Section "Gas Piping For Laboratory And Healthcare Facilities", and to equipment specified in other Sections requiring medical compressed-air service.
16. Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
17. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
18. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.
19. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.



- C. Valve Installation
1. Install shutoff valve at each connection to and from compressed-air equipment and specialties.
 2. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.
 3. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
 4. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
 5. Install safety valves on compressed-air receivers where required by NFPA 99 and where recommended by specialty manufacturers.
 6. Install pressure regulators on compressed-air piping where reduced pressure is required.
 7. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain so contents spill over or into it.
 8. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter, **as directed**, of each air compressor.
- D. Joint Construction
1. Ream ends of PVC pipes and remove burrs.
 2. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
 3. Threaded Joints: Apply appropriate tape to external pipe threads.
 4. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.
 5. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.
 6. Pressure-Sealed Joints: Join copper tube and press-type fittings with tools recommended by fitting manufacturer.
 7. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.
 8. Solvent-Cemented Joints: Clean and dry joining surfaces. Join PVC pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. Apply primer and join according to ASME B31.9 for solvent-cemented joints, and ASTM D 2672.
- E. Compressed-Air Service Component Installation
1. Install compressed-air pressure control panel in walls. Attach to substrate.
 2. Install compressed-air manifolds on concrete base, **as directed**, anchored to substrate.
 3. Install compressed-air cylinders and connect to manifold piping.
 4. Install compressed-air manifolds with seismic restraints as indicated.
 5. Install compressed-air-cylinder wall storage racks attached to substrate.
- F. Medical Compressed-Air-Piping Alarm System Installation
1. Alarm panels for medical compressed-air piping systems may be combined in single panels with medical vacuum piping systems and medical gas piping systems.
 2. Install alarm system components for medical compressed-air-piping according to and in locations required by NFPA 99.
 3. Install area and master alarm panels for medical compressed-air piping system where indicated.
 4. Install computer interface cabinet with connection to medical compressed-air-piping alarm system and to facility computer.
- G. Sleeve Installation
1. Sleeves are not required for core-drilled holes.
 2. Permanent sleeves are not required for holes formed by removable PE sleeves.



3. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe **OR** galvanized-steel sheet **OR** stack sleeve fittings **OR** PVC pipe, **as directed**.
 - a. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
 - b. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

OR

Install sleeves in new walls and slabs as new walls and slabs are constructed.
4. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger penetrating gypsum board partitions.
 - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
 - 1) Seal space outside of sleeve fittings with grout.
5. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".

H. Escutcheon Installation

1. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - 2) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
 - 3) Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.
 - 4) Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
 - 5) Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
 - 6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
 - b. Existing Piping:
 - 1) Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
 - 2) Insulated Piping: Split plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - 3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.



- 4) Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
 - 5) Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
 - 6) Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
 - 7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.
- I. Hanger And Support Installation
1. Comply with requirements in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
 2. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices.
 3. Vertical Piping: MSS Type 8 or 42, clamps.
 4. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.
 5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for trapeze hangers.
 6. Base of Vertical Piping: MSS Type 52, spring hangers.
 7. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
 8. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
 9. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - e. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - f. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - g. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
 - h. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
 - i. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
 - j. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
 - k. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
 - l. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.
 - m. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
 - n. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.
 10. Install supports for vertical copper tubing every 10 feet (3 m).
- J. Labeling And Identification
1. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification For Plumbing Piping And Equipment".
 2. Install identifying labels and devices for medical compressed-air piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
 - a. Medical Air: Black letters on yellow background.



- b. Dental Air: Black letters on yellow-and-white diagonal stripe background.
 - c. Instrument Air: White letters on red background.
 - d. Medical Laboratory Air: Black letters on yellow-and-white checkerboard background.
- K. Field Quality Control For Compressed-Air Piping In Nonmedical Laboratory Facilities
1. Perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.
 2. Tests and Inspections:
 - a. Piping Leak Tests for Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - b. Repair leaks and retest until no leaks exist.
 - c. Inspect filters and pressure regulators for proper operation.
- L. Field Quality Control For Medical Compressed-Air Piping In Healthcare Facilities
1. Perform tests and inspections of medical compressed-air piping systems in healthcare facilities and prepare test reports.
 2. Tests and Inspections:
 - a. Medical Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of medical vacuum piping and medical gas piping systems.
 - b. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
 - 1) Initial blowdown.
 - 2) Initial pressure test.
 - 3) Cross-connection test.
 - 4) Piping purge test.
 - 5) Standing pressure test for positive-pressure medical compressed-air piping.
 - 6) Repair leaks and retest until no leaks exist.
 - c. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical compressed-air piping systems and perform the following tests and inspections:
 - 1) Standing pressure test.
 - 2) Individual-pressurization **OR** Individual-pressurization or pressure-differential **OR** Pressure-differential, **as directed**, cross-connection test.
 - 3) Valve test.
 - 4) Master and area alarm tests.
 - 5) Piping purge test.
 - 6) Piping particulate test.
 - 7) Piping purity test.
 - 8) Final tie-in test.
 - 9) Operational pressure test.
 - 10) Medical air purity test.
 - 11) Verify correct labeling of equipment and components.
 - d. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - 1) Inspections performed.
 - 2) Procedures, materials, and gases used.
 - 3) Test methods used.
 - 4) Results of tests.
 3. Remove and replace components that do not pass tests and inspections and retest as specified above.



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**SECTION 22 11 16 00h - VACUUM PIPING FOR LABORATORY AND HEALTHCARE FACILITIES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for vacuum piping for laboratory and healthcare facilities. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Laboratory low-vacuum piping and specialties, designated "laboratory low vacuum" operating at 12 inches mercury (40.6 kPa vacuum) **OR** 20 inches mercury (67.7 kPa vacuum), **as directed**.
 - b. Laboratory high-vacuum piping and specialties, designated "laboratory high vacuum" operating at 24 inches mercury (81.3 kPa vacuum) **OR** 29 inches mercury (98.2 kPa vacuum), **as directed**.
 - c. Medical surgical vacuum piping and specialties, designated "medical vacuum" operating at 15 inches mercury (380 mm mercury or 50.7 kPa vacuum) **OR** 20 inches mercury (510 mm mercury or 67.7 kPa vacuum) **OR** 30 inches mercury (760 mm mercury or 101.4 kPa vacuum), **as directed**.
 - d. Waste anesthetic gas disposal piping and specialties, designated "WAGD evacuation" operating at 14 inches mercury (355 mm mercury or 47.2 kPa vacuum) **OR** 15 inches mercury (380 mm mercury or 50.7 kPa vacuum), **as directed**.
 - e. Dental vacuum piping and specialties, designated "dental vacuum" operating at 10 inches mercury (255 mm mercury or 33.8 kPa vacuum) **OR** 12 inches mercury (305 mm mercury or 40.6 kPa vacuum), **as directed**.
 - f. Oral-evacuation piping and specialties, designated "HVE" operating at 5 inches mercury (127 mm mercury or 16.9 kPa vacuum) **OR** 8 inches mercury (203 mm mercury or 27.0 kPa vacuum), **as directed**.
 - g. Healthcare laboratory vacuum piping and specialties, designated "medical laboratory vacuum" operating at 12 inches mercury (40.6 kPa vacuum) **OR** 20 inches mercury (67.7 kPa vacuum) **OR** 24 inches mercury (81.3 kPa vacuum), **as directed**.

C. Definitions

1. D.I.S.S.: Diameter-index safety system.
2. HVE: High-volume (oral) evacuation.
3. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
4. WAGD: Waste anesthetic gas disposal.
5. Medical vacuum piping systems include medical vacuum, WAGD evacuation, dental vacuum, HVE, and medical laboratory vacuum piping systems.

D. Submittals

1. Product Data: For the following:
 - a. Vacuum pipes **OR** tubes, **as directed**, and fittings.
 - b. Vacuum valves and valve boxes.
 - c. Medical vacuum service connections and vacuum-bottle brackets.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings: Diagram power, signal, and control wiring.



4. Piping Material Certification: Signed by Installer certifying that medical vacuum piping materials comply with NFPA 99 requirements.
5. Qualification Data: For Installer and testing agency.
6. Brazing certificates.
7. Field quality-control test reports.
8. Operation and maintenance data.

E. Quality Assurance

1. Installer Qualifications:
 - a. Medical Vacuum Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.
 - b. Extruded-Tee Outlet Procedure: Qualify operators according to training provided by T-DRILL Industries Inc., for making branch outlets.
 - c. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.
2. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.
 - a. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.
3. Source Limitations: Obtain vacuum service connections of same type and from same manufacture as service connections provided for in Division 22 Section "Gas Piping For Laboratory And Healthcare Facilities".
4. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
6. Comply with ASME B31.9, "Building Services Piping," for vacuum piping in laboratory facilities.
7. NFPA Compliance: Comply with NFPA 99, "Health Care Facilities," for medical vacuum system materials and installation in healthcare facilities.

F. Project Conditions

1. Interruption of Existing Laboratory or Medical Vacuum Service(s): Do not interrupt laboratory or medical vacuum service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of laboratory or medical vacuum service(s).
 - b. Do not proceed with interruption of laboratory or medical vacuum service(s) without the Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue.
 - a. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.



- b. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
 - c. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
 - d. Press-Type Fittings:
 - 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
2. Copper Water Tube: ASTM B 88, Type M (ASTM B 88M, Type C), seamless, drawn temper.
 - a. Cast-Copper Fittings: ASME B16.18, solder-joint pressure type.
 - b. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type.
 - c. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
 - d. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
 - e. Press-Type Fittings:
 - 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
 3. Extruded-Tee Outlets: ASTM F 2014 procedure for making branch outlets in copper tube.
 4. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.
 5. PVC Pipe: ASTM D 1785, Schedule 40 and Schedule 80.
 - a. PVC Pressure Fittings: ASTM D 2466, Schedule 40 and ASTM D 2467, Schedule 80; socket type.
- B. Joining Materials
1. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
 2. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
 3. Threaded-Joint Tape: PTFE.
 4. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, full-face type.
 5. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
 6. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.
 - a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Valves
1. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
 - a. Exception: Factory cleaning and bagging are not required for valves for WAGD service.
 2. Copper-Alloy Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Ball: Full-port, chrome-plated brass.
 - c. Seats: PTFE or TFE.
 - d. Handle: Lever type with locking device, **as directed**.
 - e. Stem: Blowout proof with PTFE or TFE seal.
 - f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
 3. Bronze Check Valves: In-line pattern.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Operation: Spring loaded.



- c. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
 4. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Ball: Full-port, chrome-plated brass.
 - c. Seats: PTFE or TFE.
 - d. Handle: Lever type with locking device, **as directed**.
 - e. Stem: Blowout proof with PTFE or TFE seal.
 - f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
 - g. Vacuum Gage: Manufacturer installed on one copper-tube extension.
 5. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with vacuum gages and in sizes required to permit manual operation of valves.
 - a. Interior Finish: Factory-applied white enamel.
 - b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Satin-chrome finish steel **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
 - c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.
 6. Zone Valve Boxes: Formed or extruded aluminum with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with vacuum gages and in sizes required to permit manual operation of valves.
 - a. Interior Finish: Factory-applied white enamel.
 - b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
 - c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.
 7. PVC Ball Valves: MSS SP-122, with union ends and 150-psig (1035-kPa) minimum working-pressure rating and suitable for vacuum service.
 8. PVC Butterfly Valves: Lug type with lever handle and 150-psig (1035-kPa) minimum working-pressure rating and suitable for vacuum service.
 9. PVC Check Valves: Ball-, in-line-, piston-, or swing-check design with flanged or union ends and 70-psig (480-kPa) **OR** 100-psig (690-kPa), **as directed**, minimum working-pressure rating and suitable for vacuum service.
 10. Safety Valves: Bronze-body, ASME-construction, pressure-relief type with settings to match system requirements.
 11. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket where wall mounting is indicated.
- D. Medical Vacuum Service Connections
1. Connection Devices: For specific medical vacuum service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.
 - a. Roughing-in Assembly:
 - 1) Steel outlet box for recessed mounting and concealed piping.
 - 2) Brass-body inlet block.
 - 3) Seals that will prevent vacuum leakage.
 - 4) ASTM B 819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.
 - b. Finishing Assembly:
 - 1) Brass housing with primary check valve.
 - 2) Seals that will prevent vacuum leakage.
 - 3) Cover plate with gas-service label.



- c. Quick-Coupler Service Connections: Suction inlets for medical vacuum **OR** medical vacuum and WAGD evacuation **OR** WAGD evacuation, **as directed**, service outlets with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.
 - d. D.I.S.S. Service Connections: Suction inlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
 - 1) Medical Vacuum Service Connections: CGA V-5, D.I.S.S. No. 1220.
 - 2) WAGD Evacuation Service Connections: CGA V-5, D.I.S.S. No. 2220.
 - e. Vacuum Bottle Brackets: One piece, with pattern and finish matching corresponding service cover plate.
 - f. Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish **OR** metal, with chrome-plated finish **OR** anodized aluminum, **as directed**, and permanent, color-coded, identifying label matching corresponding service.
- E. Medical Vacuum Piping Alarm Systems
- 1. Panels for medical vacuum piping systems may be combined in single panels with medical compressed-air and medical gas piping systems.
 - 2. Components: Designed for continuous service and to operate on power supplied from 120-V **OR** 240-V **OR** 277-V, **as directed**, ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.
 - 3. Vacuum Switches or Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.
 - a. Vacuum Operating Range: 0- to 30-in. Hg (0- to 101-kPa vacuum).
 - 4. General Requirements for Medical Vacuum Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.
 - a. Mounting: Exposed, surface **OR** Recessed, **as directed**, installation.
 - b. Enclosures: Fabricated from minimum 0.047-inch- (1.2-mm-) thick steel or minimum 0.05-inch- (1.27-mm-) thick aluminum, with knockouts for electrical and piping connections.
 - 5. Master Alarm Panels: With separate trouble alarm signals, vacuum gages, and indicators for medical vacuum piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Medical Vacuum: Vacuum drops below 12-in. Hg (40 kPa vacuum) and backup vacuum pump is in operation.
 - 2) WAGD Evacuation: Vacuum drops below 12-in. Hg (40 kPa vacuum).
 - 3) Dental Vacuum: Vacuum drops below 6-in. Hg (20 kPa vacuum) and backup vacuum producer is in operation.
 - 4) HVE: 4-in. Hg (13 kPa vacuum) and backup vacuum producer is in operation.
 - 5) Medical Laboratory Vacuum: Vacuum drops below 10-in. Hg (34 kPa vacuum).
 - 6. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Medical Vacuum: Vacuum drops below 12-in. Hg (40 kPa vacuum).
 - 2) WAGD Evacuation: Vacuum drops below 12-in. Hg (40 kPa vacuum).
 - 7. Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
 - a. Include alarm signals when the following condition exists:
 - 1) Medical Vacuum: Vacuum drops below 12-in. Hg (40 kPa vacuum).
 - 8. Dental Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Dental Vacuum: Vacuum drops below 6-in. Hg (20 kPa vacuum) and backup vacuum producer is in operation.
 - 2) HVE: 4-in. Hg (13 kPa vacuum) and backup vacuum producer is in operation.



9. Medical Laboratory Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
 - a. Include alarm signals when the following condition exists:
 - 1) Medical Vacuum: Vacuum drops below 12-in. Hg (40 kPa vacuum).
- F. Computer Interface Cabinet
 1. Description: Wall-mounting, welded-steel, control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical vacuum piping system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing 20 alarm signals.
- G. Flexible Pipe Connectors
 1. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - a. Working-Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
 - b. End Connections: Threaded copper pipe or plain-end copper tube.
- H. Sleeves
 1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
 2. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.
- I. Escutcheons
 1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
 3. One-Piece, Cast-Brass Escutcheons: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 7. One-Piece, Floor-Plate Escutcheons: Cast iron.
 8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.
- J. Grout
 1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.
- K. Nitrogen
 1. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.



1.3 EXECUTION

A. Preparation

1. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
 - a. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
 - b. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.
 - 1) Scrub to ensure complete cleaning.
 - 2) Rinse with clean, hot water to remove cleaning solution.

B. Piping Applications

1. Connect new copper tubing to existing tubing with memory-metal couplings.
2. Nonhealthcare Laboratory Low Vacuum Piping: Use one of the following piping materials for each size range:
 - a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
 - b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
 - c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
3. Nonhealthcare Laboratory High Vacuum Piping: Use one of the following piping materials for each size range:
 - a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
 - b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
 - c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
4. Medical Vacuum Piping: Use one of the following piping materials for each size range:
 - a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
 - b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
 - c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
5. WAGD Evacuation Piping: Use one of the following piping materials for each size range:
 - a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
 - b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
 - c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
6. Dental Vacuum Piping: Use one of the following piping materials for each size range:
 - a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
 - b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
 - c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
7. HVE Piping: Use one of the following piping materials for each size range:



- a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
 - b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
 - c. NPS 4 (DN 100) and Smaller: Schedule 40 PVC pipe, Schedule 40 PVC fittings **OR** Schedule 80 PVC pipe, Schedule 80 PVC fittings, **as directed**, and solvent-cemented joints.
 - d. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
 - e. NPS 5 to NPS 8 (DN 125 to DN 200): Schedule 40 PVC pipe, Schedule 40 PVC fittings **OR** Schedule 80 PVC pipe, Schedule 80 PVC fittings, **as directed**, and solvent-cemented joints.
8. Medical Laboratory Vacuum Piping: Use one of the following piping materials for each size range:
- a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
 - b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
 - c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
9. Drain Piping: Use one of the following piping materials:
- a. Copper water tube, cast- or wrought-copper fittings, and soldered **OR** press-type fittings, and pressure-sealed, **as directed**, joints.
 - b. PVC pipe, PVC fittings, and solvent-cemented joints.

C. Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Comply with ASSE Standard #6010 for installation of vacuum piping.
3. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
6. Install piping adjacent to equipment and specialties to allow service and maintenance.
7. Install vacuum and drain piping with 1 percent slope downward in direction of flow.
8. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications below unless otherwise indicated.
9. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
10. Provide drain leg and drain trap at end of each main and branch and at low points.
11. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver and separator, **as directed**. Comply with requirements in Division 22 Section "Meters And Gages For Plumbing Piping".
12. Install piping to permit valve servicing.
13. Install piping free of sags and bends.
14. Install fittings for changes in direction and for branch connections. Extruded-tee branch outlets in copper tubing may be made where specified.
15. Install medical vacuum piping to medical vacuum service connections specified in this Section and to equipment specified in other Sections requiring medical vacuum service.



16. Install seismic restraints on vacuum piping. Seismic-restraint devices are specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
17. Install medical vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
18. Install medical vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.
19. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.
20. Install unions, in copper vacuum tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.
21. Install unions, in PVC vacuum piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.
22. Install flanges, in PVC vacuum piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment, machine, and specialty.

D. Valve Applications

1. Valves for Copper Vacuum Tubing: Use copper alloy ball and bronze check types.
2. Valves for PVC Vacuum Piping:
 - a. NPS 4 (DN 100) and Smaller: Use copper alloy ball and bronze **OR** PVC ball, butterfly, and, **as directed**, check types.
 - b. NPS 5 (DN 125) and Larger: Use PVC butterfly and check types.

E. Valve Installation

1. Install shutoff valve at each connection to and from vacuum equipment and specialties.
2. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.
3. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
4. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
5. Install safety valves on vacuum receivers, where required by NFPA 99, and where recommended by specialty manufacturers.
6. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain, so contents spill over or into it.
7. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

F. Joint Construction

1. Ream ends of pipes and tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Threaded Joints: Apply appropriate tape to external pipe threads.
5. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.
6. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.
7. Extruded-Tee Outlets: Form branches in copper tube according to ASTM F 2014, with tools recommended by procedure manufacture.
8. Flanged Joints:
 - a. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
 - b. PVC Piping: Install PVC flange on PVC pipes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
9. Pressure-Sealed Joints: Join copper tube and copper and copper-alloy fittings with tools recommended by fitting manufacturer.
10. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.
11. Solvent-Cemented Joints: Clean and dry joining surfaces. Join PVC pipe and fittings according to the following:



- a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
- b. Apply primer and join according to ASME B31.9 for solvent-cemented joints and to ASTM D 2672.

G. Medical Vacuum Piping Alarm System Installation

1. Panels for medical vacuum piping systems may be combined in single panels with medical compressed-air piping systems and medical gas piping systems.
2. Install medical vacuum piping system alarm system components in locations required by and according to NFPA 99.
3. Install medical vacuum piping system area and master alarm panels where indicated.
4. Install computer interface cabinet with connection to medical vacuum piping alarm system and to facility computer.

H. Sleeve Installation

1. Sleeves are not required for core-drilled holes.
2. Permanent sleeves are not required for holes formed by removable PE sleeves.
3. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe **OR** galvanized-steel sheet **OR** stack sleeve fittings **OR** PVC pipe, **as directed**.
 - a. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
 - b. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

OR

Install sleeves in new walls and slabs as new walls and slabs are constructed.

4. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
 - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
 - 1) Seal space outside of sleeve fittings with grout.
5. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".

I. Escutcheon Installation

1. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - 2) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
 - 3) Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One-piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.



- 4) Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
- 5) Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
- 6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
- b. Existing Piping:
 - 1) Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
 - 2) Insulated Piping: Split plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - 3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
 - 4) Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
 - 5) Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
 - 6) Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
 - 7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

J. Hanger And Support Installation

1. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices.
2. Vertical Piping: MSS Type 8 or 42, clamps.
3. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.
4. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for trapeze hangers.
5. Base of Vertical Piping: MSS Type 52, spring hangers.
6. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
7. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
8. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - e. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - f. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - g. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
 - h. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
 - i. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
 - j. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
 - k. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
 - l. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.



- m. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
 - n. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.
 - 9. Install supports for vertical copper tubing every 10 feet (3 m).
 - 10. Install hangers **OR** vinyl-coated hangers, **as directed**, for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1 (DN 25) and Smaller: 30 inches (760 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): 36 inches (900 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1150 mm) with 1/2-inch (13-mm) rod.
 - d. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 1/2-inch (13-mm) rod.
 - e. NPS 6 and NPS 8 (DN 150 and DN 200): 54 inches (1350 mm) with 5/8-inch (16-mm) rod.
 - 11. Install supports for vertical PVC piping every 48 inches (1220 mm).
- K. Labeling And Identification
- 1. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification For Plumbing Piping And Equipment".
 - 2. Install identifying labels and devices for medical vacuum piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
 - a. Medical Vacuum: Black letters on white background.
 - b. WAGD: White letters on violet background.
 - c. Dental Vacuum: Black boxed letters on white-and-black diagonal stripe background.
 - d. HVE: Black boxed letters on white-and-black diagonal stripe background.
 - e. Medical Laboratory Vacuum: Black boxed letters on white-and-black checkerboard background.
- L. Field Quality Control For Laboratory Facility Nonmedical Vacuum Piping
- 1. Perform tests and inspections of vacuum piping in nonmedical laboratory facilities.
 - 2. Tests and Inspections:
 - a. Piping Leak Tests for Vacuum Piping: Test new and modified parts of existing piping. Cap and fill vacuum piping with oil-free, dry nitrogen. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - 1) Test Pressure for Copper Tubing: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
 - 2) Test Pressure for PVC Piping: 50 psig (345 kPa) **OR** 100 psig (690 kPa), **as directed**.
 - b. Repair leaks and retest until no leaks exist.
 - c. Inspect filters for proper operation.
 - 3. Prepare test reports.
- M. Field Quality Control For Healthcare Facility Medical Vacuum Piping
- 1. Perform tests and inspections of medical vacuum piping systems in healthcare facilities and prepare test reports.
 - 2. Tests and Inspections:
 - a. Medical Vacuum Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum piping systems concurrently with tests, inspections, and certification of medical compressed-air piping and medical gas piping systems.
 - b. Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
 - 1) Initial blow down.
 - 2) Initial pressure test.
 - 3) Cross-connection test.
 - 4) Piping purge test.



- 5) Standing pressure test for vacuum systems.
 - 6) Repair leaks and retest until no leaks exist.
 - c. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical vacuum piping systems and perform the following tests and inspections:
 - 1) Standing pressure test.
 - 2) Individual-pressurization **OR** Pressure-differential, **as directed**, cross-connection test.
 - 3) Valve test.
 - 4) Master and area alarm tests.
 - 5) Piping purge test.
 - 6) Final tie-in test.
 - 7) Operational vacuum test.
 - 8) Verify correct labeling of equipment and components.
 - d. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - 1) Inspections performed.
 - 2) Procedures, materials, and gases used.
 - 3) Test methods used.
 - 4) Results of tests.
 3. Remove and replace components that do not pass tests and inspections and retest as specified above.
- N. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain medical vacuum alarm systems.

END OF SECTION 22 11 16 00h



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**SECTION 22 11 16 00i - GAS PIPING FOR LABORATORY AND HEALTHCARE FACILITIES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for gas piping for laboratory and healthcare facilities. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Carbon dioxide piping and specialties designated "medical carbon dioxide" operating at 50 to 55 psig (345 to 380 kPa).
 - b. Helium piping, designated "medical helium" operating at 50 to 55 psig (345 to 380 kPa).
 - c. Nitrogen piping and specialties designated "medical nitrogen" operating at 160 to 185 psig (1100 to 1275 kPa) **OR** higher than 200 psig (1380 kPa), **as directed**.
 - d. Nitrous oxide piping and specialties designated "medical nitrous oxide" operating at 50 to 55 psig (345 to 380 kPa).
 - e. Oxygen piping and specialties designated "medical oxygen" operating at 50 to 55 psig (345 to 380 kPa).

C. Definitions

1. CR: Chlorosulfonated polyethylene synthetic rubber.
2. D.I.S.S.: Diameter-index safety system.
3. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
4. Medical gas piping systems include medical carbon dioxide, medical helium, medical nitrogen, medical nitrous oxide, and medical oxygen nonflammable gas for healthcare facility patient care or for healthcare laboratory applications.
5. Specialty Gas: Gas, other than medical gas, for nonmedical laboratory facility applications.

D. Performance Requirements

1. Seismic Performance: Gas manifolds, Bulk gas storage tanks, Gas manifolds and bulk gas storage tanks, and piping shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

E. Submittals

1. Product Data: For the following:
 - a. Tubes and fittings.
 - b. Valves and valve boxes.
 - c. Medical gas service connections.
 - d. Electrical service connections.
 - e. Patient service consoles.
 - f. Medical nitrogen pressure control panels.
 - g. Ceiling columns. Include integral service connections.
 - h. Ceiling hose assemblies. Include integral service connections.
 - i. Gas manifolds.
 - j. Bulk gas storage tanks. Include rated capacities and operating weights.
 - k. Medical gas alarm system components.
 - l. Gas cylinder storage racks.
2. Shop Drawings: Diagram power, signal, and control wiring.



3. Piping Material Certification: Signed by Installer certifying that medical gas piping materials comply with NFPA 99 requirements.
4. Brazing certificates.
5. Manufacturer Seismic Qualification Certification: Submit certification that gas manifolds and bulk gas storage tanks, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment". Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
6. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.
7. Field quality-control test reports.
8. Operation and maintenance data.

F. Quality Assurance

1. Installer Qualifications:
 - a. Medical Gas Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010 for installers.
2. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the medical gas piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - a. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.
3. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. ASME Compliance: Fabricate and label bulk medical gas storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
6. NFPA Compliance:
 - a. Comply with NFPA 50, "Bulk Oxygen Systems at Consumer Sites," for bulk oxygen storage tanks.
 - b. Comply with NFPA 99, "Health Care Facilities," for medical gas piping system materials and installation.
7. CGA Compliance: Comply with CGA G-8.1, "Nitrous Oxide Systems at Consumer Sites," for bulk nitrous oxide storage tanks.
8. UL Compliance:
 - a. Comply with UL 498, "Attachment Plugs and Receptacles," for electrical service connections.
 - b. Comply with UL 544, "Medical and Dental Equipment," for medical gas specialties.

G. Project Conditions

1. Interruption of Existing Specialty and Medical Gas Service(s): Do not interrupt specialty or medical gas service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of specialty and medical gas service(s).
 - b. Do not proceed with interruption of specialty and medical gas service(s) without the Owner's written permission.



1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. Copper Medical Gas Tube: ASTM B 819, Type K **OR** Type L, **as directed**, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.
 - a. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
 - b. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
 - c. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
 - d. Press-Type Fittings:
 - 1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
 - e. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory-alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.
2. PVC Pipe: ASTM D 1785, Schedule 40 and Schedule 80.
 - a. PVC Fittings: ASTM D 2466, Schedule 40 **OR** ASTM D 2467, Schedule 80, **as directed**; socket type.

B. Joining Materials

1. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.
2. Threaded-Joint Tape: PTFE.
3. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.

C. Valves

1. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
2. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Ball: Full-port, chrome-plated brass.
 - c. Seats: PTFE or TFE.
 - d. Handle: Lever type with locking device, **as directed**.
 - e. Stem: Blowout proof with PTFE or TFE seal.
 - f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
3. Check Valves: In-line pattern, bronze.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Operation: Spring loaded.
 - c. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
4. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
 - a. Pressure Rating: 300 psig (2070 kPa) minimum.
 - b. Ball: Full-port, chrome-plated brass.
 - c. Seats: PTFE or TFE.
 - d. Handle: Lever type with locking device, **as directed**.
 - e. Stem: Blowout proof with PTFE or TFE seal.
 - f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
 - g. Pressure Gage: Manufacturer-installed on one copper-tube extension.
5. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.
 - a. Interior Finish: Factory-applied white enamel.



- b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Satin-chrome finish steel **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
- c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

OR

Zone Valve Boxes: Formed or extruded aluminum with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.

- a. Interior Finish: Factory-applied white enamel.
 - b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
 - c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.
6. Emergency Oxygen Connections: Low-pressure oxygen inlet assembly for connection to building oxygen piping systems.
 - a. Enclosure: Weatherproof hinged locking cover with caption similar to "Emergency Low-Pressure Gaseous Oxygen Inlet."
 - b. Inlet: Manufacturer-installed, NPS 1 or NPS 1-1/4 (DN 25 or DN 32), ASTM B 819, copper tubing with NPS 1 (DN 25) minimum ball valve and plugged inlet.
 - c. Safety Valve: Bronze-body, pressure relief valve set at 75 or 80 psig (520 or 550 kPa).
 - d. Instrumentation: Pressure gage.
 7. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.
 8. Pressure Regulators: Bronze **OR** Stainless-steel, **as directed**, body and trim; spring-loaded, diaphragm-operated, relieving type; manual pressure-setting adjustment; rated for 250-psig (1725-kPa) minimum inlet pressure; and capable of controlling delivered gas pressure within 0.5 psig for each 10-psig (5.0 kPa for each 100-kPa) inlet pressure.

D. Medical Gas Service Connections

1. General Requirements for Medical Gas Service Connections: For specific medical gas pressure and suction service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.
 - a. Roughing-in Assembly:
 - 1) Steel outlet box for recessed mounting and concealed piping.
 - 2) Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed. Suction inlets to be without secondary valve.
 - 3) Double seals that will prevent gas leakage.
 - 4) ASTM B 819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.
 - b. Finishing Assembly:
 - 1) Brass housing with primary check valve.
 - 2) Double seals that will prevent gas leakage.
 - 3) Cover plate with gas-service label.
 - c. Quick-Coupler Service Connections: Pressure outlets for carbon dioxide, nitrous oxide, oxygen, and **<Insert medical gas>** service connections with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.
 - d. D.I.S.S. Service Connections: Pressure outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
 - 1) Medical Carbon Dioxide Service Connections: D.I.S.S. No. 1080.



- 2) Medical Helium Service Connections: D.I.S.S. No. 1060.
 - 3) Medical Nitrogen Service Connections: D.I.S.S. No. 1120.
 - 4) Medical Nitrous Oxide Service Connections: D.I.S.S. No. 1040.
 - 5) Medical Oxygen Service Connections: D.I.S.S. No. 1240.
 - e. Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish **OR** metal, with chrome-plated finish **OR** anodized aluminum, **as directed**, and permanent, color-coded, identifying label matching corresponding service.
- E. Electrical Service Connections
1. Power Outlets: UL 498, Hospital Grade, 125-V receptacles; color selected. Include the following configurations complying with NEMA WD 1:
 - a. L5-20R, locking type, 20 A, single or duplex.
 - b. L5-20R, isolated ground, locking type, 20 A, single or duplex.
 - c. Explosion proof, 20 A, 2 pole, 3 wire, single; suitable for Class I, Group C hazardous location and interchangeable with receptacles used in nonhazardous areas; flush mounted.
 - d. 5-20R, straight blade, 20 A, duplex.
 - e. 5-20R, isolated ground, straight blade, 20 A, duplex.
 2. Electrical Accessory Outlets: Provide the following configured receptacles in color selected:
 - a. Patient Equipment Ground Jack: Single pole, 30 A.
 - b. Patient Monitoring: Single, 5 and 37 pin.
 3. Wall Outlet Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish **OR** metal, with chrome-plated finish **OR** anodized aluminum, **as directed**, and permanent identifying label.
- F. Patient Service Consoles
1. General Requirements for Patient Service Consoles: Recessed- or semirecessed-mounting wall units with medical gas service connections as specified in "Medical Gas Service Connections" Article and electrical service connections as specified in "Electrical Service Connections" Article, **as directed**. Include labels indicating services, and the following:
 - a. Recessed- or semirecessed-mounting steel console box or mounting bracket.
 - b. Concealed supplies.
 - c. Cover Plate: One piece, anodized aluminum **OR** stainless steel, **as directed**, and permanent identifying label with service connections for the following:
 - 1) Medical Air: Quick-coupler pressure outlet.
 - 2) Medical Oxygen: Quick-coupler pressure outlet.
 - 3) Medical Vacuum: Quick-coupler suction inlet.
 - 4) Medical vacuum bottle bracket.
 - 5) L5-20R, locking type, 20 A, single **OR** duplex, **as directed**.
- G. Medical Nitrogen Pressure Control Panels
1. Description: Steel box and support brackets for recessed roughing-in with stainless-steel or anodized-aluminum cover plate with printed operating instructions. Include manifold assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.
 - a. Minimum Working Pressure: 200 psig (1380 kPa).
 - b. Line-Pressure Control Regulator: Self-relieving diaphragm type with precision manual adjustment.
 - c. Pressure Gages: 0- to 300-psig (0- to 2070-kPa) range.
 - d. Service Connection: CGA V-5, D.I.S.S. No. 1120, nitrogen outlet.
 - e. Before final assembly, provide temporary dust shield and U-tube for testing.
 - f. Label cover plate "Nitrogen Pressure Control."
- H. Ceiling Columns
1. General Requirements for Ceiling Columns: Ceiling-mounting units with medical gas service connections as specified in "Medical Gas Service Connections" Article and electrical service



connections as specified in "Electrical Service Connections" Article, **as directed**. Include labels indicating services, and the following:

- a. Ceiling-Mounting Plate: Manufacturer's standard plate or roughing-in assembly.
 - b. Exposed Surfaces: Minimum 0.0375-inch- (0.95-mm-) thick stainless steel with NAAMM AMP 503, No. 4 directional polish.
 - c. Servicing: Include access panels or means of removing shroud.
 - d. Blank cover plates for cutouts not having service connections.
 - e. ASTM B 819, NPS 3/8 (DN 10) copper-tube extensions for connection to medical gas systems.
 - f. Service Connections: Type and number indicated.
 - g. Dust Covers: For medical gas service connection.
2. Rigid Ceiling Columns: 44-inch- (1120-mm-) long, rectangular fixed column section with 2 **OR** 4, **as directed**, double intravenous medication hooks. Include 0.078-inch- (2.0-mm-) thick, stainless-steel bottom plate with the following service connections:
- a. Instrument Air: One D.I.S.S. No. 1160 pressure outlet(s).
 - b. Medical Air: One quick-coupler **OR** D.I.S.S. No. 1160, **as directed**, pressure outlet(s).
 - c. Medical Carbon Dioxide: One quick-coupler **OR** D.I.S.S. No. 1080, **as directed**, pressure outlet(s).
 - d. Medical Helium: One D.I.S.S. No. 1060, pressure outlet(s).
 - e. Medical Nitrogen: One D.I.S.S. No. 1120 pressure outlet(s).
 - f. Medical Nitrous Oxide: One quick-coupler **OR** D.I.S.S. No. 1040, **as directed**, pressure outlet(s).
 - g. Medical Oxygen: Two quick-coupler **OR** D.I.S.S. No. 1240, **as directed**, pressure outlets.
 - h. Medical Vacuum: Two quick-coupler **OR** D.I.S.S. No. 1220, **as directed**, suction inlets.
 - i. Vacuum Bottle Brackets: Two.
 - j. WAGD Evacuation: One quick-coupler **OR** D.I.S.S. No. 2220, **as directed**, suction inlet(s).
 - k. Power: 2 **OR** 4, **as directed**, L5-20R, locking-type, 20-A, single receptacles.
 - l. Patient Equipment: 2 **OR** 4, **as directed**, ground-jack, single-pole, 30-A receptacles.
3. Retractable Ceiling Columns: Manually adjustable using release and lock handles capable of locking column in all positions from fully retracted to fully extended; 15-inch- (380-mm-) long, rectangular counterbalanced telescoping section with 2 **OR** 4, **as directed**, double intravenous medication hooks; and 36-inch- (915-mm-) long, fixed column section. Include 0.078-inch- (2.0-mm-) thick, stainless-steel bottom plate with the following service connections:
- a. Instrument Air: One D.I.S.S. No. 1160 pressure outlet(s).
 - b. Medical Air: One quick-coupler **OR** D.I.S.S. No. 1160, **as directed**, pressure outlet(s).
 - c. Medical Carbon Dioxide: One quick-coupler **OR** D.I.S.S. No. 1080, **as directed**, pressure outlet(s).
 - d. Medical Helium: One D.I.S.S. No. 1060, pressure outlet(s).
 - e. Medical Nitrogen: One D.I.S.S. No. 1120 pressure outlet(s).
 - f. Medical Nitrous Oxide: One quick-coupler **OR** D.I.S.S. No. 1040, **as directed**, pressure outlet(s).
 - g. Medical Oxygen: Two quick-coupler **OR** D.I.S.S. No. 1240, **as directed**, pressure outlets.
 - h. Medical Vacuum: Two quick-coupler **OR** D.I.S.S. No. 1220, **as directed**, suction inlets.
 - i. Vacuum Bottle Brackets: Two.
 - j. WAGD Evacuation: One quick-coupler **OR** D.I.S.S. No. 2220, **as directed**, suction inlet(s).
 - k. Power: 2 **OR** 4, **as directed**, L5-20R, locking-type, 20-A, single receptacles.
 - l. Patient Equipment: 2 **OR** 4, **as directed**, ground-jack, single-pole, 30-A receptacles.
- I. Ceiling Hose Assemblies
1. Ceiling Hose Assemblies, General: Ceiling-mounting units with medical gas service connections as specified in "Medical Gas Service Connections" Article and electrical service connections as specified in "Electrical Service Connections" Article, **as directed**. Include labels indicating services, and the following:
 - a. Ceiling-Mounting Plate: Manufacturer's standard plate or roughing-in assembly.



- b. Exposed Surfaces: Minimum 0.0375-inch- (0.95-mm-) thick stainless steel with NAAMM AMP 503, No. 4 directional polish.
 - c. Servicing: Include access panels or means of removing shroud.
 - d. Blank cover plates for cutouts not having service connections.
 - e. ASTM B 819, NPS 3/8 (DN 10) copper-tube extensions for connection to medical gas systems.
 - f. Service Connections: Type and number indicated.
 - g. Dust Covers: For medical gas service connection.
2. Hose-Reel Service Assemblies: Individual, concealed, retractable hose-reel units with stainless-steel face plates, steel mounting boxes, factory- or field-fabricated mounting brackets, and color-coded service hoses with adjustable stops and service connections matching hoses. Include 15 feet (4.5 m) minimum of conductive, CR, 1/4- or 5/16-inch- (6.4- or 7.9-mm-) ID, medical gas hoses rated for 200-psig (1380-kPa) minimum working pressure, and the following service connections:
- a. Instrument Air Hose: D.I.S.S. No. 1160 pressure outlet.
 - b. Medical Air Hose: Quick-coupler **OR** D.I.S.S. No. 1160, **as directed**, pressure outlet.
 - c. Medical Carbon Dioxide Hose: Quick-coupler **OR** D.I.S.S. No. 1080, **as directed**, pressure outlet.
 - d. Medical Nitrogen Hose: D.I.S.S. No. 1120 pressure outlet.
 - e. Medical Nitrous Oxide Hose: Quick-coupler **OR** D.I.S.S. No. 1040, **as directed**, pressure outlet.
 - f. Medical Oxygen Hose: Quick-coupler **OR** D.I.S.S. No. 1240, **as directed**, pressure outlet.
 - g. Medical Vacuum Hose: Quick-coupler **OR** D.I.S.S. No. 1220, **as directed**, suction inlet.
 - h. WAGD Evacuation Hose: Quick-coupler **OR** D.I.S.S. No. 2220, **as directed**, suction inlet.
 - i. Power: L5-20R, locking-type, 20-A, single, power receptacle.
3. Fixed Hose Service Assemblies: Individual, concealed hose connection with stainless-steel face plates, steel mounting boxes, factory- or field-fabricated mounting brackets, and color-coded service hoses with retractor device and service connections matching hoses. Include 72 inches (1830 mm) of conductive, CR, 1/4- or 5/16-inch- (6.4- or 7.9-mm-), ID, medical gas hoses rated for 200-psig (1380-kPa) minimum working pressure, and the following service hose connections:
- a. Instrument Air Hose: D.I.S.S. No. 1160 pressure outlet.
 - b. Medical Air Hose: Quick-coupler **OR** D.I.S.S. No. 1160, **as directed**, pressure outlet.
 - c. Medical Carbon Dioxide Hose: Quick-coupler **OR** D.I.S.S. No. 1080, **as directed**, pressure outlet.
 - d. Medical Nitrogen Hose: D.I.S.S. No. 1120 pressure outlet.
 - e. Medical Nitrous Oxide Hose: Quick-coupler **OR** D.I.S.S. No. 1040, **as directed**, pressure outlet.
 - f. Medical Oxygen Hose: Quick-coupler **OR** D.I.S.S. No. 1240, **as directed**, pressure outlet.
 - g. Medical Vacuum Hose: Quick-coupler **OR** D.I.S.S. No. 1220, **as directed**, suction inlet.
 - h. WAGD Evacuation Hose: Quick-coupler **OR** D.I.S.S. No. 2220, **as directed**, suction inlet.
 - i. Power: L5-20R, locking-type, 20-A, single, power receptacle.
- J. Gas Manifolds
1. Simplex Specialty Gas Manifolds:
 - a. Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, line-pressure regulator, shutoff valves, and safety valve.
 - b. Manifold and Header: Nonferrous-metal header for number of cylinders indicated. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure. Include cylinder bank header with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
 - c. **<Insert specialty gas>** Manifold: For **<Insert number cylinders>** capacity at 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.
 - d. Specialty Gas Cylinders: Will be furnished by the Owner **OR** Number and type of medical gas cylinders required for complete manifold systems, **as directed**.



- e. Label manifold control unit with permanent label identifying specialty gas type and system operating pressure.
 - f. Mounting: Wall with mounting brackets for manifold control cabinet and header **OR** Floor with support legs for manifold control cabinet, **as directed**.
2. Duplex Specialty Gas Manifolds:
- a. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, line-pressure regulator, shutoff valves, and safety valve.
 - b. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure. Include cylinder bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
 - c. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.
 - d. **<Insert specialty gas>** Manifold: For **<Insert number cylinders>** capacity at 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.
 - e. Specialty Gas Cylinders: Will be furnished by the Owner **OR** Number and type of medical gas cylinders required for complete manifold systems, **as directed**.
 - f. Label manifold control unit with permanent label identifying specialty gas type and system operating pressure.
 - g. Mounting: Wall with mounting brackets for manifold control cabinet and headers **OR** Floor with support legs for manifold control cabinet, **as directed**.
3. Medical Gas Manifolds: Comply with NFPA 99, Ch. 5, for high-pressure medical gas cylinders.
- a. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.
 - b. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure, except nitrous oxide manifolds may be designed for 800 psig (5520 kPa) and carbon dioxide manifolds may be designed for 1500 psig (10.35 MPa). Include cylinder bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
 - c. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.
 - d. Medical Carbon Dioxide Manifolds: For 2 cylinders and 250-cfh (1.97-L/s) **OR** 4 cylinders and 500-cfh (3.94-L/s), **as directed**, capacity at 55-psig (380-kPa) line pressure.
 - e. Medical Helium Manifolds: For 2 cylinders and 250-cfh (1.97-L/s) **OR** 4 cylinders and 500-cfh (3.94-L/s), **as directed**, capacity at 55-psig (380-kPa) line pressure.
 - f. Medical Nitrous Oxide Manifolds: For 8 cylinders and 1333-cfh (10.5-L/s) **OR** 12 cylinders and 2000-cfh (15.7-L/s), **as directed**, capacity at 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.
 - g. Medical Nitrogen Manifolds: For 8 cylinders and 2000-cfh (15.7-L/s) **OR** 12 cylinders and 3000-cfh (23.6-L/s), **as directed**, capacity at 180-psig (1240-kPa) **OR** higher than 200-psig (1380-kPa), **as directed**, line pressure.
 - h. Medical Oxygen Manifolds: For 12 cylinders and 1500-cfh (11.8-L/s) **OR** 20 cylinders 2500-cfh (19.7-L/s), **as directed**, capacity at 55-psig (380-kPa), **as directed**, line pressure.
 - i. Medical Gas Cylinders: Will be furnished by the Owner **OR** Number and type of medical gas cylinders required for complete manifold systems, **as directed**.
 - j. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.



- k. Mounting: Wall with mounting brackets for manifold control cabinet and headers **OR** Floor with support legs for manifold control cabinet, **as directed**.

K. Bulk Gas Storage Tanks

1. Bulk Specialty Gas Storage Tanks:
2. Bulk Medical Gas Storage Tanks:
 - a. Bulk Medical Gas Storage Tank Systems: Bulk storage tank with connections for alarm system, continuous supply, and reserve supply that will operate only during emergencies, complying with NFPA 99, "Health Care Facilities."
 - b. Controls: Include actuating switch for alarm system connection and means for automatic actuating of reserve supply.
 - c. Bulk Medical Gas Storage Tanks: Vertical mounting, double-wall construction with inner vessel fabricated according to ASME Boiler and Pressure Vessel Code for unfired pressure vessels and suitable for medical gas service. Include insulation and vacuum seal between walls. Fabricate outer shell from carbon steel with factory-applied manufacturer's standard protective paint finish suitable for exterior installation. Include the following features, specialties, and components:
 - 1) Safety Valves: ASME construction with pressure setting to correspond to tank working pressure and as required for component or system being protected.
 - 2) Pressure Gages: For tank pressure and facility service line pressure.
 - 3) Contents Gage: High- and low-level indicator with electric signal circuit connection.
 - 4) Drain Valves: For piping, inner vessel, and outer shell.
 - 5) Fill Assembly: Fill connection, piping, valves, relief devices, and controls.
 - 6) Facility Service Assembly: Piping, valves, relief devices, vaporizer, shutoff valve, pressure regulator, line shutoff valve or check valve, and reserve supply connection for connection to building service piping.
 - 7) Include permanent label showing medical gas type, storage tank capacity, tank pressure rating, vaporizer capacity, and operating instructions.
 - 8) Liquid Oxygen Storage Tank: Nickel-steel or stainless-steel inner vessel with 250-psig (1725-kPa) minimum working pressure. Include electric **OR** steam **OR** ambient vaporizer, **as directed**.
 - 9) Liquid Nitrous Oxide Storage Tank: Steel-alloy inner vessel with 300-psig (2070-kPa) minimum working pressure. Include electric **OR** steam, **as directed**, vaporizer.
 - d. Oxygen Reserve Supply: Manifold header for high-pressure cylinders, fabricated from copper-tube or brass pipe and fittings and suitable for pressures up to 4000 psig (27.6 MPa). Include header inlet connections complying with CGA V-1, with individual inlet check valves, header shutoff valve, header pressure regulator, line shutoff valve or check valve, pressure gage, and inlet connections for number of cylinders indicated.
 - e. Nitrous Oxide Reserve Supply: Manifold header for high-pressure cylinders, fabricated from copper-tube or brass pipe and fittings and suitable for pressures up to 4000 psig (27.6 MPa). Include header inlet connections complying with CGA V-1, with individual inlet check valves, header shutoff valve, header pressure regulator, line shutoff valve or check valve, pressure gage, inlet connections for number of cylinders indicated, and electric heater.

L. Medical Gas Piping Alarm Systems

1. Panels for medical gas piping systems may be combined in single panels with medical compressed-air and medical vacuum piping systems.
2. Components: Designed for continuous service and to operate on power supplied from 120 **OR** 240 **OR** 277, **as directed**, -V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.
3. Pressure Switches or Pressure Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.
 - a. Low-Pressure Operating Range: 0- to 100-psig (0- to 690-kPa).
 - b. High-Pressure Operating Range: Up to 250-psig (1725-kPa).



4. General Requirements for Medical Gas Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.
 - a. Mounting: Exposed, surface **OR** Recessed, **as directed**, installation.
 - b. Enclosures: Fabricated from minimum 0.047-inch- (1.2-mm-) thick steel or minimum 0.05-inch- (1.27-mm-) thick aluminum, with knockouts for electrical and piping connections.
5. Master Alarm Panels: With separate trouble alarm signals, pressure gages, and indicators for medical gas piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Medical Carbon Dioxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
 - 2) Medical Helium: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
 - 3) Medical Nitrogen: Pressure drops below 145 psig (1000 kPa) or rises above 200 psig (1380 kPa) and changeover is made to alternate bank.
 - 4) Medical Nitrous Oxide (for bulk oxygen storage tank system with cylinder reserve): Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, and reserve level is low.
 - 5) Medical Nitrous Oxide (for nitrous oxide manifold system): Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
 - 6) Medical Oxygen (for bulk oxygen storage tank system with cylinder reserve): Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, reserve level is low, and reserve pressure is low.
 - 7) Medical Oxygen (for oxygen manifold system): Pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
6. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals; pressure gages; and indicators for medical gas piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Medical Carbon Dioxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
 - 2) Medical Helium: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
 - 3) Medical Nitrous Oxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
 - 4) Medical Nitrogen: Pressure drops below 145 psig (1000 kPa) or rises above 200 psig (1380 kPa).
 - 5) Medical Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
7. Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for medical gas piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
8. Dental Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for medical gas piping systems.
 - a. Include alarm signals when the following conditions exist:
 - 1) Medical Nitrogen: Pressure drops below 145 psig (1000 kPa) or rises above 200 psig (1380 kPa) and changeover is made to alternate bank.
 - 2) Medical Nitrous Oxide (for bulk nitrous oxide storage tank system with cylinder reserve): Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, and reserve level is low.



- 3) Medical Nitrous Oxide (for nitrous oxide manifold system): Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
 - 4) Medical Oxygen (for bulk oxygen storage tank system with cylinder reserve): Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, reserve level is low, and reserve pressure is low.
 - 5) Medical Oxygen (for nitrous oxide manifold system): Pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
9. Medical Laboratory Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for medical gas piping systems.
- a. Include alarm signals when the following conditions exist:
 - 1) Medical Carbon Dioxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
 - 2) Medical Helium: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
 - 3) Medical Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
- M. Computer Interface Cabinet
1. Description: Wall-mounting, welded-steel, control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical gas system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing 20, **as directed**, alarm signals.
- N. Gas Cylinder Storage Racks
1. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.
 2. Freestanding Storage Racks: Fabricate racks as indicated or provide equivalent manufactured storage racks.
- O. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
 2. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.
- P. Escutcheons
1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
 3. One-Piece, Cast-Brass Escutcheons: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 7. One-Piece, Floor-Plate Escutcheons: Cast iron.
 8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.
- Q. Grout



1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.

R. Nitrogen

1. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

1.3 EXECUTION

A. Earthwork

1. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling and for underground warning tapes.

B. Piping Applications

1. Nonhealthcare, Specialty Gas Piping: Type L, copper medical gas tube; wrought-copper fittings; and brazed **OR** press-type fittings and pressure-sealed, **as directed**, joints.
2. Nonhealthcare, Specialty Gas Piping NPS 2-1/2 (DN 65) and Smaller: Type K **OR** Type L, **as directed**, copper medical gas tube; wrought-copper fittings; and brazed **OR** press-type fittings and pressure-sealed, **as directed**, joints.
3. Nonhealthcare, Specialty Gas Piping NPS 3 (DN 80) and Larger: Type K, copper tube; wrought-copper fittings; and brazed **OR** press-type fittings and pressure-sealed, **as directed**, joints.
4. Medical Gas Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
5. Medical Gas Piping Except Nitrogen: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
6. Medical Nitrogen Piping: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
7. Medical Nitrogen Piping NPS 2-1/2 (DN 65) and Smaller: Type K **OR** Type L, **as directed**, copper medical gas tube; wrought-copper fittings; and brazed joints.
8. Medical Nitrogen Piping NPS 3 (DN 80) and Larger: Type K, copper tube; wrought-copper fittings; and brazed joints.
9. Protective Conduit: Use PVC pipe, PVC fittings, and solvent-cemented joints.

C. Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Comply with ASSE Standard #6010 for installation of medical gas piping.
3. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
6. Install piping adjacent to equipment and specialties to allow service and maintenance.
7. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.
8. Install piping to permit valve servicing.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.



11. Install medical gas piping to medical gas service connections specified in this Section, to medical gas service connections in equipment specified in this Section, and to equipment specified in other Sections requiring medical gas service.
 12. Install exterior, buried medical gas piping in protective conduit fabricated with PVC pipe and fittings. Do not extend conduit through foundation wall.
 13. Install seismic restraints on gas piping. Seismic-restraint devices are specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
 14. Install medical gas service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
 15. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.
 16. Install unions, in copper tubing adjacent to each valve and at final connection to each piece of equipment and specialty.
- D. Valve Installation
1. Install shutoff valve at each connection to gas laboratory and healthcare equipment and specialties.
 2. Install check valves to maintain correct direction of gas flow from laboratory and healthcare gas supplies.
 3. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
 4. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
 5. Install pressure regulators on gas piping where reduced pressure is required.
 6. Install emergency oxygen connection with pressure relief valve and full-size discharge piping to outside, with check valve downstream from pressure relief valve and with ball valve and check valve in supply main from bulk oxygen storage tank.
- E. Joint Construction
1. Ream ends of PVC pipes and remove burrs.
 2. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
 3. Threaded Joints: Apply appropriate tape to external pipe threads.
 4. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free, dry nitrogen during brazing.
 5. Pressure-Sealed Joints: Join copper tube and press-type fittings with tools recommended by fitting manufacturer.
 6. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.
 7. Solvent-Cemented Joints: Clean and dry joining surfaces. Join PVC pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. Apply primer and join according to ASME B31.9 for solvent-cemented joints and to ASTM D 2672.
- F. Gas Service Component Installation
1. Assemble patient service console with service connections. Install with supplies concealed, in walls. Attach console box or mounting bracket to substrate.
 2. Install nitrogen pressure-control panels in walls. Attach to substrate.
 3. Assemble ceiling columns and install anchored to substrate. Provide structural steel, hanger rods, anchors, and fasteners in addition to components furnished with specialties necessary to fabricate supports.
 4. Assemble ceiling assemblies and install anchored to substrate. Provide structural steel, hanger rods, anchors, and fasteners in addition to components furnished with specialties necessary to fabricate supports.
 5. Install gas manifolds on concrete base, **as directed**, anchored to substrate.
 6. Install gas cylinders and connect to manifold piping.



7. Install gas manifolds with seismic restraints as indicated.
8. Install bulk gas storage tanks and reserve supply tanks level on concrete bases. Set tanks and connect gas piping to tanks according to applicable requirements in NFPA 50 for bulk oxygen storage systems, **as directed**. Install tanks level and plumb, firmly anchored to concrete bases; maintain NFPA 50 and tank manufacturer's recommended clearances. Orient tanks so controls and devices are accessible for servicing.
9. Install bulk gas storage tanks and reserve supply tanks with seismic restraints.

G. Medical Gas Piping Alarm System Installation

1. Install medical gas alarm system components in locations required by and according to NFPA 99.
2. Install medical gas area and master alarm panels where indicated.
3. Install computer interface cabinet with connection to medical gas piping alarm system and facility computer.

H. Sleeve Installation

1. Sleeves are not required for core-drilled holes.
2. Permanent sleeves are not required for holes formed by removable PE sleeves.
3. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe **OR** galvanized-steel sheet **OR** stack sleeve fittings **OR** PVC pipe, **as directed**.
 - a. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
 - b. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

OR

Install sleeves in new walls and slabs as new walls and slabs are constructed.

4. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
 - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
 - 1) Seal space outside of sleeve fittings with grout.
5. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".

I. Escutcheon Installation

1. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - 2) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
 - 3) Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.



- 4) Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
 - 5) Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
 - 6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
 - b. Existing Piping:
 - 1) Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
 - 2) Insulated Piping: Split plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - 3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
 - 4) Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
 - 5) Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
 - 6) Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
 - 7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.
- J. Hanger And Support Installation
1. Comply with requirements in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
 2. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices.
 3. Vertical Piping: MSS Type 8 or 42, clamps.
 4. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.
 5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for trapeze hangers.
 6. Base of Vertical Piping: MSS Type 52, spring hangers.
 7. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
 8. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
 9. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - e. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - f. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - g. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
 - h. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
 - i. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
 - j. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.



- k. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
 - l. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.
 - m. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
 - n. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.
10. Install supports for vertical copper tubing every 10 feet (3 m).
- K. Labeling And Identification
- 1. Install identifying labels and devices for specialty gas piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification For Plumbing Piping And Equipment".
 - 2. Install identifying labels and devices for healthcare medical gas piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
 - a. Carbon Dioxide: Black or white letters on gray background.
 - b. Helium: White letters on brown background.
 - c. Nitrogen: White letters on black background.
 - d. Nitrous Oxide: White letters on blue background.
 - e. Oxygen: White letters on green background or green letters on white background.
- L. Field Quality Control For Laboratory Facility Specialty Gas
- 1. Perform field tests and inspections of specialty gas piping for nonhealthcare laboratory facilities and prepare test reports.
 - 2. Tests and Inspections:
 - a. Piping Leak Tests for Specialty Gas Piping: Test new and modified parts of existing piping. Cap and fill specialty gas piping with oil-free, dry nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - b. Repair leaks and retest until no leaks exist.
 - c. Inspect specialty gas regulators for proper operation.
- M. Field Quality Control For Healthcare Facility Medical Gas
- 1. Perform tests and inspections of medical gas piping systems in healthcare facilities and prepare test reports.
 - 2. Tests and Inspections:
 - a. Medical Gas Piping Testing Coordination: Perform tests, inspections, verifications, and certification of medical gas piping systems concurrently with tests, inspections, and certification of medical compressed-air piping and medical vacuum piping systems.
 - b. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
 - 1) Initial blow down.
 - 2) Initial pressure test.
 - 3) Cross-connection test.
 - 4) Piping purge test.
 - 5) Standing pressure test for positive pressure medical gas piping.
 - 6) Standing pressure test for vacuum systems.
 - 7) Repair leaks and retest until no leaks exist.
 - c. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical gas piping systems and perform the following tests and inspections:
 - 1) Standing pressure test.
 - 2) Individual-pressurization **OR** Pressure-differential, **as directed**, cross-connection test.
 - 3) Valve test.
 - 4) Master and area alarm tests.
 - 5) Piping purge test.



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- 6) Piping particulate test.
 - 7) Piping purity test.
 - 8) Final tie-in test.
 - 9) Operational pressure test.
 - 10) Medical gas concentration test.
 - 11) Medical air purity test.
 - 12) Verify correct labeling of equipment and components.
 - 13) Verify the following source equipment:
 - a) Medical gas supply sources.
- d. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
- 1) Inspections performed.
 - 2) Procedures, materials, and gases used.
 - 3) Test methods used.
 - 4) Results of tests.
3. Remove and replace components that do not pass tests and inspections and retest as specified above.

END OF SECTION 22 11 16 00i



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Task	Specification	Specification Description
22 11 16 00	07 63 00 00	Common Work Results for Fire Suppression
22 11 16 00	07 63 00 00a	Common Work Results for Plumbing
22 11 16 00	07 63 00 00b	Common Work Results for HVAC
22 11 19 00	01 22 16 00	No Specification Required
22 11 19 00	22 05 23 00	Piped Utilities Basic Materials And Methods
22 11 19 00	21 05 19 00	Water Distribution
22 11 19 00	07 63 00 00	Common Work Results for Fire Suppression
22 11 19 00	07 63 00 00a	Common Work Results for Plumbing
22 11 19 00	07 63 00 00b	Common Work Results for HVAC
22 11 19 00	22 11 16 00d	Steam And Condensate Piping



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SECTION 22 11 23 13 - WATER DISTRIBUTION PUMPS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for domestic water pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. In-line, sealless centrifugal pumps.
 - b. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - c. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - d. Vertically mounted, in-line, close-coupled centrifugal pumps.

C. Definitions

1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Submittals

1. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Operation and Maintenance Data: For domestic water pumps to include in operation and maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. UL Compliance: Comply with UL 778 for motor-operated water pumps.

F. Delivery, Storage, And Handling

1. Retain shipping flange protective covers and protective coatings during storage.
2. Protect bearings and couplings against damage.
3. Comply with pump manufacturer's written rigging instructions for handling.

G. Coordination

1. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.2 PRODUCTS

A. In-Line, Sealless Centrifugal Pumps

1. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.
2. Pump Construction:
 - a. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
 - b. Casing: Bronze, with threaded or companion-flange connections.
 - c. Impeller: Plastic.
 - d. Motor: Single speed, unless otherwise indicated.



- B. Horizontally Mounted, In-Line, Separately Coupled Centrifugal Pumps
1. Description: Factory-assembled and -tested, in-line, single-stage, separately coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shafts mounted horizontal.
 2. Pump Construction:
 - a. Casing: Radially split with threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.
 - b. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
 - c. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 - d. Coupling: Flexible.
 - e. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket.
 - f. Bearings: Oil-lubricated; bronze-journal or ball type.
 - g. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
 3. Motor: Single speed, with grease-lubricated ball bearings; and resiliently **OR** rigidly, **as directed**, mounted to pump casing.
- C. Horizontally Mounted, In-Line, Close-Coupled Centrifugal Pumps
1. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.
 2. Pump Construction:
 - a. Casing: Radially split with threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.
 - b. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
 - c. Shaft and Shaft Sleeve: Steel shaft with deflector, with copper-alloy shaft sleeve. Include water slinger on shaft between motor and seal.
 - d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket.
 - e. Bearings: Oil-lubricated; bronze-journal or ball type.
 - f. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
 3. Motor: Single speed, with grease-lubricated ball bearings; and resiliently or rigidly mounted to pump casing.
- D. Vertically Mounted, In-Line, Close-Coupled Centrifugal Pumps
1. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted vertical.
 2. Pump Construction:
 - a. Casing: Radially split, cast iron, with wear rings and threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections. Include pump manufacturer's base attachment for mounting pump on concrete base, **as directed**.
 - b. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
 - c. Shaft and Shaft Sleeve: Stainless-steel or steel **OR** Stainless-steel, **as directed**, shaft, with copper-alloy shaft sleeve.
 - d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
 - e. Bearings: Oil-lubricated; bronze-journal or ball type.
 - f. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.
 3. Motor: Single speed, with grease-lubricated ball bearings; and rigidly mounted to pump casing.
- E. Motors



1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "Common Motor Requirements For Plumbing Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

F. Controls

1. Pressure Switches: Electric, adjustable for control of water-supply pump.
 - a. Type: Water-immersion pressure sensor, for installation in piping.
 - b. Enclosure: NEMA 250, Type 4X.
 - c. Operation of Pump: On or off.
 - d. Transformer: Provide if required.
 - e. Power Requirement: 24 V, ac **OR** 120 V, ac, **as directed**.
 - f. Settings: Start pump at **<Insert pressure>** and stop pump at **<Insert pressure>**.
2. Thermostats: Electric; adjustable for control of hot-water circulation pump.
 - a. Type: Water-immersion temperature sensor, for installation in piping.
 - b. Range: 50 to 125 deg F (10 to 52 deg C) **OR** 65 to 200 deg F (18 to 93 deg C) **OR** 100 to 240 deg F (38 to 116 deg C), **as directed**.
 - c. Enclosure: NEMA 250, Type 4X.
 - d. Operation of Pump: On or off.
 - e. Transformer: Provide if required.
 - f. Power Requirement: 24 V, ac **OR** 120 V, ac, **as directed**.
 - g. Settings: Start pump at 105 deg F (41 deg C) **OR** 110 deg F (43 deg C) **OR** 115 deg F (46 deg C), **as directed**, and stop pump at 120 deg F (49 deg C) **OR** 125 deg F (52 deg C), **as directed**.
3. Timers: Electric, for control of hot-water circulation pump.
 - a. Type: Programmable, seven-day clock with manual override on-off switch.
 - b. Enclosure: NEMA 250, Type 1, suitable for wall mounting.
 - c. Operation of Pump: On or off.
 - d. Transformer: Provide if required.
 - e. Power Requirement: 24 V, ac **OR** 120 V, ac, **as directed**.
 - f. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.
4. Time-Delay Relays: Electric, for control of hot-water circulation pump between water heater and connected hot-water storage tank.
 - a. Type: Adjustable time-delay relay.
 - b. Range: Up to five minutes.
 - c. Setting: Five minutes.
 - d. Enclosure: NEMA 250, Type 4X.
 - e. Operation of Pump: On or off.
 - f. Transformer: Provide if required.
 - g. Power Requirement: 24 V, ac **OR** 120 V, ac, **as directed**.
 - h. Programmable Sequence of Operation: Limit pump operation to periods of burner operation plus maximum five minutes after the burner stops.

1.3 EXECUTION

A. Examination

1. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

B. Pump Installation

1. Comply with HI 1.4.
2. Install in-line, sealless centrifugal pumps with shaft horizontal unless otherwise indicated.



3. Install horizontally mounted, in-line, separately coupled and close-coupled centrifugal pumps with shaft(s) horizontal.
4. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.
5. Pump Mounting: Install vertically mounted, in-line, close-coupled centrifugal pumps with cast-iron base mounted on concrete base using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install continuous-thread hanger rods and spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of size required to support pump weight.
 - a. Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment". Fabricate brackets or supports as required.
 - b. Comply with requirements for hangers and supports specified in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment".
7. Install pressure switches in water supply piping.
8. Install thermostats in hot-water return piping.
9. Install timers on wall in engineer's office, **as directed**.
10. Install time-delay relays in piping between water heaters and hot-water storage tanks.

C. Connections

1. Comply with requirements for piping specified in Division 22 Section "Domestic Water Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to pumps to allow service and maintenance.
3. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
 - a. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - 1) Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - 2) Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - 3) Vertically mounted, in-line, close-coupled centrifugal pumps.
 - 4) Comply with requirements for flexible connectors specified in Division 22 Section "Domestic Water Piping".
 - b. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Division 22 Section "General-duty Valves For Plumbing Piping" and comply with requirements for strainers specified in Division 22 Section "Domestic Water Piping Specialties".
 - c. Install pressure gage and snubber, **as directed**, at suction of each pump and pressure gage and snubber, **as directed**, at discharge of each pump. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Comply with requirements for pressure gages and snubbers specified in Division 22 Section "Meters And Gages For Plumbing Piping".
4. Comply with Division 22 for electrical connections, and wiring methods.
5. Connect pressure switches, thermostats, time-delay relays, and timers to pumps that they control.
6. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.



- D. Identification
1. Comply with requirements for identification specified in Division 22 Section "Identification For Plumbing Piping And Equipment" for identification of pumps.
- E. Startup Service
1. Engage a factory-authorized service representative to perform **OR** Perform, **as directed**, startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Check piping connections for tightness.
 - c. Clean strainers on suction piping.
 - d. Set pressure switches, thermostats, timers, and time-delay relays for automatic starting and stopping operation of pumps.
 - e. Perform the following startup checks for each pump before starting:
 - 1) Verify bearing lubrication.
 - 2) Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - 3) Verify that pump is rotating in the correct direction.
 - f. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - g. Start motor.
 - h. Open discharge valve slowly.
 - i. Adjust temperature settings on thermostats.
 - j. Adjust timer settings.
- F. Adjusting
1. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
 2. Adjust initial temperature set points.
 3. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 22 11 23 13



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SECTION 22 11 23 13a - PACKAGED BOOSTER PUMPS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for packaged booster pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Simplex, constant-speed booster pumps.
 - b. Multiplex, constant-speed booster pumps.
 - c. Simplex, variable-speed booster pumps.
 - d. Multiplex, variable-speed booster pumps.

C. Definitions

1. VFC: Variable-frequency controller(s).

D. Performance Requirements

1. Seismic Performance: Booster pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the booster pump will remain in place without separation of any parts from the booster pump when subjected to the seismic forces specified and the booster pump will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, and dimensions of individual components and profiles **OR** Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories, **as directed**.
2. Shop Drawings: For booster pumps. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For booster pumps, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Operation and Maintenance Data: For booster pumps to include in emergency, operation, and maintenance manuals.

F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Comply with ASME B31.9 for piping.
3. UL Compliance for Packaged Pumping Systems:
 - a. UL 508, "Industrial Control Equipment."



- b. UL 508A, "Industrial Control Panels."
 - c. UL 778, "Motor-Operated Water Pumps."
 - d. UL 1995, "Heating and Cooling Equipment."
 - 4. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.
- G. Delivery, Storage, And Handling
- 1. Retain protective coatings and flange's protective covers during storage.
- H. Coordination
- 1. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.2 PRODUCTS

A. Simplex, Constant-Speed Booster Pumps

- 1. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pump, piping, valves, specialties, and controls, and mounted on base.
- 2. Pump:
 - a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
 - b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
 - c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **s directed**; statically and dynamically balanced and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
 - e. Seal: Mechanical.
 - f. Orientation: Mounted horizontally or vertically.
- 3. Motor: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings, and directly mounted to pump casing. Select motor that will not overload through full range of pump performance curve.
- 4. Piping: Copper tube and copper fittings **OR** Stainless-steel pipe and fittings **OR** Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump **OR** Galvanized-steel pipe and cast-iron fittings, **as directed**.
- 5. Valves:
 - a. Shutoff Valves NPS 2 (DN 50) and smaller: Gate valve or two-piece, full-port ball valve, in pump suction and discharge piping.
 - b. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in pump suction and discharge piping.
 - c. Check Valve NPS 2 (DN 50) and smaller: Silent or swing type in pump discharge piping.
 - d. Check Valve NPS 2-1/2 (DN 65) and Larger: Silent type in pump discharge piping.
 - e. Control Valve: Adjustable, automatic, pilot-operated or direct-acting, pressure-reducing type in pump discharge piping.
 - f. Control Valve: Combination adjustable, automatic, pilot-operated or direct-acting pressure-reducing-and-check type in pump discharge piping.
 - g. Thermal-Relief Valve: Temperature-and-pressure relief type in pump discharge piping.
- 6. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
- 7. Hydropneumatic Tank: Precharged, ASME-construction, **as directed**, diaphragm or bladder tank made of materials complying with NSF 61.
- 8. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for single-pump, constant-speed operation, with load control and protection functions.
 - a. Control Logic: Electromechanical system with switches, relays **OR** Solid-state system with transducers, programmable microprocessor, **as directed**, and other devices in the controller.



- b. Motor Controller: NEMA ICS 2, general-purpose, Class A, full-voltage, combination-magnetic type with undervoltage release feature, motor-circuit-protector-type disconnect, and short-circuit protective device.
 - 1) Control Voltage: 24 **OR** 120, **as directed**, -V ac, with integral control-power transformer.
 - c. Motor Controller: NEMA ICS 2, solid-state, reduced-voltage type.
 - 1) Control Voltage: 24 **OR** 120, **as directed**, -V ac, with integral control-power transformer.
 - d. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 4 **OR** Type 12, **as directed**.
 - e. Motor Overload Protection: Overload relay in each phase.
 - f. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 - g. Pump Operation: Current- or pressure- sensing method.
 - 1) Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
 - h. Instrumentation: Suction and discharge pressure gages.
 - i. Light: Running light for pump.
 - j. Thermal-bleed cutoff.
 - k. Low-suction-pressure **OR** Water-storage-tank, low-level, **as directed**, cutout.
 - l. High-suction-pressure cutout.
 - m. Low-discharge-pressure cutout.
 - n. High-discharge-pressure cutout.
 - o. Building Automation System Interface: Provide auxiliary contacts for interface to BACnet **OR** LonWorks, **as directed**, building automation system. Building automation systems are specified in Division 23 Section "Instrumentation And Control For Hvac". Include the following:
 - 1) On-off status of pump.
 - 2) Alarm status.
9. Base: Structural steel.

B. Multiplex, Constant-Speed Booster Pumps

- 1. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.
- 2. Pumps:
 - a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
 - b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
 - c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
 - e. Seal: Mechanical.
 - f. Orientation: Mounted horizontally or vertically.

OR

Pumps:

 - a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, frame-mounted, separately coupled, single-stage, overhung-impeller, centrifugal pump. Include back-pullout design, **as directed**.
 - b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
 - c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Stainless-steel or steel, **as directed**, shaft, with copper-alloy shaft sleeve and deflector.
 - e. Seal: Mechanical.
 - f. Bearing: Grease-lubricated or pre-greased, permanently shielded ball type.
 - g. Coupling: Flexible, with metal guard.

OR

Pumps:



- a. Type: In line, single stage as defined in HI 1.1-1.2 and HI 1.3 for in-line, single-stage, close-coupled, overhung-impeller, centrifugal pump.
 - b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
 - c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Stainless-steel or steel, **as directed**, shaft, with copper-alloy shaft sleeve.
 - e. Seal: Mechanical.
 - f. Bearing: Grease-lubricated or pre-greased, permanently shielded ball type.
- OR**
- Pumps:
- a. Type: Vertical, multistage as defined in HI 1.1-1.2 and HI 1.3 for in-line, multistage, separately coupled, overhung-impeller, centrifugal pump.
 - b. Casing: Cast-iron or steel base and stainless-steel chamber.
 - c. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 - d. Shaft: Stainless steel.
 - e. Seal: Mechanical.
 - f. Bearing: Water-lubricated sleeve type.
- OR**
- Pumps:
- a. Type: Vertical, can, as defined in HI 2.1-2.2 and HI 2.3 for in-line, barrel or can, lineshaft, vertical pump.
 - b. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 - c. Bowls: Epoxy-coated cast iron **OR** Cast iron, **as directed**.
 - d. Shaft: Stainless steel.
 - e. Seals: Mechanical and stuffing-box types.
 - f. Bearings: Water-lubricated bushing type.
3. Motors: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings. Select motors that will not overload through full range of pump performance curve.
 4. Piping: Copper tube and copper fittings **OR** Stainless-steel pipe and fittings **OR** Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump **OR** Galvanized-steel pipe and cast-iron fittings, **as directed**.
 5. Valves:
 - a. Shutoff Valves NPS 2 (DN 50) and smaller: Gate valve or two-piece, full-port ball valve, in each pump's suction and discharge piping.
 - b. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in each pump's suction and discharge piping and in inlet and outlet headers, **as directed**.
 - c. Check Valves NPS 2 (DN 50) and smaller: Silent or swing type in each pump's discharge piping.
 - d. Check Valves NPS 2-1/2 (DN 65) and Larger: Silent type in each pump's discharge piping.
 - e. Control Valves: Adjustable, automatic, pilot-operated or direct-acting, pressure-reducing type in each pump's discharge piping.
 - f. Control Valves: Combination adjustable, automatic, pilot-operated or direct-acting pressure-reducing-and-check type in each pump's discharge piping.
 - g. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.
 6. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
 7. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, constant-speed operation, with load control and protection functions.
 - a. Control Logic: Electromechanical system with switches, relays **OR** Solid-state system with transducers, programmable microprocessor, **as directed**, and other devices in the controller.
 - b. Motor Controller: NEMA ICS 2, general-purpose, Class A, full-voltage, combination-magnetic type with undervoltage release feature, motor-circuit-protector-type disconnect, and short-circuit protective device.



- 1) Control Voltage: 24 **OR** 120, **as directed**, -V ac, with integral control-power transformer.
 - c. Motor Controller: NEMA ICS 2, solid-state, reduced-voltage type.
 - 1) Control Voltage: 24 **OR** 120, **as directed**, -V ac, with integral control-power transformer.
 - d. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 4 **OR** Type 12, **as directed**.
 - e. Motor Overload Protection: Overload relay in each phase.
 - f. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control.
 - 1) Duplex, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.
 - 2) Triplex, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to three-pump operation.
 - g. Pump Operation and Sequencing: Current- or pressure- sensing method.
 - 1) Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
 - h. Instrumentation: Suction and discharge pressure gages.
 - i. Lights: Running light for each pump.
 - j. Alarm Signal Device: Sounds alarm when backup pumps are operating.
 - 1) Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with automatic **OR** manual, **as directed**, reset.
 - k. Thermal-bleed cutoff.
 - l. Low-suction-pressure **OR** Water-storage-tank, low-level, **as directed**, cutout.
 - m. High-suction-pressure cutout.
 - n. Low-discharge-pressure cutout.
 - o. High-discharge-pressure cutout.
 - p. Building Automation System Interface: Provide auxiliary contacts for interface to BACnet **OR** LonWorks, **as directed**, building automation system. Building automation systems are specified in Division 23 Section "Instrumentation And Control For Hvac". Include the following:
 - 1) On-off status of each pump.
 - 2) Alarm status.
8. Base: Structural steel.
- C. Simplex, Variable-Speed Booster Pumps
1. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pump, piping, valves, specialties, and controls, and mounted on base.
 2. Pump:
 - a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
 - b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
 - c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
 - e. Seal: Mechanical.
 - f. Orientation: Mounted horizontally or vertically.
 3. Motor: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings, and directly mounted to pump casing. Select motor that will not overload through full range of pump performance curve.
 4. Piping: Copper tube and copper fittings **OR** Stainless-steel pipe and fittings **OR** Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump **OR** Galvanized-steel pipe and cast-iron fittings, **as directed**.
 5. Valves:
 - a. Shutoff Valves NPS 2 (DN 50) and Smaller: Gate valve or two-piece, full-port ball valve, in pump suction and discharge piping.
 - b. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in pump suction and discharge piping.



- c. Check Valve NPS 2 (DN 50) and Smaller: Silent or swing type in pump discharge piping.
 - d. Check Valve NPS 2-1/2 (DN 65) and Larger: Silent type in pump discharge piping.
 - e. Thermal-Relief Valve: Temperature-and-pressure relief type in pump discharge piping.
 6. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
 7. Hydropneumatic Tank: Precharged, ASME-construction, **as directed**, diaphragm or bladder tank made of materials complying with NSF 61.
 8. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for single-pump, variable-speed operation, with load control and protection functions.
 - a. Control Logic: Solid-state system with transducers, programmable microprocessor, VFC, and other devices in the controller.
 - b. Motor Controller: NEMA ICS 2, variable-frequency, solid-state type.
 - 1) Control Voltage: 24 **OR** 120, **as directed**, -V ac, with integral control-power transformer.
 - c. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 4 **OR** Type 12, **as directed**.
 - d. Motor Overload Protection: Overload relay in each phase.
 - e. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 - f. Pump Operation: Pressure-sensing method.
 - 1) Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
 - g. VFC: Voltage-source, pulse-width, modulating-frequency converter; installed in control panel.
 - h. Manual Bypass: Magnetic contactor arranged to transfer to constant-speed operation upon VFC failure.
 - i. Instrumentation: Suction and discharge pressure gages.
 - j. Light: Running light for pump.
 - k. Thermal-bleed cutoff.
 - l. Low-suction-pressure **OR** Water-storage-tank, low-level, **as directed**, cutout.
 - m. High-suction-pressure cutout.
 - n. Low-discharge-pressure cutout.
 - o. High-discharge-pressure cutout.
 - p. Building Automation System Interface: Provide auxiliary contacts for interface to BACnet **OR** LonWorks, **as directed**, building automation system. Building automation systems are specified in Division 23 Section "Instrumentation And Control For Hvac". Include the following:
 - 1) On-off status of each pump.
 - 2) Alarm status.
 9. Base: Structural steel.
- D. Multiplex, Variable-Speed Booster Pumps
1. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.
 2. Pumps:
 - a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
 - b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
 - c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
 - e. Seal: Mechanical.
 - f. Orientation: Mounted horizontally or vertically.
 3. Pumps:
 - a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, frame-mounted, separately coupled, single-stage, overhung-impeller, centrifugal pump. Include back-pullout design, **as directed**.
 - b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.



- c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
- d. Shaft and Shaft Sleeve: Stainless-steel or steel, **as directed**, shaft, with copper-alloy shaft sleeve and deflector.
- e. Seal: Mechanical.
- f. Bearing: Grease-lubricated or pre-greased, permanently shielded ball type.
- g. Coupling: Flexible, with metal guard.
4. Pumps:
 - a. Type: In line, single stage as defined in HI 1.1-1.2 and HI 1.3 for in-line, single-stage, close-coupled, overhung-impeller, centrifugal pump.
 - b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
 - c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
 - d. Shaft and Shaft Sleeve: Stainless-steel or steel, **as directed**, shaft, with copper-alloy shaft sleeve.
 - e. Seal: Mechanical.
 - f. Bearing: Grease-lubricated or pre-greased, permanently shielded ball type.
5. Pumps:
 - a. Type: Vertical, multistage as defined in HI 1.1-1.2 and HI 1.3 for in-line, multistage, separately coupled, overhung-impeller, centrifugal pump.
 - b. Casing: Cast-iron or steel base and stainless-steel chamber.
 - c. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 - d. Shaft: Stainless steel.
 - e. Seal: Mechanical.
 - f. Bearing: Water-lubricated sleeve type.
6. Pumps:
 - a. Type: Vertical, can, as defined in HI 2.1-2.2 and HI 2.3 for in-line, barrel or can, lineshaft, vertical pump.
 - b. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 - c. Bowls: Epoxy-coated cast iron **OR** Cast iron, **as directed**.
 - d. Shaft: Stainless steel.
 - e. Seals: Mechanical and stuffing-box types.
 - f. Bearings: Water-lubricated bushing type.
7. Motors: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings. Select motors that will not overload through full range of pump performance curve.
8. Piping: Copper tube and copper fittings **OR** Stainless-steel pipe and fittings **OR** Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump **OR** Galvanized-steel pipe and cast-iron fittings, **as directed**.
9. Valves:
 - a. Shutoff Valves NPS 2 (DN 50) and Smaller: Gate valve or two-piece, full-port ball valve, in each pump's suction and discharge piping.
 - b. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in each pump's suction and discharge piping and in inlet and outlet headers, **as directed**.
 - c. Check Valves NPS 2 (DN 50) and Smaller: Silent or swing type in each pump's discharge piping.
 - d. Check Valves NPS 2-1/2 (DN 65) and Larger: Silent type in each pump's discharge piping.
 - e. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.
10. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
11. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, variable-speed operation, with load control and protection functions.
 - a. Control Logic: Solid-state system with transducers, programmable microprocessor, VFC, and other devices in controller. Install VFC for pump motors larger than 25 hp in separate panel; same type as motor control panel enclosure.
 - b. Motor Controller: NEMA ICS 2, variable-frequency, solid-state type.



- 1) Control Voltage: 24 **OR** 120, **as directed**, -V ac, with integral control-power transformer.
 - c. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 4 **OR** Type 12, **as directed**.
 - d. Motor Overload Protection: Overload relay in each phase.
 - e. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control.
 - 1) Duplex, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.
 - 2) Triplex, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to three-pump operation.
 - f. Pump Operation and Sequencing: Pressure-sensing method or flow-sensing method **OR** Pressure-sensing method for lead pump and flow-sensing method for lag pumps, **as directed**.
 - 1) Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
 - g. VFC: Voltage-source, pulse-width, modulating-frequency converter for each **OR** lead, **as directed**, pump.
 - h. Manual Bypass: Magnetic contactor arranged to transfer to constant-speed operation upon VFC failure.
 - i. Instrumentation: Suction and discharge pressure gages.
 - j. Lights: Running light for each pump.
 - k. Alarm Signal Device: Sounds alarm when backup pumps are operating.
 - 1) Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with automatic **OR** manual, **as directed**, reset.
 - l. Thermal-bleed cutoff.
 - m. Low-suction-pressure **OR** Water-storage-tank, low-level, **as directed**, cutout.
 - n. High-suction-pressure cutout.
 - o. Low-discharge-pressure cutout.
 - p. High-discharge-pressure cutout.
 - q. Building Automation System Interface: Provide auxiliary contacts for interface to BACnet **OR** LonWorks, **as directed**, building automation system. Building automation systems are specified in Division 23 Section "Instrumentation And Control For Hvac". Include the following:
 - 1) On-off status of each pump.
 - 2) Alarm status.
12. Base: Structural steel.

E. Motors

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

1.3 EXECUTION

A. Examination

1. Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

B. Installation

1. Equipment Mounting: Install booster pumps on concrete base using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete", **as directed**.



- a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 2. Equipment Mounting: Install booster pumps using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 3. Support connected domestic-water piping so weight of piping is not supported by booster pumps.
- C. Connections
1. Comply with requirements for piping specified in Division 22 Section "Domestic Water Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers **OR** piping, **as directed**.
 - a. Install shutoff valves on piping connections to booster-pump suction and discharge headers **OR** piping, **as directed**. Install ball, butterfly, or gate valves same size as suction and discharge headers **OR** piping, **as directed**. Comply with requirements for general-duty valves specified in Division 22 Section "General-duty Valves For Plumbing Piping".
 - b. Install union, flanged, or grooved-joint connections on suction and discharge headers **OR** piping, **as directed**, at connection to domestic-water piping. Comply with requirements for unions and flanges specified in Division 22 Section "Domestic Water Piping".
 - c. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge headers **OR** piping, **as directed**. Comply with requirements for domestic-water piping specified in Division 22 Section "Domestic Water Piping".
 - d. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge headers **OR** piping, **as directed**. Comply with requirements for flexible connectors specified in Division 22 Section "Domestic Water Piping".
 - e. Install piping adjacent to booster pumps to allow service and maintenance.
- D. Identification
1. Identify system components. Comply with requirements for identification specified in Division 22 Section "Identification For Plumbing Piping And Equipment".
- E. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Perform visual and mechanical inspection.
 - b. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Pumps and controls will be considered defective if they do not pass tests and inspections.
 4. Prepare test and inspection reports.
- F. Startup Service
1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.



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- G. Adjusting
1. Adjust booster pumps to function smoothly, and lubricate as recommended by manufacturer.
 2. Adjust pressure set points.
 3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- H. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION 22 11 23 13a



SECTION 22 11 23 23 - WATER SUPPLY WELLS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for water supply wells. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Cable-tool, Rotary drilled, Reverse-rotary drilled, and Driven water supply wells.
 - b. Jet, Line-shaft, and Submersible well pumps.

C. Definitions

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. PA: Polyamide (nylon) plastic.
3. PE: Polyethylene plastic.
4. PP: Polypropylene plastic.
5. PVC: Polyvinyl chloride plastic.

D. Submittals

1. Product Data: Submit certified performance curves and rated capacities of selected well pumps and furnished specialties for each type and size of well pump indicated.
2. Shop Drawings: Show layout and connections for well pumps.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control reports.
4. Operation and maintenance data.

E. Quality Assurance

1. Well Driller Qualifications: An experienced water supply well driller licensed in the jurisdiction where Project is located.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with AWWA A100 for water supply wells.

F. Project Conditions

1. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - a. Notify the Owner no fewer than seven days in advance of proposed interruption of water service.
 - b. Do not proceed with interruption of water service without the Owner's written permission.
2. Well Drilling Water: Provide temporary water and piping for drilling purposes. Provide necessary piping for water supply.

1.2 PRODUCTS

A. Well Casings

1. Steel Casing: AWWA C200, single ply, steel pipe with threaded ends and threaded couplings for threaded joints.



2. ABS Casing: ASTM F 480, ABS, Schedule 40 **OR** 80, **as directed**, bell-and-spigot pipe and couplings for solvent-cemented joints.
 3. PVC Casing: ASTM F 480 and NSF 14, **as directed**, PVC, Schedule 40 **OR** 80, **as directed**, bell-and-spigot pipe and couplings for solvent-cemented joints. Include NSF listing mark "NSF wc," **as directed**.
 4. Pitless Adapter: Fitting, of shape required to fit onto casing, with waterproof seals.
 5. Pitless Unit: Factory-assembled equipment that includes pitless adapter.
 6. Well Seals: Casing cap, with holes for piping and cables, that fits into top of casing and is removable, waterproof, and vermin proof.
- B. Grout
1. Cement: ASTM C 150, Type II.
 2. Aggregates: ASTM C 33, fine and coarse grades.
 3. Water: Potable.
- C. Water Well Screens
1. Screen Material: Fabricated of ASTM A 666, Type 304 stainless steel, welded; with continuous-slot, V-shaped openings that widen inwardly **OR** tube; with slotted or perforated surface and designed for well-screen applications, **as directed**.
 - a. Screen Couplings: Butt-type, stainless-steel coupling rings.
 - b. Screen Fittings: Screen, with necessary fittings, closes bottom and makes tight seal between top of screen and well casing.
 - c. Maximum Entering Velocity: 0.1 fps (0.03 m/s).
- D. Pack Materials
1. Coarse, uniformly graded filter sand, maximum 1/8 inch (3 mm) in diameter.
 2. Fine gravel, maximum 1/4 inch (6 mm) in diameter.
- E. Jet-Type Well Pumps
1. Description: Shallow **OR** Deep, **as directed**, -well-design, jet well pump; self-priming; centrifugal pump capable of continuous operation; with the following features:
 - a. Housing: Cast iron.
 - b. Impeller: Single stage **OR** Multistage, **as directed**, centrifugal; fabricated of corrosion-resistant materials.
 - c. Seals: Mechanical.
 - d. Shaft: Stainless steel.
 - e. Motor: Manufacturer's standard, NEMA MG 1 motor, panel, and accessories.
 - f. Motor Controls: Electronic; variable speed.
 - g. Check valve, ejector, and pressure-control valve.
 2. Pump Accessories:
 - a. Compression Tanks: Comply with requirements in Division 22 Section "Facility Indoor Potable-water Storage Tanks" **OR** Precharged butyl rubber diaphragm, steel shell, fused polymeric lining, and 100-psig (690-kPa) working pressure, **as directed**.
 - b. Pressure Switches: For pump control; for installation in piping.
 - c. Water Piping: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends.
 - 1) Cast-Iron Fittings: ASME B16.4, threaded, galvanized.
 - d. Water Piping: ASTM D 2239, SDR Numbers 5.3, 7, or 9 PE pipe; made with PE compound number required to give pressure rating not less than 160 psig (1100 kPa) **OR** 200 psig (1380 kPa), **as directed**. Include NSF listing mark "NSF pw."
 - 1) Fittings for PE Pipe: ASTM D 2609, made of PA, PP, or PVC with serrated, male insert ends matching inside of pipe. Include bands or crimp rings.
- F. Line-Shaft Well Pumps
1. Description: Line-shaft, water **OR** oil, **as directed**, -lubricated, vertical-turbine well pump complying with HI 2.1-2.2 and HI 2.3; with the following features:



- a. Impeller Material: Stainless steel **OR** Carbon steel **OR** Bronze, **as directed**.
- b. Motor: Full-voltage starting, vertical hollow- or solid-shaft, squirrel-cage induction type complying with ANSI C50.10.
- c. Pump Base: Cast iron or fabricated steel.
- d. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel threaded couplings.

G. Submersible Well Pumps

1. Description: Submersible, vertical-turbine well pump complying with HI 2.1-2.2 and HI 2.3; with the following features:
 - a. Impeller Material: Stainless steel **OR** Silicon bronze, **as directed**.
 - b. Motor: Capable of continuous operation under water, with protected submersible power cable.
 - c. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel threaded couplings.
 - d. Discharge Piping: ASTM D 2239, SDR Numbers 5.3, 7, or 9 PE pipe; made with PE compound number required to give pressure rating not less than 160 psig (1100 kPa) **OR** 200 psig (1380 kPa), **as directed**. Include NSF listing mark "NSF pw."
 - 1) Insert Fittings for PE Pipe: ASTM D 2609, made of PA, PP, or PVC with serrated, male insert ends matching inside of pipe. Include bands or crimp rings.

H. Motors

1. General requirements for motors are specified in Division 22 Section "Common Motor Requirements For Plumbing Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.

1.3 EXECUTION

A. Preparation

1. Pilot-Hole Data: Review pilot-hole test analysis furnished by the Owner.
2. Neighborhood Well Data: Review operating and test analyses.

B. Installation

1. Construct well using cable-tool **OR** rotary drilling **OR** reverse-rotary drilling **OR** driven, **as directed**, method.
2. Take samples of substrata formation at 10-foot (3-m) intervals and at changes in formation throughout entire depth of each water supply well. Carefully preserve samples on-site in glass jars properly labeled for identification.
3. If selecting rotary drilled or reverse-rotary drilled method, excavate for mud pit or provide aboveground structure, acceptable to authorities having jurisdiction, to allow settlement of cuttings and circulation of drill fluids back to well without discharging to on-site waterways.
4. Enlarge pilot hole and install permanent casing, screen, and grout. Install first section of casing with hardened steel driving shoe of an OD slightly larger than casing couplings if threaded couplings are used.
5. Set casing and liners round, plumb, and true to line.
6. Join casing pipe as follows:
 - a. Ream ends of pipe and remove burrs.
 - b. Remove scale, slag, dirt, and debris from inside and outside casing before installation.
 - c. Cut bevel in ends of steel casing pipe and make threaded joints.
 - d. Clean and make solvent-cemented joints for ABS and PVC casings.
7. If rotary drilled or reverse-rotary drilled well, mix grout in proportions of 1 cu. ft. (0.03 cu. m) or a 94-lb (42.6-kg) sack of cement with 5 to 6 gal. (19 to 23 L) of water. Bentonite clay may be added



in amounts of 3 to 5 lb/cu. ft. (1.4 to 2.3 kg/0.03 cu. m) for a 94-lb (42.6-kg) sack of cement. If bentonite clay is added, water may be increased to 6.5 gal./cu. ft. (25 L/0.03 cu. m) of cement.

8. If rotary drilled or reverse-rotary drilled well, place grout continuously, from bottom to top surface, to ensure filling of annular space in one operation. Do not perform other operations in well within 72 hours after grouting of casing. When quick-setting cement is used, this period may be reduced to 24 hours.
9. Provide permanent casing with temporary well cap. Install with top of casing 36 inches (910 mm) above finished grade, **as directed**.
10. Develop wells to maximum yield per foot (meter) of drawdown.
 - a. Extract maximum practical quantity of sand, drill fluid, and other fine materials from water-bearing formation.
 - b. Avoid settlement and disturbance of strata above water-bearing formation.
 - c. Do not disturb sealing around well casings.
 - d. Continue developing wells until water contains no more than 2 ppm of sand by weight when pumped at maximum testing rate.
11. Install jet well pumps with ejector in or attached to pump housing. Place check valve on suction line to prevent drainage of compression tank.
12. Install jet well pumps and pressure and suction lines. Install ejector where pressure and suction lines connect above well screen. Install check valve in suction line, or install foot valve below ejector, to prevent drainage of compression tank.
13. Install line-shaft **OR** submersible, **as directed**, well pumps according to HI 2.1-2.4 and provide access for periodic maintenance.
 - a. Before lowering permanent pump into well, lower a dummy pump that is slightly longer and wider than permanent pump to determine that permanent pump can be installed. Correct alignment problems.
 - b. Before lowering permanent pump into well, start pump to verify correct rotation.
 - c. Securely tighten discharge piping joints.
 - d. Locate line-shaft well pump near well bottom; locate motor above grade. Install driver plate to correctly align motor and pump.
 - e. Connect motor to submersible pump and locate near well bottom.
 - 1) Connect power cable while connection points are dry and undamaged.
 - 2) Do not damage power cable during installation; use cable clamps that do not have sharp edges.
 - 3) Install water-sealed surface plate that will support pump and piping.

C. Connections

1. Piping installation requirements are specified in Division 22 Section "Facility Water Distribution Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
 - a. Connect piping between well pump and water piping.
 - b. Connect water distribution system in trench to well pipe at pitless adapter **OR** unit, **as directed**.
 - c. Connect building water distribution to well pipe inside well house.
2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

D. Well Abandonment

1. Comply with AWWA A100 when abandoning water supply wells. Fill and seal holes and casings and restore ground surface to finished grade.
OR
Follow well-abandonment procedures of authorities having jurisdiction. Restore ground surface to finished grade.

E. Field Quality Control



1. Plumbness and Alignment Testing: Comply with AWWA A100.
2. Furnish samples of water-bearing formation to testing laboratory and well-screen manufacturer for mechanical sieve analysis.
3. Prepare reports on static level of ground water, level of water for various pumping rates, and depth to water-bearing strata.
4. Performance Testing: Conduct final pumping tests after wells have been constructed, cleaned, and tested for plumbness and alignment.
 - a. Provide discharge piping to conduct water to locations where disposal will not create a nuisance or endanger adjacent property. Comply with requirements of authorities having jurisdiction.
 - b. Measure elevation to water level in wells.
 - c. Perform two bailer or air-ejection tests to determine expected yield. Test at depths with sufficient quantity of water to satisfy desired yields.
 - d. Test Pump: Variable capacity test pump with capacity equal to maximum expected yields at pressure equal to drawdown in wells, plus losses in pump columns and discharge pipes.
 - e. Start and adjust test pumps and equipment to required pumping rates.
 - f. Record readings of water levels in wells and pumping rates at 30-minute maximum intervals throughout 24-hour minimum period.
 - g. Record maximum yields when drawdown is 60 inches (1500 mm) above top of suction screens after designated times.
 - h. Operate pumping units continuously for eight hours after maximum drawdown is reached.
 - i. Record returning water levels in wells and plot curves of well recovery rates.
 - j. Remove sand, stones, and other foreign materials that may become deposited in wells after completing final tests.
5. Water Analysis Testing:
 - a. Engage] a qualified testing agency to make bacteriological, physical, and chemical analyses of water from each finished well and report the results. Make analyses according to requirements of authorities having jurisdiction.
OR
Analyze water sample from each finished well for bacteriological, physical, and chemical quality and report the results. Make analyses according to requirements of authorities having jurisdiction.

F. Cleaning

1. Disinfect water supply wells according to AWWA A100 and AWWA C654 before testing well pumps.
OR
Follow water supply well disinfection procedures required by authorities having jurisdiction before testing well pumps.

G. Protection

1. Water Quality Protection: Prevent well contamination, including undesirable physical and chemical characteristics.
2. Ensure that mud pit will not leak or overflow into streams or wetlands. When well is accepted, remove mud and solids in mud pit from Project site and restore site to finished grade.
3. Provide casings, seals, sterilizing agents, and other materials to eliminate contamination; shut off contaminated water.
4. Exercise care to prevent breakdown or collapse of strata overlaying that from which water is to be drawn.
5. Protect water supply wells to prevent tampering and introducing foreign matter. Retain temporary well cap until installation is complete.

END OF SECTION 22 11 23 23



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**SECTION 22 11 23 23a - HYDRONIC PUMPS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for hydronic pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Close-coupled, in-line centrifugal pumps.
 - b. Close-coupled, end-suction centrifugal pumps.
 - c. Separately coupled, horizontal, in-line centrifugal pumps.
 - d. Separately coupled, vertical, in-line centrifugal pumps.
 - e. Separately coupled, base-mounted, end-suction centrifugal pumps.
 - f. Separately coupled, base-mounted, double-suction centrifugal pumps.
 - g. Separately coupled, vertical-mounted, double-suction centrifugal pumps.
 - h. Separately coupled, vertical-mounted, turbine centrifugal pumps.
 - i. Automatic condensate pump units.

C. Definitions

1. Buna-N: Nitrile rubber.
2. EPT: Ethylene propylene terpolymer.

D. Submittals

1. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
2. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. UL Compliance: Comply with UL 778 for motor-operated water pumps.

F. Delivery, Storage, And Handling

1. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
2. Store pumps in dry location.
3. Retain protective covers for flanges and protective coatings during storage.
4. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
5. Comply with pump manufacturer's written rigging instructions.



1.2 PRODUCTS

A. Close-Coupled, In-Line Centrifugal Pumps

1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
 - a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, and threaded companion-flange **OR** union end, **as directed**, connections.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 - c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.
 - d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket. Include water slinger on shaft between motor and seal.
 - e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 - f. Pump Bearings: Permanently lubricated ball bearings **OR** Oil lubricated; bronze-journal or thrust type, **as directed**.
3. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

B. Close-Coupled, End-Suction Centrifugal Pumps

1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa), **as directed**, minimum working pressure and a continuous water temperature of 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
 - a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and threaded companion-flange **OR** flanged, **as directed**, connections.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 - c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.
 - d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket. Include water slinger on shaft between motor and seal.
 - e. Pump Bearings: Permanently lubricated ball bearings **OR** Oil lubricated; bronze-journal or thrust type, **as directed**.
 - f. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings, unless otherwise indicated; rigidly mounted to pump casing with integral pump support. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

C. Separately Coupled, Horizontal, In-Line Centrifugal Pumps

1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa), **as**



- directed**, minimum working pressure and a continuous water temperature of 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
 - a. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange **OR** union end, **as directed**, connections.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
 - c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.
 - d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket. Include water slinger on shaft between motor and seal.
 - e. Pump Bearings: Permanently lubricated ball bearings **OR** Oil lubricated; bronze-journal or thrust type, **as directed**.
 3. Shaft Coupling: Molded rubber insert with interlocking spider **OR** Interlocking frame with interconnecting springs, **as directed**, capable of absorbing vibration.
 4. Motor: Single speed, with permanently lubricated ball **OR** oil-lubricated sleeve, **as directed**, bearings, unless otherwise indicated; and resiliently **OR** rigidly, **as directed**, mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- D. Separately Coupled, Vertical, In-Line Centrifugal Pumps
1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
 2. Pump Construction:
 - a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, and threaded companion-flange **OR** union end, **as directed**, connections.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 - c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.
 - d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket. Include water slinger on shaft between motor and seal.
 - e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 - f. Pump Bearings: Permanently lubricated ball bearings **OR** Oil lubricated; bronze-journal or thrust type, **as directed**.
 3. Shaft Coupling: Axially split spacer coupling.
 4. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings, unless otherwise indicated; rigidly mounted to pump casing with lifting eye and supporting lugs in motor enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- E. Separately Coupled, Base-Mounted, End-Suction Centrifugal Pumps
1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
 2. Pump Construction:
 - a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded companion-flange **OR** flanged, **as directed**, connections. Provide integral mount



on volute to support the casing, and attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft, **as directed**.

- b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 - c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.
 - d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket.
 - e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 - f. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.
3. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor **OR** EPDM coupling sleeve for variable-speed applications, **as directed**.
 4. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
 5. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
 6. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

F. Separately Coupled, Base-Mounted, Double-Suction Centrifugal Pumps

1. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
 - a. Casing: Radially **OR** Horizontally, **as directed**, split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, Class 125 **OR** 250, **as directed**, flanges. Casing supports shall allow removal and replacement of impeller without disconnecting piping, **as directed**.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
 - c. Pump Shaft: Stainless steel.
 - d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket.
 - e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 - f. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.
3. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor **OR** EPDM coupling sleeve for variable-speed applications, **as directed**.
4. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
5. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.



6. Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- G. Separately Coupled, Vertical-Mounted, Double-Suction Centrifugal Pumps
1. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
 2. Pump Construction:
 - a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, drain plug at bottom of volute, mounting support, and ASME B16.1, Class 125 **OR** 250, **as directed**, flanges.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
 - c. Pump Shaft: Stainless steel.
 - d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket.
 - e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 - f. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.
 3. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration.
 4. Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to casing. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- H. Separately Coupled, Vertical-Mounted, Turbine Centrifugal Pumps
1. Description: Factory-assembled and -tested, single-stage **OR** multistage, **as directed**, centrifugal, impeller-between-bearings, end-suction pump as defined in HI 2.1-2.2 and HI 2.3; designed for installation with pump and motor shafts mounted vertically and projecting into a sump. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C).
 2. Pump Construction:
 - a. Pump Bowl: Cast iron, with replaceable bronze wear ring, **as directed**, cone **OR** basket, **as directed**, strainer, and suction bell. Water passages of intermediate bowls shall be coated with porcelain enamel, **as directed**.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
 - c. Pump Shaft: Carbon **OR** Stainless, **as directed**, steel sized per AWWA E-101.
 - d. Pump Bearings: Water-lubricated bronze and rubber sleeve bearings contained in cast-iron housing.
 - e. Pump Column: ASTM A 53/A 53M, Grade B steel pipe.
 - f. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Seal shall be replaceable without removing the motor or disturbing the piping.
 - g. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 3. Shaft Coupling: Keyed with locking collets.
 4. Discharge Head: ASME B16.1, Class 125 **OR** 250, **as directed**, discharge flange with threaded gage tapping. Top of discharge head shall have a registered fit to accurately locate the driver.
 5. Drive Ratchet: Nonreversing ratchet.



6. Hollow Shaft Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to discharge head. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

I. Automatic Condensate Pump Units

1. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- (1800-mm-) minimum, electrical power cord with plug.

J. Pump Specialty Fittings

1. Suction Diffuser: Angle pattern, 175-psig (1204-kPa) **OR** 300-psig (2060-kPa), **as directed**, pressure rating, cast **OR** ductile, **as directed**,-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.
2. Triple-Duty Valve: Angle or straight pattern, 175-psig (1204-kPa) **OR** 300-psig (2060-kPa), **as directed**, pressure rating, cast **OR** ductile, **as directed**,-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

1.3 EXECUTION

A. Concrete Bases

1. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 23 Section "Common Work Results For Hvac"
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Cast-in-place concrete materials and placement requirements are specified in Division 31.

B. Pump Installation

1. Comply with HI 1.4 **OR** HI 2.4, **as directed**.
2. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
3. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
4. Install continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of sufficient size to support pump weight. Vibration isolation devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Fabricate brackets or supports as required. Hanger and support materials are specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
5. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of sufficient size to support pump weight. Vibration isolation devices are specified in Division 21 Section(s) "Vibration And Seismic Controls For Fire-suppression Piping And Equipment" AND Division 23 Section(s) "Vibration And Seismic Controls For Hvac Piping And Equipment". Hanger and support materials are specified in Division 22 Section(s) "Hangers And Supports For Plumbing Piping And Equipment" AND Division 23 Section(s) "Hangers And Supports For Hvac Piping And Equipment".



6. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
 - a. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches (19 to 38 mm) between pump base and foundation for grouting.
 - b. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
7. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

C. Alignment

1. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
2. Comply with pump and coupling manufacturers' written instructions.
3. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation" **OR** HI 2.1-2.5, "Vertical Pumps for Nomenclature, Definitions, Application and Operation", **as directed**.
4. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

D. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
4. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
5. Install check valve and throttling **OR** triple-duty, **as directed**, valve on discharge side of pumps.
6. Install Y-type strainer **OR** suction diffuser, **as directed**, and shutoff valve on suction side of pumps.
7. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
8. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.
9. Install check valve and gate or ball valve on each condensate pump unit discharge.
10. Install electrical connections for power, controls, and devices.
11. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
12. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

END OF SECTION 22 11 23 23a



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Task	Specification	Specification Description
22 11 23 23	22 05 23 00	Piped Utilities Basic Materials And Methods



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**SECTION 22 12 19 00 - SURFACE WATER-STORAGE TANKS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for surface water-storage tanks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes welded-steel reservoirs and standpipes for storage of domestic and fire-suppression water.
2. This Section includes bolted-steel reservoirs and standpipes for storage of domestic and fire-suppression water.
3. This Section includes wire- or strand-wound, concrete, surface water-storage tanks for storage of domestic and fire-suppression water.
4. This Section includes circular, prestressed-concrete, surface water-storage tanks for storage of domestic and fire-suppression water.

C. Definitions

1. Reservoir: Flat-bottomed, cylindrical, surface water-storage tank with shell height equal to or less than its diameter.
2. Standpipe: Flat-bottomed, cylindrical, surface water-storage tank with shell height greater than its diameter.
3. CR: Chlorosulfonated polyethylene synthetic rubber.
4. NR: Natural rubber.
5. PVC: Polyvinyl chloride plastic.

D. Performance Requirements

1. Structural Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of dead and live gravity loads and winds of 100 mph (161 km/h).
2. Seismic Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of earthquake motions determined according to authorities having jurisdiction.
3. Thermal Movements: Surface water-storage tank, including structural reinforcement and foundation, shall allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Submittals

1. Product Data: Include rated capacities, accessories, appurtenances, and furnished specialties for each surface water-storage tank indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details for each surface water-storage tank, including the following:
 - a. Tank, roof, and shell openings.
 - b. Safety railings and ladders.
 - c. Plans, elevations, sections, details, and attachments to other work.



- d. Structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- e. Power, signal, and control wiring.
3. Welding certificates.
4. Bacteriological test results.
5. Field quality-control test reports.
6. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
 - a. Obstruction lighting.
 - b. Lightning protection.
 - c. Cathodic protection.
 - d. Tank heaters.

F. Quality Assurance

1. Welding: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code--Steel."
 - b. AWS D1.3, "Structural Welding Code--Sheet Steel."
 - c. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
2. Pipe Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. Comply with AWWA D100, "Welded Steel Tanks for Water Storage," and with AWWA M42, "Steel Water-Storage Tanks," for welded-steel, surface water-storage tanks.
5. Comply with AWWA D103, "Factory-Coated Bolted Steel Tanks for Water Storage," and with AWWA M42, "Steel Water-Storage Tanks," for bolted-steel, surface water-storage tanks.
6. Comply with AWWA D110, "Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks," for concrete, surface water-storage tanks with steel diaphragm.
7. Comply with AWWA D110, "Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks," for cast-in-place-concrete, surface water-storage tanks with vertical prestressed reinforcement.
8. Comply with AWWA D115, "Circular Prestressed Concrete Water Tanks with Circumferential Tendons," for concrete, surface water-storage tanks with circumferential tendons.
9. Comply with NFPA 22, "Water Tanks for Private Fire Protection," for surface water-storage tanks for fire-suppression water supply.

1.2 PRODUCTS

A. Welded-Steel Reservoirs/Standpipes

1. Description: Welded-steel plates, bolts, rods, and reinforcing steel; designed and fabricated according to AWWA D100, AWWA M42, and NFPA 22 (if tank is for fire-suppression water supply).
 - a. Capacity: 50,000 gal. (189 cu. m) **OR** 5,000,000 gal. (18 930 cu. m), **as directed**.
 - b. Shell Roof (if self-supporting roof is required): Conical **OR** Dome **OR** Ellipsoidal, **as directed**, welded steel and self-supporting.
 - c. Shell Roof (if supported roof is required): Conical with knuckle and column-rafter support.
 - d. Reservoir Shell Diameter: as directed by the Owner.
 - e. Standpipe Shell Height: Height, as directed by the Owner from top of foundation to lower capacity **OR** overflow, **as directed**, level.
 - f. Range of Head: Height, as directed by the Owner from lower capacity level to overflow level.
 - g. Pipe Connection: Match size of water-distribution pipe.



- h. Overflow Piping: ASTM A 53/A 53M, Grade B, Schedule 40, welded-steel pipe with ASTM A 234/A 234M, Grade WPB, Schedule 40, carbon-steel butt-weld fittings.
 - i. Roof Hatch: Steel, hinged cover, 24 by 15 inches (600 by 380 mm) minimum with 4-inch (100-mm) neck and 2-inch (50-mm) downward overlap with hasp and lock, located over interior ladder and adjacent to exterior ladder.
 - j. Roof Manhole: Steel, removable, 20-inch- (500-mm-) minimum-diameter cover with 4-inch (100-mm) neck and 2-inch- (50-mm-) downward overlap with hasp and lock. Construct opening with capability of supporting ventilation fan.
 - k. Shell Sidewall Manholes: Two, steel, circular, 24 inches (600 mm) in diameter **OR** elliptical, 18 by 22 inches (450 by 560 mm) minimum, **as directed**.
 - l. Painter's Accessories: Include lugs **OR** couplings **OR** rail, **as directed**, inside and outside tank for painting.
 - m. Tank Vent: Steel pipe with stainless-steel screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen, **as directed**.
 - n. Foundation: Reinforced concrete. Refer to Division 03 Section "Cast-in-place Concrete".
- B. Bolted-Steel Reservoirs/Standpipes
- 1. Description: Bolted-steel plates, bolts, rods, and reinforcing steel; designed and fabricated according to AWWA D100, AWWA M42, and NFPA 22 (if tank is for fire-suppression water supply).
 - a. Capacity: 4000 gal. (15 cu. m) **OR** 160,000 gal. (605 cu. m), **as directed**.
 - b. Shell Roof: Comply with AWWA D103.
 - c. Reservoir Shell Diameter: as directed by the Owner.
 - d. Standpipe Shell Height: Height, as directed by the Owner from top of foundation to lower capacity **OR** overflow, **as directed**, level.
 - e. Range of Head: Height, as directed by the Owner from lower capacity level to overflow level.
 - f. Pipe Connection: Match size of water-distribution pipe.
 - g. Overflow Piping: ASTM A 53/A 53M, Grade B, Schedule 40, welded-steel pipe with ASTM A 234/A 234M, Grade W.B., Schedule 40, carbon-steel butt-weld fittings.
 - h. Roof Hatch: Steel, hinged cover, 24 by 15 inches (600 by 380 mm) minimum with 4-inch (100-mm) neck and 2-inch (50-mm) downward overlap with hasp and lock, located over interior ladder and adjacent to exterior ladder.
 - i. Roof Manhole: Steel, removable, 20-inch- (500-mm-) minimum-diameter cover with 4-inch (100-mm) neck and 2-inch- (50-mm-) downward overlap with hasp and lock. Construct opening with capability of supporting ventilation fan.
 - j. Shell Sidewall Manholes: Two, steel, circular, 24 inches (600 mm) in diameter **OR** elliptical, 18 by 22 inches (450 by 560 mm) minimum, **as directed**.
 - k. Painter's Accessories: Include lugs **OR** couplings **OR** rail, **as directed**, inside and outside tank for painting.
 - l. Tank Vent: Steel pipe with stainless-steel screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen, **as directed**.
 - m. Foundation: Reinforced concrete. Refer to Division 03 Section "Cast-in-place Concrete".
- C. Wire- Or Strand-Wound, Concrete, Surface Water-Storage Tanks
- 1. Comply with AWWA D110 and NFPA 22 (if tank is for fire-suppression water supply).
 - 2. Tank Capacity: 100,000 gal. (379 cu. m) **OR** 40,000,000 gal. (151 400 cu. m), **as directed**.
 - 3. Tank Height: as directed by the Owner.
 - 4. Tank Wall Diameter: as directed by the Owner.
 - 5. Tank Floor: Reinforced, cast-in-place concrete.
 - 6. Tank Wall (for cast-in-place concrete with vertical prestressed reinforcement):
 - a. Materials: Cast-in-place concrete, with at least 7 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer and with vertical prestressed reinforcement. Superplasticizers are prohibited.



- b. Wall-Base Joint Sealant: ASTM C 920, Class 25, Type S, Grade P or NS, polyurethane.
 - c. Threadbars: Hot-dip galvanized steel, 1.25 to 1.375 inches (31 to 35 mm) in diameter.
 - d. Wire: Hot-dip galvanized.
7. Tank Wall (for shotcrete with steel diaphragm):
- a. Materials: Shotcrete, with at least 10 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer. Include steel diaphragm. Air-entrainment admixtures and superplasticizers are prohibited.
 - b. Wall-Base Joint Sealant: ASTM C 920, Class 25, Type S, Grade P or NS, polyurethane.
 - c. Diaphragm: Galvanized-steel sheet, at least 0.017 inch (0.43 mm) thick, complying with ASTM A 924/A 924M. Height of sheet shall be same as wall height.
 - d. Diaphragm Sealants: ASTM C 920, Type M, polysulfide; ASTM C 920, Class 25, Type M, Grade P or NS, polyurethane; or ASTM C 881/C 881M, Type III, Grade 1, epoxy or double-fold vertical joints with mechanical seamer.
 - e. Wire: Hot-dip galvanized.
8. Tank Wall (for precast concrete with steel diaphragm):
- a. Materials: Precast concrete, with at least 7 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer and with vertical prestressed reinforcement. Include steel diaphragm. Superplasticizers are prohibited.
 - b. Wall-Base Joint Sealant: ASTM C 920, Class 25, Type S, Grade P or NS, polyurethane.
 - c. Diaphragm: Galvanized-steel sheet, at least 0.017 inch (0.43 mm) thick, complying with ASTM A 924/A 924M. Height of sheet shall be same as wall height.
 - d. Diaphragm Sealants: ASTM C 920, Type M, polysulfide; ASTM C 920, Class 25, Type M, Grade P or NS, polyurethane; or ASTM C 881/C 881M, Type III, Grade 1, epoxy or double-fold vertical joints with mechanical seamer.
 - e. Wire: Hot-dip galvanized.
9. Tank Wall (for cast-in-place concrete with steel diaphragm):
- a. Materials: Cast-in-place concrete, with at least 7 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer and with vertical prestressed reinforcement. Include steel diaphragm. Superplasticizers are prohibited.
 - b. Wall-Base Joint Sealant: ASTM C 920, Class 25, Type S, Grade P or NS, polyurethane.
 - c. Diaphragm: Galvanized-steel sheet, at least 0.017 inch (0.43 mm) thick, complying with ASTM A 924/A 924M. Height of sheet shall be same as wall height.
 - d. Diaphragm Sealants: ASTM C 920, Type M, polysulfide; ASTM C 920, Class 25, Type M, Grade P or NS, polyurethane; or ASTM C 881/C 881M, Type III, Grade 1, epoxy or double-fold vertical joints with mechanical seamer.
 - e. Wire: Hot-dip galvanized.
10. Domed Tank Roof: Reinforced, cast-in-place **OR** precast **OR** shotcrete, **as directed**, concrete, with at least 7 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer. Air-entrainment admixtures are permitted. Superplasticizers are prohibited.
11. Flat Tank Roof: Reinforced, cast-in-place **OR** precast, **as directed**, concrete, with at least 7 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer. Air-entrainment admixtures are permitted. Superplasticizers are prohibited.
12. Reinforcing Steel: ASTM A 767/A 767M, Grade 60 (Grade 240), zinc-coated billet steel bars.
13. Waterstops: Ribbed, PVC, 6 and 9 inches wide by 3/8 inch (150 and 225 mm wide by 10 mm) thick.
14. Bearing Pads:
- a. Material: NR **OR** ASTM D 2240, CR, with durometer hardness of 40 to 50, **as directed**.
 - b. Minimum Thickness: 1 inch (25 mm) under walls and 1/2 inch (13 mm) under roof.
 - c. Minimum Width: 3 inches (75 mm) under walls and 2 inches (50 mm) under roof.
15. Sponge Filler: ASTM D 1056, Types 2A1 through 2A4, closed-cell CR; or ASTM D 1752, Type I, sponge rubber.
16. Bolts, Nuts, Washers, and Expansion Sleeve Inserts: Stainless steel.
17. Construction and Maintenance Hatch: Aluminum **OR** Galvanized-steel, **as directed**, frame and cover at least 3/16 inch (5 mm) thick, 48-by-48-inch- (1200-by-1200-mm-) minimum-size, hinged



- cover with a 4-inch (100-mm) neck and 2-inch (50-mm) downward overlap and having a hasp and lock. Locate top of hatch above grade, **as directed**.
18. Personnel Hatch: Aluminum **OR** Galvanized-steel, **as directed**, frame and cover at least 3/16 inch (5 mm) thick, 30-inch- (760-mm-) minimum, square hinged cover with a 4-inch (100-mm) neck and 2-inch (50-mm) downward overlap and having a hasp and lock. Construct opening with capability of supporting ventilation fan. Locate top of hatch above grade, **as directed**.
 19. Tank Vents: Fiberglass **OR** Galvanized-steel, **as directed**, pipe with aluminum **OR** stainless-steel, **as directed**, screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen, **as directed**.
 20. Tank Interior Surface Sealer: Cementitious coating modified with acrylic or styrene-acrylic based polymer.
- D. Circular, Prestressed-Concrete, Surface Water-Storage Tanks
1. Comply with AWWA D115 and NFPA 22 (if tank is for fire-suppression water supply).
 2. Tank Capacity: 100,000 gal. (379 cu. m) **OR** 40,000,000 gal. (151 400 cu. m), **as directed**.
 3. Tank Height: as directed by the Owner.
 4. Tank Wall Diameter: as directed by the Owner.
 5. Tank Floor: Reinforced, cast-in-place concrete.
 6. Tank Wall:
 - a. Materials: Cast-in-place concrete, with at least 7 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer and with vertical prestressed reinforcement. Superplasticizers are prohibited.
 - b. Wall-Base Joint Sealant: ASTM C 920, Class 25, Type S, Grade P or NS, polyurethane.
 - c. Wire: Hot-dip galvanized.
 7. Domed Tank Roof: Reinforced, cast-in-place **OR** precast **OR** shotcrete, **as directed**, concrete, with at least 7 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer. Air-entrainment admixtures are permitted. Superplasticizers are prohibited.
 8. Flat Tank Roof: Reinforced, cast-in-place **OR** precast, **as directed**, concrete, with at least 7 sacks of portland cement to 1 cu. yd. (0.76 cu. m) of concrete sand in mixer. Air-entrainment admixtures are permitted. Superplasticizers are prohibited.
 9. Reinforcing Steel: ASTM A 767/A 767M, Grade 60 (Grade 240), zinc-coated billet steel bars.
 10. Waterstops: Ribbed, PVC, 6 and 9 inches wide by 3/8 inch (150 and 225 mm wide by 10 mm) thick.
 11. Bearing Pads:
 - a. Material: NR **OR** ASTM D 2240, CR, with durometer hardness of 40 to 50, **as directed**.
 - b. Minimum Thickness: 1 inch (25 mm) under walls and 1/2 inch (13 mm) under roof.
 - c. Minimum Width: 3 inches (75 mm) under walls and 2 inches (50 mm) under roof.
 12. Sponge Filler: ASTM D 1056, Types 2A1 through 2A4, closed-cell CR; or ASTM D 1752, Type I, sponge rubber.
 13. Bolts, Nuts, Washers, and Expansion Sleeve Inserts: Stainless steel.
 14. Construction and Maintenance Hatch: Aluminum **OR** Galvanized-steel, **as directed**, frame and cover at least 3/16 inch (5 mm) thick, 48-by-48-inch- (1200-by-1200-mm-) minimum-size, hinged cover with a 4-inch (100-mm) neck and 2-inch (50-mm) downward overlap and having a hasp and lock. Locate top of hatch above grade, **as directed**.
 15. Personnel Hatch: Aluminum **OR** Galvanized-steel, **as directed**, frame and cover at least 3/16 inch (5 mm) thick, 30-inch- (760-mm-) minimum, square hinged cover with a 4-inch (100-mm) neck and 2-inch (50-mm) downward overlap and having a hasp and lock. Construct opening with capability of supporting ventilation fan. Locate top of hatch above grade, **as directed**.
 16. Tank Vents: Fiberglass **OR** Galvanized-steel, **as directed**, pipe with aluminum **OR** stainless-steel, **as directed**, screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen, **as directed**.
 17. Tank Interior Surface Sealer: Cementitious coating modified with acrylic or styrene-acrylic based polymer.



- E. Paint Materials
1. Paint: Comply with AWWA D102.
 2. Primer: Tank fabricator's standard epoxy-polyamide paint.
 3. Tank Shell Interior Finish Paint: Tank fabricator's standard epoxy-polyamide paint complying with NSF 61 and compatible with prime coat.
 4. Tank Shell Exterior Intermediate Paint: Tank fabricator's standard, two-component epoxy paint compatible with prime and finish paint. Intermediate coat shall have a slight color contrast with finish coat.
 5. Tank Shell Exterior Finish Paint: Tank fabricator's standard urethane paint.
 - a. Color: As selected by the Owner from tank manufacturer's paint chart.
- F. Shop Painting
1. Factory coating according to AWWA D103.
 2. Tank Shell Interior Finish Coat: Comply with NSF 61.
 3. Tank Shell Exterior Finish Coat: Factory coating according to AWWA D103.
- G. Surface Water-Storage Tank Appurtenances
1. Water-Level Controls: Automatic controls for maintaining water level in tank, with valves, piping, and audible and visual alarms to indicate the following:
 - a. High- and low-water levels.
 - b. Tank overflowing or tank not filling.
 2. Obstruction Lighting: Comply with requirements of authorities having jurisdiction.
 3. Lightning Protection: Comply with requirements in Division 26 Section "Lightning Protection For Structures".
 4. Cathodic Protection: Comply with requirements in Division 26 Section "Cathodic Protection" and with AWWA D104.
 5. Tank Heaters: Comply with NFPA 22 and with capacity to maintain 42 deg F (6 deg C) water temperature inside surface water-storage tank.

1.3 EXECUTION

- A. Steel, Surface Water-Storage Tank Installation
1. Erect tank shell, accessories, and appurtenances according to AWWA D100 and AWWA M42.
 2. Fabricate steel plate sections in the shop (for welded-steel, surface water-storage tanks). Erect tank shell by welding plate sections in the field.
 3. Fabricate tank sections and drill or punch bolt holes in the shop (for bolted-steel, surface water-storage tanks). Install bolts during field erection of tank.
 4. Set top of reinforced-concrete foundation at least 6 inches (150 mm) above finish grade.
 5. Install roof hatch near exterior ladder.
 6. Install roof manhole near center of roof.
 7. Install tank vent at center of roof.
 8. Install two manholes in tank wall near grade.
- B. Concrete, Surface Water-Storage Tank Installation
1. Tank Wall (for wire- or strand-wound, prestressed-concrete, surface water-storage tanks): Construct tank wall and install accessories and appurtenances according to AWWA D110 and the following:
 - a. Construct cast-in-place **OR** Erect precast, **as directed**, core wall with steel diaphragm. Install solid neoprene bearing pad and 9-inch- (225-mm-) wide waterstop between wall and wall footing.
 - b. Install steel diaphragm. Apply shotcrete to interior of diaphragm to form core wall.
 - 1) Seal vertical joints in diaphragm with polysulfide, polyurethane, or epoxy sealant; or double-fold with a mechanical seamer.



- 2) Sand blast exterior of core wall to provide a well-pitted surface free from curing compounds, laitance, and form oils. Use 1.5 lb (7.3 kg) of silica sand (No. 16 grit) per square foot (meter) of surface area.
 - 3) After sandblasting, wind wires or strands around exterior of core wall separating wires by at least 2.5 wire diameters or 3/8 inch (10 mm) to ensure that mortar will be located between wires. Do not install wires at horizontal level of pipe penetrations.
 - 4) After installation of wires or strands, apply at least 3 coats of wet-mix shotcrete to exterior of tank wall in layers of at least 3/8 inch (10 mm) thick for a minimum total thickness of 1-1/2 inches (38 mm). Apply shotcrete when temperature range is at least 35 deg F (2 deg C) and rising to a maximum temperature of 95 deg F (35 deg C). Do not apply shotcrete if temperature is 40 deg F (5 deg C) and falling.
 - 5) Fill voids in wall-to-base joint and seal around waterstops, base pads, and sponge fillers with polyurethane filler.
2. Tank Wall (for circular, prestressed-concrete, surface water-storage tanks): Construct tank wall and install accessories and appurtenances according to AWWA D115 and the following:
- a. Install vertical prestressed wall with threadbars and screw nut anchors.
 - b. Sand blast exterior of core wall to provide well-pitted surface free from curing compounds, laitance, and form oils. Use 1.5 lb (7.3 kg) of silica sand (No. 16 grit) per square foot (meter) of surface area.
 - c. Apply at least 3 coats of wet-mix shotcrete to exterior of tank wall in layers of at least 3/8 inch (10 mm) thick for a minimum total thickness of 1-1/2 inches (38 mm). Apply shotcrete when temperature range is at least 35 deg F (2 deg C) and rising to a maximum temperature of 95 deg F (35 deg C). Do not apply shotcrete if temperature is 40 deg F (5 deg C) and falling.
3. Floor: Reinforced, cast-in-place concrete. Slope floor 1.0 to 1.5 percent from highest point to water outlet pipe. Pour monolithically without cold joints and provide mechanical float finish.
4. Dome Roof: Install reinforced, cast-in-place concrete with circumferential prestressing. Place 6-inch (150-mm) waterstop between roof and wall if backfill level is within 6 inches (150 mm) of top of tank wall.
- a. Install curb on roof perimeter with at least 6 downspouts spaced 60 degrees and no more than 50 feet (15 m) apart.
5. Flat Slab Roof: Install reinforced, cast-in-place concrete with drop panels and support having reinforced, cast-in-place concrete columns. Place solid neoprene bearing pads and 6-inch (150-mm) waterstop (if backfill level is within 6 inches (150 mm) of top of tank wall) between roof and wall. If voids are present between wall and roof after use of solid bearing pads, fill voids with closed-cell CR pads and soft mastic.
- a. Install curb on roof perimeter with at least 6 downspouts spaced 60 degrees and no more than 50 feet (15 m) apart.
6. Install construction and maintenance hatch near wall **OR** ladder, **as directed**.
7. Install ventilators at highest point of roof. Install others where indicated.
- C. Connections
1. Piping installation requirements are specified in Division 21 OR Division 22. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Connect tanks to water-distribution piping.
 3. Connect drains to storm-drainage piping.
 4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 5. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- D. Surface Preparation Of Steel Tanks
1. Field Cleaning: After erecting tank shell, remove burrs, dirt, and construction debris and repair damaged finishes. Remove weld splatter, sharp edges on weld seams, and scabs and slivers by grinding. Remove weld flux, slag, fins, and laminations.



2. Field Surface Preparation: After field cleaning, prepare steel surfaces where shop prime coat has been damaged, according to Specifications listed above for shop cleaning, and remove dust or residue from cleaned surfaces.
3. If surface develops rust before prime coat is applied, repeat field surface preparation.

E. Field Painting

1. Apply paint according to AWWA D102.
2. Prime-Coat Touchup: Apply primer to cleaned areas and where shop finish has been damaged during shipping, handling, and erection. Apply prime coat to a dry film thickness of 3.0 to 5.0 mils (0.08 to 0.13 mm) for tank interior and to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm) for exterior tank and support surfaces.
3. Tank Shell Interior Finish Coats: Apply 2 coats of interior finish paint above bottom ring to a dry film thickness of 4.0 to 5.0 mils (0.1 to 0.13 mm). Apply interior finish paint to surfaces below bottom ring to a dry film thickness of 8.0 to 10.0 mils (0.2 to 0.25 mm).
4. Tank Shell and Steel Support Exterior Coats: Apply intermediate paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm). Apply finish paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm).
5. Concrete tanks do not require painting **OR** Paint concrete, surface water-storage tanks according to Division 07 OR Division 09 Section(s) "High-performance Coatings", **as directed**.
6. Tank Exterior Lettering and Logo, **as directed**, (for all surface water-storage tanks): Apply one coat **OR** two coats, **as directed**, of urethane paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm) for each application.
7. Overflow Pipe: Paint pipe exterior that is outside tank and structure as indicated for tank exterior.
8. Exterior Ladders: Paint as indicated for tank shell exterior.
9. Do not paint if ambient temperature is less than 50 deg F (10 deg C) or is expected to drop below 40 deg F (5 deg C) in the next 18 hours. Do not paint if temperature of steel surface is higher than 125 deg F (52 deg C). Do not apply paint if surfaces are wet or damp, if precipitation is expected, or if relative humidity will exceed 85 percent. Do not spray paint when wind velocity exceeds 15 mph (24 km/h). Maintain at least a 24-hour waiting period between coats. Provide adequate ventilation in tank during painting to maintain clear atmosphere and provide explosion-proof flood lighting and spot lighting.
10. Complete daily painting to allow time for paint to dry before condensation is expected.

F. Surface Water-Storage Tank Appurtenance Installation

1. Install and adjust water-level control valves, piping, and alarms.
2. Install obstruction lighting according to authorities having jurisdiction.
3. Install lightning protection according Division 26 Section "Lightning Protection For Structures".
4. Install cathodic protection according to Division 26 Section "Cathodic Protection" and AWWA D104.
5. Install tank heaters according to NFPA 22.

G. Field Quality Control

1. Testing: Engage a qualified testing agency to perform the following field quality-control testing:
 - a. Tank Weld Test: Use radiographic method according to AWWA D100. Repair failures and retest.
 - b. Leak Test (for welded-steel, surface water-storage tanks): Comply with AWWA D100 and NFPA 22 (if tank is for fire-suppression water supply). Fill tanks with potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.
 - 1) Water will be furnished by the Owner.
 - c. Leak Test (for bolted-steel, surface water-storage tanks): Comply with AWWA D103 and NFPA 22 (if tank is for fire-suppression water supply). Fill tanks with potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.
 - 1) Water will be furnished by the Owner.
 - d. Leak Test (for concrete, surface water-storage tanks): Comply with AWWA D110, AWWA D115 and NFPA 22 (if tank is for fire-suppression water supply). Fill tanks with



potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.

1) Water will be furnished by the Owner.

e. Test and adjust controls and safeties (for all surface water-storage tanks). Replace damaged and malfunctioning controls and equipment.

2. Remove and replace malfunctioning units and retest as specified above.

H. Cleaning

1. Clean interior and exterior of surface water-storage tanks.

2. Disinfect surface water-storage tanks according to AWWA C652 **OR** requirements of authorities having jurisdiction, **as directed**.

END OF SECTION 22 12 19 00



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SECTION 22 12 19 00a - POTABLE-WATER STORAGE TANKS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for potable-water storage tanks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes potable-water storage tanks and related accessories for indoor installation.

C. Definitions

1. FRP: Fiberglass-reinforced plastic.
2. HDPE: High-density polyethylene plastic.
3. LDPE: Low-density polyethylene plastic.
4. PE: Polyethylene plastic.

D. Submittals

1. Product Data: For each type of potable-water storage tank indicated.
2. Manufacturer Seismic Qualification Certification
3. Source quality-control test reports.
4. Manufacturer Seismic Qualification Certification, **as directed**.

E. Quality Assurance

1. ASME Compliance for Steel Tanks: Fabricate and label steel, potable-water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.
2. ASME Compliance for FRP Tanks: Fabricate and label FRP, potable-water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, where indicated.
3. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic potable-water storage tanks and components. Include appropriate NSF marking.
4. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 to 9," for potable-water storage tanks. Include appropriate NSF marking.

1.2 PRODUCTS

A. Steel, Pressure, Potable-Water Storage Tanks

1. Description: Steel, horizontal **OR** vertical, **as directed**, pressure-rated tank with cylindrical sidewalls.
2. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
3. Construction: ASME code, steel **OR** Steel, **as directed**, constructed with nontoxic welded joints, for 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working pressure.
4. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter; same pressure rating as tank.
5. Tappings: Factory-fabricated steel **OR** stainless steel, **as directed**, welded to tank before testing and labeling.
 - a. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
 - b. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.
6. Specialties and Accessories: Include pressure relief valve; pressure gage; thermometer; air-charging connection; and gage glass, brass fittings, compression stops, and gage-glass guard.



7. Horizontal Tank Supports: Factory-fabricated steel saddles, welded to tank before testing and labeling.
 8. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.
 9. Tank Interior Finish: Materials and thicknesses complying with NSF 61 barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
 - a. Lining Material: Cement **OR** Copper, **as directed**.
 - b. Coating: Epoxy resin **OR** Galvanized **OR** Glass **OR** Nickel, **as directed**.
 10. Exterior Coating: Galvanized **OR** Manufacturer's standard enamel paint **OR** Primer paint, **as directed**.
- B. Steel, Nonpressure, Potable-Water Storage Tanks
1. Description: Steel, horizontal **OR** vertical, **as directed**, nonpressure-rated tank with cylindrical sidewalls.
 2. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
 3. Construction: Steel, constructed with nontoxic welded joints.
 4. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter.
 5. Cover for Open Tank: Plastic **OR** Steel, with lining same as or similar to tank lining and, **as directed**, with shape that encloses top of tank.
 6. Tappings: Factory-fabricated steel **OR** stainless steel, **as directed**, welded to tank.
 - a. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
 - b. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.
 7. Specialties and Accessories: Include tappings in the tank and the following:
 - a. Vacuum relief valve.
 - b. Free air vent with insect screen.
 - c. Thermometer.
 - d. Gage glass, brass fittings, compression stops, and gage-glass guard.
 8. Horizontal Tank Supports: Factory-fabricated steel saddles, welded to tank before testing and labeling.
 9. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.
 10. Tank Interior Finish: Materials and thicknesses complying with NSF 61 barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
 - a. Lining Material: Cement **OR** Copper, **as directed**.
 - b. Coating: Epoxy resin **OR** Galvanized **OR** Glass **OR** Nickel, **as directed**.
 11. Exterior Coating: Galvanized **OR** Manufacturer's standard enamel paint **OR** Primer paint, **as directed**.
- C. Steel, Floating-Wafer, Pressure, Potable-Water Storage Tanks
1. Description: Steel, vertical, pressure-rated tank with cylindrical sidewalls and with floating-wafer separator.
 2. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
 3. Construction: ASME code, steel **OR** Steel, **as directed**, constructed with nontoxic welded joints, for 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working pressure.
 4. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter; same pressure rating as tank.
 5. Floating Wafer: Nontoxic plastic, of diameter to match tank.
 6. Tappings: Factory-fabricated steel **OR** stainless steel, **as directed**, welded to tank before testing and labeling.
 - a. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
 - b. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.
 7. Specialties and Accessories: Include tappings in tank and the following:
 - a. Pressure relief valve.



- b. Pressure gage.
 - c. Thermometer.
 - d. Air-charging connection.
 - e. Gage glass, brass fittings, compression stops, and gage-glass guard.
 8. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.
 9. Tank Interior Finish: Materials and thicknesses complying with NSF 61 barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
 - a. Lining Material: Cement **OR** Copper, **as directed**.
 - b. Coating: Epoxy resin **OR** Galvanized **OR** Glass **OR** Nickel, **as directed**.
 10. Exterior Coating: Galvanized **OR** Manufacturer's standard enamel paint **OR** Primer paint, **as directed**.
- D. Steel, Precharged, Pressure, Potable-Water Storage Tanks
1. Steel, Precharged, Diaphragm, Pressure, Potable-Water Storage Tanks
 - a. Description: Steel, vertical, pressured-rated tank with cylindrical sidewalls and with air-charging valve and air precharge.
 - b. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
 - c. Operation: Factory-installed, butyl-rubber diaphragm.
 2. Steel, Precharged, Bladder, Water Storage Tanks
 - a. Description: Steel, vertical, pressured-rated tank with cylindrical sidewalls and with air-charging valve and air precharge.
 - b. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
 - c. Operation: Factory-installed, butyl-rubber bladder.
 3. Construction: ASME code, steel **OR** Steel, **as directed**, constructed with nontoxic welded joints, for 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working pressure.
 4. Tappings: Factory-fabricated steel **OR** stainless steel, **as directed**, welded to tank before testing and labeling.
 - a. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
 - b. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.
 5. Specialties and Accessories: Include tappings in tank and pressure gage.
 6. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.
 7. Tank Interior Finish: Materials and thicknesses complying with NSF 61 barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
 - a. Lining Material: Cement **OR** Copper, **as directed**.
 - b. Coating: Epoxy resin **OR** Galvanized **OR** Glass **OR** Nickel, **as directed**.
 8. Exterior Coating: Galvanized **OR** Manufacturer's standard enamel paint **OR** Primer paint, **as directed**.
- E. Insulated, Steel, Pressure, Potable-Water Storage Tanks
1. Description: Steel, vertical, pressure-rated tank with cylindrical sidewalls.
 2. Construction: ASME code, steel **OR** Steel, **as directed**, constructed with nontoxic welded joints, for 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working pressure.
 3. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter; same pressure rating as tank.
 4. Tappings: Factory-fabricated steel **OR** stainless steel, **as directed**, welded to tank before testing and labeling.
 - a. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
 - b. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.
 5. Specialties and Accessories: Include pressure relief valve; pressure gage; thermometer; air-charging connection; and gage glass, brass fittings, compression stops, and gage-glass guard.
 6. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.



7. Tank Interior Finish: Materials and thicknesses complying with NSF 61 barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
 - a. Lining Material: Cement **OR** Copper, **as directed**.
 - b. Coating: Epoxy resin **OR** Galvanized **OR** Glass **OR** Nickel, **as directed**.
 8. Insulation: Factory-installed, fiberglass or polyurethane foam; surrounding entire tank except connections and other openings; suitable for tank operating temperature; and complying with ASHRAE/IESNA 90.1.
 9. Jacket: Steel, with manufacturer's standard finish, unless otherwise indicated.
- F. Steel, Gravity, Nonpressure, Potable-Water Storage Tanks
1. Description: Steel, horizontal **OR** vertical, **as directed**, nonpressure-rated tank with cylindrical **OR** rectangular, **as directed**, sidewalls.
 2. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
 3. Construction: Nonpressure rated, factory or field fabricated from ASTM A 794 steel sheets, with nontoxic welded joints.
 4. Reinforcement: ASTM A 36/A 36M, structural-steel shapes, welded to tank as required to maintain tank shape.
 5. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter **OR** wide, **as directed**.
 6. Tappings: Factory-fabricated steel **OR** stainless steel, **as directed**, welded to tank.
 - a. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
 - b. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.
 7. Specialties and Accessories: Include tappings in tank and the following:
 - a. Vacuum relief valve.
 - b. Free air vent with insect screen.
 - c. Thermometer.
 - d. Gage glass, brass fittings, compression stops, and gage-glass guard.
 8. Horizontal Tank Supports: Factory-fabricated steel saddles or legs, welded to tank.
 9. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank.
 10. Tank Interior Finish: Materials and thicknesses complying with NSF 61 barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
 - a. Lining Material: Cement **OR** Copper, **as directed**.
 - b. Coating: Epoxy resin **OR** Galvanized **OR** Glass **OR** Nickel, **as directed**.
 11. Exterior Coating: Galvanized **OR** Manufacturer's standard enamel paint **OR** Primer paint, **as directed**.
- G. Plastic, Pressure, Potable-Water Storage Tanks
1. Description: FRP, vertical, pressure-rated tank with cylindrical sidewalls.
 2. Construction: ASME code, composite FRP **OR** Composite FRP, **as directed**, contact-molded or filament-wound, thermosetting-resin tank for 100-psig (690-kPa) **OR** 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working pressure.
 - a. Tank Lining Material: Nontoxic HDPE **OR** LDPE, **as directed**, complying with NSF 61 barrier materials for potable-water tanks.
 3. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter; same pressure rating as tank.
 4. Tappings: Factory-fabricated, reinforced FRP flanged-end nozzle.
 - a. NPS 2 (DN 50) and Smaller: Include plastic-to-steel transition fitting from tank nozzle flange to ASME B1.20.1, female thread.
 - b. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.
 5. Specialties and Accessories: Include tappings in tank and the following:
 - a. Pressure relief valve.
 - b. Pressure gage.
 - c. Thermometer.
 6. Vertical Tank Supports: Factory-fabricated steel legs or reinforced FRP skirt attached by FRP brackets to tank sidewall.



7. Tank Interior Finish: Materials and thicknesses complying with NSF 61 barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
- H. Plastic, Nonpressure, Potable-Water Storage Tanks
1. FRP, Potable-Water Storage Tanks:
 - a. Description: FRP, vertical, nonpressure-rated water tank; complying with NSF 61 barrier materials for potable-water tanks.
 - b. Construction: ASTM D 3299, filament-wound **OR** ASTM D 4097, contact-molded, **as directed**, FRP.
 - c. Tappings: Factory-fabricated, FRP flanged-end nozzle.
 - 1) NPS 2 (DN 50) and Smaller: Include plastic-to-steel transition fitting from tank nozzle flange to ASME B1.20.1, female thread.
 - a) Exception: Tappings may be threaded FRP coupling integral with nozzle for connections for plastic piping.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged.
 - d. Vertical Tank Support: Separate factory-fabricated steel stand, capable of supporting tank.
 2. PE, Potable-Water Storage Tanks:
 - a. Description: PE, vertical, flat-bottom, nonpressure-rated water tank; complying with NSF 61 barrier materials for potable-water tanks.
 - b. Construction: ASTM D 1998, molded PE.
 - c. Tappings: Factory-fabricated bulkhead fittings, attached to tank.
 - 1) NPS 2 (DN 50) and Smaller: With female thread.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged.
 - d. Vertical Tank Support: Separate factory-fabricated steel stand, capable of supporting entire bottom of tank.
 3. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter.
 4. Cover for Open Tank: Plastic, same as or similar to tank material and with shape that encloses top of tank.
 5. Specialties and Accessories: Include vacuum relief valve; free air vent with insect screen; thermometer; and gage glass, brass fittings, compression stops, and gage-glass guard.
- I. Source Quality Control
1. Test and inspect potable-water storage tanks according to the following tests and inspections and prepare test reports:
 - a. Pressure Testing for ASME-Code, Potable-Water Storage Tanks: Hydrostatically test to ensure structural integrity and freedom from leaks. Fill tanks with water, vent air, pressurize to 1-1/2 times tank pressure rating, disconnect test equipment, hold pressure for 30 minutes with no drop in pressure, and check for leaks. Replace tanks that fail test with new tanks, and repeat until test is satisfactory.
 - b. Pressure Testing for Non-ASME-Code, Pressure, Potable-Water Storage Tanks: Hydrostatically test to ensure structural integrity and freedom from leaks at pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Fill tanks with water, vent air, pressurize tanks, disconnect test equipment, hold pressure for two hours with no drop in pressure, and check for leaks. Repair or replace tanks that fail test with new tanks and repeat until test is satisfactory.
 - c. Nonpressure Testing for Potable-Water Storage Tanks: Fill tanks to water operating level to ensure structural integrity and freedom from leaks. Hold water level for two hours with no drop in water level. Repair or replace tanks that fail test with new tanks, and repeat until test is satisfactory.

1.3 EXECUTION

A. Concrete Bases

1. Install concrete bases of dimensions indicated for tanks. Refer to Division 03 Section(s) "Cast-in-place Concrete" AND Division 22 Section(s) "Common Work Results For Plumbing".

**B. Installation**

1. Install water storage tanks on concrete bases, level and plumb, firmly anchored. Arrange so devices needing servicing are accessible.
 - a. Install horizontal tanks on concrete piers and factory-fabricated **OR** fabricated steel supports and, **as directed**, saddles.
2. Anchor tank supports and tanks to substrate.
 - a. Use steel or FRP straps over or around plastic tanks.
3. Install tank seismic restraints.
4. Install thermometers and pressure gages on water storage tanks and piping, if indicated. Thermometers and pressure gages are specified in Division 22 Section "Meters And Gages For Plumbing Piping".
5. Install the following devices on tanks where indicated:
 - a. Pressure relief valves.
 - b. Temperature and pressure relief valves.
 - c. Vacuum relief valves.
 - d. Tank vents on nonpressure tanks.
 - e. Connections to accessories.
6. After installing tanks with factory finish, inspect finishes and repair damages to finishes.

C. Connections

1. Piping installation requirements are specified in other Division 14.. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to potable-water storage tanks to allow service and maintenance.
3. Connect water piping to water storage tanks with unions or flanges and with shutoff valves. Connect tank drains with shutoff valves and discharge over closest floor drains.
 - a. General-duty valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
 - 1) Valves NPS 2 (DN 50) and Smaller: Gate or ball.
 - 2) Valves NPS 2-1/2 (DN 65) and Larger: Gate or butterfly.
 - 3) Drain Valves: NPS 3/4 (DN 20) gate or ball valve. Include outlet with, or nipple in outlet with, ASME B1.20.7, 3/4-11.5NH thread for garden-hose service, threaded cap, and chain.
 - b. Water Piping Connections: Make connections to dissimilar metals with dielectric fittings. Dielectric fittings are specified in Division 22 Section "Common Work Results For Plumbing".
 - c. Connect air piping to hydropneumatic tanks with unions or flanges and gate or ball valves. Make connections to dissimilar metals with dielectric fittings, which are specified in Division 22 Section "Common Work Results For Plumbing".

D. Field Quality Control

1. Perform the following final checks before filling:
 - a. Verify that air precharge in precharged tanks is correct.
 - b. Test operation of tank accessories and devices.
 - c. Verify that pressure relief valves have correct setting.
 - 1) Manually operate pressure relief valves.
 - 2) Adjust pressure settings.
 - d. Verify that vacuum relief valves are correct size.
 - 1) Manually operate vacuum relief valves.
 - 2) Adjust vacuum settings.
2. Filling Procedures: Follow manufacturer's written procedures. Fill tanks with water to operating level.

E. Cleaning

1. Clean and disinfect potable-water storage tanks.



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2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed, use procedure described in AWWA C652.

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**SECTION 22 12 23 13 - ELECTRIC, DOMESTIC WATER HEATERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for electric, water heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following electric water heaters:
 - a. Household, small-capacity electric water heaters.
 - b. Household, storage electric water heaters.
 - c. Household, collector-to-tank, solar-electric water heaters.
 - d. Household, collector-to-tank, heat-exchanger-coil, solar-electric water heaters.
 - e. Flow-control, instantaneous electric water heaters.
 - f. Thermostat-control, instantaneous electric water heaters.
 - g. Light-commercial electric water heaters.
 - h. Commercial electric booster heaters.
 - i. Commercial, storage electric water heaters.
 - j. Compression tanks.
 - k. Water heater accessories.

C. Submittals

1. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
 - a. Product Data for Prerequisite EA 2: Documentation indicating that units comply with ASHRAE/IESNA 90.1, Section 7 - "Service Water Heating."
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
3. ASME Compliance: Where indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
4. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for all components that will be in contact with potable water.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Structural failures including storage tank and supports.



- 2) Faulty operation of controls.
- 3) Deterioration of metals, metal finishes, and other materials beyond normal use.
- b. Warranty Period(s): From date of Final Completion:
 - 1) Household Electric Water Heaters:
 - a) Storage Tank: Five **OR** Six **OR** 10, **as directed**, years.
 - b) Controls and Other Components: Two **OR** Three, **as directed**, years.
 - 2) Instantaneous Electric Water Heaters: One **OR** Two **OR** Five, **as directed**, year(s).
 - 3) Light-Commercial Electric Water Heaters:
 - a) Storage Tank: Three **OR** Five, **as directed**, years.
 - b) Controls and Other Components: Two **OR** Three, **as directed**, years.
 - 4) Commercial Electric Water Heaters:
 - a) Storage Tank: Three **OR** Five, **as directed**, years.
 - b) Controls and Other Components: Three **OR** Five, **as directed**, years.
 - 5) Compression Tanks: One year.

1.2 PRODUCTS

A. Household Electric Water Heaters

1. Household, Small-Capacity Electric Water Heaters: Comply with UL 174.
 - a. Storage-Tank Construction: Corrosion-resistant metal or steel with corrosion-resistant coating, **as directed**.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed Storage-Tank Appurtenances:
 - 1) Drain Valve: ASSE 1005, if tank has drain outlet. Provide hose-end drain valve in piping for water heaters without drain outlet. Hose-end drain valves are specified in Division 22 Section "Domestic Water Piping Specialties".
 - 2) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 3) Jacket: Steel with enameled finish.
 - 4) Heating Element: Electric, screw-in immersion type.
 - 5) Temperature Control: Adjustable thermostat.
 - 6) Safety Control: High-temperature-limit cutoff device or system.
 - 7) Power Supply Cord: 24 to 72 inches (610 to 1830 mm) with plug.
 - 8) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
2. Household, Standard **OR** Tabletop, **as directed**, Storage Electric Water Heaters: Comply with UL 174.
 - a. Storage-Tank Construction: Steel.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - a) Standard: Cylindrical shape.



- b) Tabletop: Rectangular shape, with flat-top work surface and raised back.
 - 6) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - 7) Heating Elements: Two; electric, screw-in immersion type with 12 kW or less total, and wired for nonsimultaneous operation, unless otherwise indicated.
 - 8) Temperature Control: Adjustable thermostat for each element.
 - 9) Safety Control: High-temperature-limit cutoff device or system.
 - 10) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
3. Household, Collector-to-Tank, Solar-Electric Water Heaters: Comply with UL 174 with piping and electrical connections for UL 1279 solar collector system.
- a. Storage-Tank Construction: Steel.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed Storage-Tank Appurtenances:
 - 1) Sensor electrical connections and tank stud for sensor.
 - 2) Anode Rod: Replaceable magnesium.
 - 3) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 4) Drain Valve: ASSE 1005.
 - 5) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 6) Jacket: Steel with enameled finish.
 - 7) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - 8) Heating Element: One; electric, screw-in immersion type with 6 kW or less.
 - 9) Temperature Control: Adjustable thermostat for each element.
 - 10) Safety Control: High-temperature-limit cutoff device or system.
 - 11) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
4. Household, Collector-to-Tank, Heat-Exchanger-Coil, Solar-Electric Water Heaters: Comply with UL 174 with integral coil-type heat exchanger.
- a. Storage-Tank Construction: Steel.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - 7) Heat Exchanger: Corrosion-resistant-metal immersion coil.
 - 8) Heating Element: One; electric, screw-in immersion type with 6 kW or less.
 - 9) Temperature Control: Adjustable thermostat for each element.
 - 10) Safety Control: High-temperature-limit cutoff device or system.
 - 11) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater



working-pressure rating. Select relief valve with sensing element that extends into storage tank.

B. Instantaneous Electric Water Heaters

1. Flow-Control, Instantaneous Electric Water Heaters: Comply with UL 499 for tankless electric (water heater) heating appliance.
 - a. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
 - 1) Connections: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Heating Element: Resistance heating system.
 - 4) Temperature Control: Flow-control fitting.
 - 5) Safety Control: High-temperature-limit cutoff device or system.
 - 6) Jacket: Aluminum or steel with enameled finish or plastic.
 - b. Support: Bracket for wall mounting.
2. Thermostat-Control, Instantaneous Electric Water Heaters: Comply with UL 499 for tankless electric (water heater) heating appliance.
 - a. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
 - 1) Connections: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Heating Element: Resistance heating system.
 - 4) Temperature Control: Thermostat.
 - 5) Safety Control: High-temperature-limit cutoff device or system.
 - 6) Jacket: Aluminum or steel with enameled finish or plastic.
 - b. Support: Bracket for wall mounting.

C. Light-Commercial Electric Water Heaters

1. Description: Comply with UL 174 for household, storage electric water heaters.
 - a. Storage-Tank Construction: Steel, vertical arrangement.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - 7) Heating Elements: Two; electric, screw-in immersion type; wired for simultaneous operation, unless otherwise indicated.
 - 8) Temperature Control: Adjustable thermostat for each element.
 - 9) Safety Control: High-temperature-limit cutoff device or system.
 - 10) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
 - c. Special Requirements: NSF 5 construction with legs for off-floor installation.

D. Commercial Electric Water Heaters

1. Commercial Electric Booster Heaters: Comply with UL 1453 requirements for booster-type water heaters.



- a. Storage-Tank Construction: Corrosion-resistant metal **OR** Steel, **as directed**.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 3) Insulation: Comply with ASHRAE/IESNA 90.1.
 - 4) Jacket: Rectangular shaped, with stainless-steel front panel, unless otherwise indicated.
 - 5) Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
 - a) Option: Booster heaters with 9 kW or less total may have 2 or 3 elements.
 - b) Staging: Input not exceeding 18 kW per step.
 - 6) Temperature Control: Adjustable thermostat, to setting of at least 180 deg F (82 deg C).
 - 7) Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 - 8) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3, combination temperature and pressure relief valve. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
 - 9) Gages: Combination temperature and pressure type or separate thermometer and pressure gage.
 - c. Special Requirements: NSF 5 construction with brackets for undercounter **OR** legs for floor, **as directed**, installation.
2. Commercial, Storage Electric Water Heaters: Comply with UL 1453 requirements for storage-tank-type water heaters.
 - a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel horizontal **OR** vertical, **as directed**, arrangement.
 - 1) Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 3) Insulation: Comply with ASHRAE/IESNA 90.1.
 - 4) Jacket: Steel with enameled finish.
 - 5) Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
 - a) Staging: Input not exceeding 18 kW per step.
 - 6) Temperature Control: Adjustable thermostat.
 - 7) Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 - 8) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - c. Special Requirements: NSF 5 construction.



- d. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

E. Compression Tanks

1. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
 - a. Construction:
 - 1) Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Air-Charging Valve: Factory installed.

F. Water Heater Accessories

1. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.
2. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than water heater working-pressure rating.
3. Water Heater Stand and Drain-Pan Units: High-density-polyethylene-plastic, 18-inch- (457-mm-) high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 (DN 25) drain outlet with ASME B1.20.1 pipe thread.
4. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Include dimension that will support bottom of water heater a minimum of 18 inches (457 mm) above the floor.
5. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.
6. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 3/4 (DN 20).
7. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that are capable of isolating each water heater and of providing balanced flow through each water heater.
8. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
9. Water Regulators: ASSE 1003, water-pressure reducing valve. Set at 25-psig- (172.5-kPa-) maximum outlet pressure, unless otherwise indicated.
10. Shock Absorbers: ASSE 1010 or PDI WH 201, Size A water hammer arrester.

G. Source Quality Control

1. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
2. Hydrostatically test commercial, **as directed**, water heater storage tanks before shipment to minimum of one and one-half times pressure rating.
3. Prepare test reports.

1.3 EXECUTION

A. Water Heater Installation

1. Install commercial water heaters on concrete bases.
 - a. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.



- b. Concrete base construction requirements are specified in Division 22 Section "Common Work Results For Plumbing".
 2. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 3. Install seismic restraints for light-commercial and commercial water heaters. Anchor to substrate.
 4. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
 5. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
 6. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.
 7. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters And Gages For Plumbing Piping" for thermometers.
 8. Install thermometers on inlet and outlet piping of household, collector-to-tank, solar-electric water heaters. Refer to Division 22 Section "Meters And Gages For Plumbing Piping" for thermometers.
 9. Install pressure gage(s) on inlet and outlet of commercial electric water- heater piping. Refer to Division 22 Section "Meters And Gages For Plumbing Piping" for pressure gages.
 10. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve, thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section "General-duty Valves For Plumbing Piping" for general-duty valves and to Division 22 Section "Meters And Gages For Plumbing Piping" for thermometers.
 11. Install water regulator, with integral bypass relief valve, in booster-heater inlet piping and water hammer arrester in booster-heater outlet piping.
 12. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
 13. Fill water heaters with water.
 14. Charge compression tanks with air.
- B. Connections
 1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
 3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
 2. Perform the following field tests and inspections and prepare test reports:
 - a. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - b. Operational Test: After electrical circuitry has been energized, confirm proper operation.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.



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3. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

D. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial and instantaneous electric water heaters.

END OF SECTION 22 12 23 13

**SECTION 22 12 23 13a - FUEL-FIRED, DOMESTIC WATER HEATERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fuel-fired water heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following fuel-fired water heaters:
 - a. Household, atmospheric, storage, gas water heaters.
 - b. Household, direct-vent, storage, gas water heaters.
 - c. Household, power-vent, storage, gas water heaters.
 - d. Instantaneous, tankless, gas water heaters.
 - e. Commercial, atmospheric, storage, gas water heaters.
 - f. Commercial, power-burner, storage, gas water heaters.
 - g. Commercial, power-vent, storage, gas water heaters.
 - h. Commercial, high-efficiency, gas water heaters.
 - i. Commercial, coil-type, finned-tube, gas water heaters.
 - j. Commercial, grid-type, finned-tube, gas water heaters.
 - k. Household, oil-fired water heaters.
 - l. Commercial, oil-fired water heaters.
 - m. Large-capacity, oil-fired water heaters.
 - n. Dual-fuel, gas and oil-fired water heaters.
 - o. Compression tanks.
 - p. Water heater accessories.

C. Definitions

1. LP Gas: Liquefied-petroleum fuel gas.

D. Submittals

1. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
 - a. Product Data for Prerequisite EA 2: Documentation indicating that units comply with ASHRAE/IESNA 90.1, Section 7 - "Service Water Heating."
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment". Include the following:
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
3. ASME Compliance:



- a. Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.
4. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Structural failures including storage tank and supports.
 - 2) Faulty operation of controls.
 - 3) Deterioration of metals, metal finishes, and other materials beyond normal use.
 - b. Warranty Period(s): From date of Final Completion:
 - 1) Household, Gas Water Heaters:
 - a) Storage Tank: Five **OR** Six **OR** 10, **as directed**, years.
 - b) Controls and Other Components: Two **OR** Three, **as directed**, years.
 - 2) Instantaneous, Gas Water Heaters:
 - a) Heat Exchanger: Five years.
 - b) Controls and Other Components: Three years.
 - 3) Commercial, Gas Water Heaters:
 - a) Storage Tank: Three **OR** Five, **as directed**, years.
 - b) Controls and Other Components: Three **OR** Five, **as directed**, years.
 - 4) Oil-Fired Water Heaters:
 - a) Storage Tank: Three **OR** Five, **as directed**, years.
 - b) Burner and Controls: One **OR** Two **OR** Three, **as directed**, year(s).
 - c) Other Components: Three **OR** Five, **as directed**, years.
 - 5) Dual-Fuel Water Heaters:
 - a) Storage Tank: Three **OR** Five, **as directed**, years.
 - b) Burner and Controls: One **OR** Two **OR** Three, **as directed**, year(s).
 - c) Other Components: Three **OR** Five, **as directed**, years.
 - 6) Compression Tanks: One year.

1.2 PRODUCTS

A. Household, Gas Water Heaters

1. Household, Atmospheric, Storage, Gas Water Heaters: Comply with ANSI Z21.10.1/CSA 4.1.
 - a. Storage-Tank Construction: Steel.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Burner: For use with atmospheric water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.



- 8) Temperature Control: Adjustable thermostat.
 - 9) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - 10) Combination Temperature and Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
 - c. Draft Hood: Low-profile-type, draft diverter; complying with ANSI Z21.12.
 - d. Automatic Damper: ANSI Z21.66, electrically operated **OR** mechanically activated **OR** thermally activated, **as directed**, automatic-vent-damper device with size matching draft hood.
2. Household, Direct-Vent, Storage, Gas Water Heaters: Comply with ANSI Z21.10.1/CSA 4.1.
- a. Storage-Tank Construction: Steel.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Burner: For use with direct-vent water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
 - 8) Temperature Control: Adjustable thermostat.
 - 9) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - 10) Combination Temperature and Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
 - c. Direct-Vent System: Through-wall **OR** Through-roof, **as directed**, coaxial- or double-channel, vent assembly with water heater manufacturers' outside intake/exhaust screen.
3. Household, Power-Vent, Storage, Gas Water Heaters: Comply with ANSI Z21.10.1/CSA 4.1.
- a. Storage-Tank Construction: Steel.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Burner: For use with power-vent water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
 - 8) Temperature Control: Adjustable thermostat.
 - 9) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - 10) Combination Temperature and Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
 - c. Power-Vent System: Exhaust fan, interlocked with burner.



B. Instantaneous, Gas Water Heaters

1. Description: Comply with ANSI Z21.10.3/CSA 4.3, except storage is not required.
 - a. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Heat Exchanger: Copper tubing.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Burner: For use with tankless water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 6) Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.
 - 7) Temperature Control: Adjustable thermostat.
 - 8) Jacket: Metal with enameled finish or plastic.
 - b. Support: Bracket for wall mounting.

C. Commercial, Gas Water Heaters

1. Commercial, Atmospheric, Storage, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.
 - a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel with 150-psig (1035-kPa) working-pressure rating.
 - 1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - 5) Jacket: Steel with enameled finish.
 - 6) Burner: For use with atmospheric water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
 - 8) Temperature Control: Adjustable thermostat.
 - 9) Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - 10) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - c. Special Requirements: NSF 5 construction.
 - d. Draft Hood: Draft diverter; complying with ANSI Z21.12.
 - e. Automatic Damper: ANSI Z21.66, electrically operated **OR** mechanically activated **OR** thermally activated, **as directed**, automatic-vent-damper device with size matching draft hood.
 - f. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
2. Commercial, Power-Burner, Storage, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.



- a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel with 150-psig (1035-kPa) working-pressure rating.
 - 1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - 5) Jacket: Steel with enameled finish.
 - 6) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - c. Burner: Comply with UL 795 for power-burner water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 1) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
 - d. Temperature Control: Adjustable thermostat.
 - e. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - f. Special Requirements: NSF 5 construction.
 - g. Draft Hood: Draft diverter; complying with ANSI Z21.12.
 - h. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
3. Commercial, Power-Vent, Storage, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.
 - a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel with 150-psig (1035-kPa) working-pressure rating.
 - 1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - 5) Jacket: Steel with enameled finish.



- 6) Burner: For use with power-vent water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
 - 8) Temperature Control: Adjustable thermostat.
 - 9) Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - 10) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valve with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - c. Special Requirements: NSF 5 construction.
 - d. Power-Vent System: Exhaust fan, interlocked with burner.
 - e. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
4. Commercial, High-Efficiency, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.
- a. Description: Manufacturer's proprietary design to provide at least 84 **OR** 85 **OR** 88 **OR** 95, **as directed**, percent combustion efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.
 - b. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.
 - 1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - c. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - 5) Jacket: Steel with enameled finish.
 - 6) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - d. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - e. Temperature Control: Adjustable thermostat.
 - f. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - g. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
 - h. Draft Hood: Draft diverter; complying with ANSI Z21.12.
5. Commercial, Coil-Type, Finned-Tube, Gas Water Heaters: Comply with ANSI Z21.13 for hot-water boilers.
- a. Description: Packaged unit with boiler, storage tank, pump, piping, and controls.



- b. Boiler Construction: ASME code with 160-psig (1100-kPa) working-pressure rating for hot-water-boiler-type water heater.
 - 1) Heat Exchanger: Helix or spiral, finned-copper-tube coils with bronze headers.
 - 2) Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - c. Boiler Appurtenances:
 - 1) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire boiler except connections and controls.
 - 2) Jacket: Steel with enameled finish.
 - 3) Burner: For use with coil-type, finned-tube water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 4) Temperature Control: Adjustable, storage tank temperature-control fitting and flow switch, interlocked with circulator and burner.
 - 5) Safety Control: Automatic, high-temperature-limit cutoff device or system.
 - 6) Automatic Ignition: Intermittent electronic ignition complying with ANSI Z21.20.
 - d. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
 - e. Support: Steel base or skids.
 - f. Draft Hood: Draft diverter; complying with ANSI Z21.12.
 - g. Automatic Damper: ANSI Z21.66, electrically operated **OR** mechanically activated **OR** thermally activated, **as directed**, automatic-vent-damper device with size matching draft hood.
 - h. Hot-Water Storage Tank: Connected with piping to circulating pump and water heater.
 - 1) Construction: According to ASME Boiler and Pressure Vessel Code: Section VIII, steel with 150-psig (1035-kPa) **OR** 125-psig (860-kPa), **as directed**, working-pressure rating.
 - 2) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - 5) Jacket: Steel with enameled finish.
 - 6) Anode Rods: Factory installed, magnesium.
 - 7) Drain Valve: Corrosion-resistant metal complying with ASSE 1005, factory installed.
 - 8) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - i. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.
 - j. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.
 - k. Mounting: Water heater, tank, and accessories factory mounted on skids.
6. Commercial, Grid-Type, Finned-Tube, Gas Water Heaters: Comply with ANSI Z21.13 for hot-water boilers.
- a. Description: Packaged unit with boiler, storage tank, pump, piping, and controls.



- b. Boiler Construction: ASME code with 160-psig (1100-kPa) working-pressure rating for hot-water-boiler-type water heater.
 - 1) Heat Exchanger: Horizontal, straight, finned-copper tubes with bronze headers.
 - 2) Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
- c. Boiler Appurtenances:
 - 1) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire boiler except connections and controls.
 - 2) Jacket: Steel with enameled finish.
 - 3) Burner: For use with grid-type, finned-tube water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
 - 4) Temperature Control: Adjustable, storage tank temperature-control fitting and flow switch, interlocked with circulator and burner.
 - 5) Safety Control: Automatic, high-temperature-limit cutoff device or system.
 - 6) Automatic Ignition: Intermittent electronic ignition complying with ANSI Z21.20.
- d. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
- e. Support: Steel base or skids.
- f. Draft Hood: Draft diverter; complying with ANSI Z21.12.
- g. Automatic Damper: ANSI Z21.66, electrically operated **OR** mechanically activated **OR** thermally activated, **as directed**, automatic-vent-damper device with size matching draft hood.
- h. Hot-Water Storage Tank: Connected with piping to circulating pump and water heater.
 - 1) Construction: According to ASME Boiler and Pressure Vessel Code: Section VIII, steel with 150-psig (1035-kPa) **OR** 125-psig (860-kPa), **as directed**, working-pressure rating.
 - 2) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - 5) Jacket: Steel with enameled finish.
 - 6) Anode Rods: Factory installed, magnesium.
 - 7) Drain Valve: Corrosion-resistant metal complying with ASSE 1005, factory installed.
 - 8) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
- i. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.
- j. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.
- k. Mounting: Water heater, tank, and accessories factory mounted on skids.

D. Oil-Fired Water Heaters



1. Household, Oil-Fired Water Heaters: Comply with UL 732 for storage water heaters.
 - a. Storage-Tank Construction: Steel.
 - 1) Tappings: ASME B1.20.1 pipe thread.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Temperature Control: Adjustable thermostat.
 - 7) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - 8) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - c. Oil Burner: Comply with UL 296 for use with No. 2 fuel oil.
 - d. Draft Regulator: Barometric type or adjustable-damper device.
2. Commercial, Oil-Fired Water Heaters: Comply with UL 732 for storage water heaters.
 - a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel with 150-psig (1035-kPa) minimum working-pressure rating.
 - 1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Temperature Control: Adjustable thermostat.
 - 7) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - c. Oil Burners: Comply with UL 296 for use with No. 2 fuel oil.
 - d. Safety Control: Automatic, high-temperature-limit cutoff device or system.
 - e. Draft Regulator: Barometric type or adjustable-damper device.
 - f. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
3. Large-Capacity, Oil-Fired Water Heaters: Comply with UL 732 for storage water heaters except when capacity is greater than 120 gal. (454 L).
 - a. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.



- 1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
- 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
- 3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
- b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Temperature Control: Adjustable thermostat.
 - 7) Safety Control: Automatic, high-temperature-limit cutoff device or system.
 - 8) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
- c. Oil Burner: Comply with UL 296 for use with No. 2 fuel oil.
- d. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
- e. Draft Regulator: Barometric type or adjustable-damper device.
- f. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

E. Dual-Fuel Water Heaters

1. Description: Comply with ANSI Z21.10.3/CSA 4.3 or UL 732 requirements appropriate for dual-fuel, gas and oil-fired water heaters.
 - a. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.
 - 1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - b. Factory-Installed, Storage-Tank Appurtenances:
 - 1) Anode Rod: Replaceable magnesium.
 - 2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - 3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - 4) Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
 - 5) Jacket: Steel with enameled finish.
 - 6) Temperature Control: Adjustable thermostat.



- 7) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - c. Dual-Fuel Burners: Combination gas-oil burner assembly, complying with appropriate requirements of UL 795; or comply with UL 296 for oil burners for No. 2 fuel oil and UL 795 for natural-gas **OR** LP-gas, **as directed**, fuel.
 - d. Safety Control: Automatic, high-temperature-limit cutoff device or system.
 - e. Vent Connection: According to standards of authorities having jurisdiction for dual-fuel water heaters.
 - f. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
- F. Compression Tanks
1. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
 - a. Construction:
 - 1) Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Air-Charging Valve: Factory installed.
- G. Water Heater Accessories
1. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.
 2. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.
 3. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.
 4. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.
 - a. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
 - b. Oil-Fired Water Heaters: ASME rated and stamped and complying with ASME PTC 25.3.
 5. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.
 - a. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
 - b. Oil-Fired Water Heaters: ASME rated and stamped and complying with ASME PTC 25.3.
 6. Water Heater Stand and Drain Pan Units: High-density-polyethylene-plastic, 18-inch- (457-mm-) high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 (DN 25) drain outlet with ASME B1.20.1 pipe thread.
 7. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Provide dimension that will support bottom of water heater a minimum of 18 inches (457 mm) above the floor.
 8. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.
 9. Drain Pans: Corrosion-resistant metal with raised edge. Provide dimensions not less than base of water heater and include drain outlet not less than NPS 3/4 (DN 20).
 10. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.
 11. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2, **as directed**.
- H. Source Quality Control



1. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
2. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.
3. Prepare test reports.

1.3 EXECUTION

A. Water Heater Installation

1. Install commercial water heaters on concrete bases.
 - a. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
 - b. Concrete base construction requirements are specified in Division 22 Section "Common Work Results For Plumbing".
2. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
3. Install seismic restraints for commercial water heaters. Anchor to substrate.
4. Install gas water heaters according to NFPA 54.
5. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.
6. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
7. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.
8. Install oil-fired water heaters according to NFPA 31.
9. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
10. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
11. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.
12. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters And Gages For Plumbing Piping" for thermometers.
13. Install pressure gage(s) on inlet and outlet piping of commercial, fuel-fired water heater piping. Refer to Division 22 Section "Meters And Gages For Plumbing Piping" for pressure gages.
14. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section "General-duty Valves For Plumbing Piping" for general-duty valves and to Division 22 Section "Meters And Gages For Plumbing Piping" for thermometers.
15. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
16. Fill water heaters with water.
17. Charge compression tanks with air.

B. Connections



1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
 3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
 2. Perform the following field tests and inspections and prepare test reports:
 - a. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - b. Operational Test: After electrical circuitry has been energized, confirm proper operation.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.
- D. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instantaneous and commercial water heaters.

END OF SECTION 22 12 23 13a



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SECTION 22 12 23 26 - UNDERGROUND STORAGE TANKS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of underground storage tanks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Intent of Work

1. It is the intent of this specification to ensure that the work, as completed, shall meet or exceed all applicable codes, ordinances, rules and regulations of every authority having jurisdiction in the area.
2. The installation shall include all necessary equipment, controls, valves and fittings, excavation, backfill as described or called for on the plans. In some cases, the Contractor shall prepare the plans. In any case, the Contractor shall obtain all permits at its expense.
3. The Contractor shall install equipment in accordance with manufacturer's recommendations. Where drawings (if any) and specification conflict with manufacturer's recommendations, it shall be the Contractor's responsibility to bring this to the attention of the Owner before installation.
4. The overall intent shall be that the Contractor shall provide everything required to make a complete and operational job in every respect.

C. Codes And Standards

1. Reference is to the latest edition of the code or standard unless otherwise noted. Comply with the latest EPA requirements.
2. The codes and standards referred to are the minimum standards. Where the requirements of these specifications and the accompanying drawings (if any) exceed those of the codes and standards, the drawings and specifications shall supersede.
3. The installation shall conform to provisions of the NFPA requirement with latest amendments.
4. The entire installation including all equipment shall conform to The Occupational and Safety Health Act of 1970, and all EPA regulations.

- #### D. Visit To Site: Bidders are advised to visit the site and carefully examine the existing conditions before submitting bids, as no allowance will be made for lack of knowledge of existing conditions where such conditions may reasonably be determined by observation.

E. Permits

1. Obtain all permits required for the installation of this work and pay all fees in connection therewith. Permits and fees involved in removal of any item from the site shall be included.
2. Provide copies of inspection and testing certificates from all agencies and authorities having jurisdiction.

F. Layout Basis

1. The layout, which must be stamped by an Engineer registered in the State in which the Project is located, is based upon the use of particular items of equipment, identified by manufacturer's make and model number. Dimensions, arrangements, efficiency and service connections required for these particular items have been considered in making the layout. Contractor shall submit any deviations proposed with its bid.
2. The Contractor may use the equipment of any manufacturer listed as approved for substitution provided they have the proper connections, capacities, efficiency and dimensions. Variances from the requirements stated herein shall be sustainable reasons for disapproval of the submitted equipment. All costs arising from variances in substituted items shall be paid for by the Contractor.



3. Equivalent products by other manufacturers must be submitted to the the Owner for prior approval at least ten (10) days prior to bid date.

G. Submittals

1. All submittals shall bear a stamp or notation indicating that the Contractor has reviewed the submittals for compliance with drawings, governing authorities and specifications.
2. All submittals shall bear sufficient notations to clearly indicate the specific make, model number, accessories, capacities, options, and specification paragraph numbers.
3. All submittals shall indicate complete compliance with all performance and specification requirements as herein specified and/or indicated or shall specifically list any exceptions. Exceptions shall be subject to approval by the the Owner.
4. The review (by the the Owner) of equipment does not relieve the Contractor of the responsibility for compliance with the contract documents or authorities as specified.
5. Contractor shall coordinate electrical characteristics of equipment with electrical specifications and the available power characteristics.
6. Materials requiring shop drawing submittals shall not be installed prior to shop drawings being reviewed by the the Owner. The Contractor agrees that failure to conform to the above may result in removal of all installed materials that have been disapproved from the project. Installation of specified equipment will be mandatory. Removal of disapproved equipment shall be at the sole expense of the Contractor.
7. Submit the following for review via shop drawings (to be approved or disapproved):
 - a. Xerxes or approved equal, double wall (do not unload manually). Size and capacity.
 - b. Bury depth.
 - c. Bed and backfill (not over 7'-0" traffic and no traffic).
 - d. Double walls when continuous vacuum pump and monitor are used require a maximum burial depth of three (3) feet from tank top to grade.
 - e. When not subjected to traffic loads, use 24" backfill or 12" minimum backfill plus 4" re-bar reinforced concrete on top.
 - f. When subjected to traffic loads, use 36" backfill or 18" minimum backfill plus 6" of re-bar reinforced concrete.
 - g. If tank is 12'-0" in diameter (actually, 7'-11" is manufactured for large gallonage) then, no traffic shall be provided with 42" minimum cover, or 38" backfill plus 4" re-bar reinforced concrete. With traffic, use 38" backfill plus 6" of asphalt or 6" of re-bar reinforced concrete.
 - h. Monitoring fittings, fiberglass reservoir, vapor sensor 4" tank fittings, tank fill tube insert, venting, stage two vapor recovery system, manway and manway extensions, manway risers, site monitoring wells, barricades, installation check list, hydrostatic tank monitoring.
 - i. Job site safety precautions.
 - j. Reservoir fiberglass sensor.
 - k. Reservoir leak detection.
 - l. Electronic control panels, sensor circuit, transmission contact switch power source circuit, alarm bell, alarm bell silence button, control panel false alarms, etc.
 - m. Piping sump bottom, usually 28 3/8" x 30".
 - n. Flex connectors to piping.
 - o. Unions, nipples, manway cover, FRP fitting, opening for stage II vapor recovery line if required.
 - p. 3" pipe sump fitting.
 - q. When using piping sump sensor equal to Owens Corning fiberglass model PSS, submit system including electrical power supply and signal wiring.
 - r. Control panel equal to Owens Corning fiberglass model SB-0011B (single circuit) or SB-0014B (4 circuit) as applicable.
 - s. Fiberglass pipe and fittings equal to "Ameron" type Dualoy 3000/L pressure rated and with chemically resistant epoxy resin for the service intended. The Dualoy 3000/L shall be a secondary containment system. No other product piping will be acceptable.

H. Guarantee



1. Contractor shall guarantee that if any materials or workmanship covered by these specifications proves defective within one (1) year, such defects shall be corrected by the Contractor at once without charge to the Owner.

1.2 PRODUCTS:

A. Single-Wall Fiberglass Underground Storage Tanks

1. The tank shall comply with the following governing standards:
 - a. Underwriters Laboratories, Inc. (UL) Standard 1316. A UL certification plate shall be attached to each tank.
 - b. National Sanitation Foundation Standard, NSF Standard 61.
 - c. ANSI/AWWA D120-02 Thermosetting Fiberglass-Reinforced Plastic Tanks.
 - d. Military Specification No. MIL-T-52777(A)
2. The Contractor shall provide and install the "fiberglass" underground storage tanks. Tanks shall be as manufactured by Xerxes Corporation, Minneapolis, MN or approved equal as judged by the Owner. Follow manufacturer's instructions for installation and testing.
3. Loading Conditions: Tank shall meet the following design criteria:
 - a. Internal Load: Tank shall be designed to withstand a 5-psig air-pressure test with 5:1 safety factor. When tank is designed for on-site testing, contractor shall individually test tank for leakage prior to installation. Maximum test pressure is 5 psig (3 psig for a 12-foot diameter tank).
 - b. Vacuum Test: Tanks 10-foot diameter and smaller shall be designed to withstand a vacuum test to 11.5 inches of mercury.
 - c. Surface Loads: Tank shall withstand surface H-20 axle loads when properly installed according to tank manufacturer's current Installation Manual and Operating Guidelines.
 - d. External Hydrostatic Pressure: Tank shall be capable of being buried in ground with 7 feet of overburden over the top of the tank, the hole fully flooded and a safety factor of 5:1 against general buckling.
 - e. Tank shall support accessory equipment- such as internal pump platforms, drop/fill tubes, submersible pumps and ladders- when installed according to tank manufacturer's current Installation Manual and Operating Guidelines.
4. Product Storage:
 - a. Tank shall be capable of storing water products with specific gravity up to 1.1.
 - b. Tank shall be vented to atmospheric pressure.
 - c. Tank shall be capable of storing products identified in the manufacturer's current standard limited warranty.
5. Materials:
 - a. Tank shall be manufactured with 100% resin and glass-fiber reinforcement No sand fillers.
 - b. The laminate materials used in the internal coating system of a portable water tank shall conform to the requirements of NSF Standard 61.
 - c. Tank Dimensions: as directed by the Owner.
6. Manways (Required for Potable Water Tanks): Shall be flanged and 22-inch I.D. **OR** 30-inch I.D (for larger tanks), **as directed**, complete with gasket, bolting hardware and cover. Optional manway extensions shall be FRP.

B. Double-Wall Fiberglass Underground Storage Tanks

1. The Contractor shall provide and install the "fiberglass" underground storage tanks of the specified volume and diameter.
2. The tank shall be of fiberglass. Tank laminates shall be constructed of 100% resin and fiberglass reinforcements without sand fillers. Ribs are to be integrally cast into tank body. Tanks shall bear the listing mark of Underwriters' Laboratories, Inc. Tank shall have an annular space between the primary and secondary shell walls to allow for free flow and containment of all leaked product from primary tank. This space shall be filled at the factory with a brine solution for hydrostatic monitoring. Tanks shall be as manufactured by Xerxes Corporation, Minneapolis, MN or approved equal as judged by the Owner.



3. The tank shall comply with the following governing standards:
 - a. ASTM Standard Document No. 4021-81
 - b. Underwriters' Laboratories, Inc. (UL.) File #MH-9061 (N) for underground storage of flammable liquids. A UL certification plate shall be attached to each tank.
 - c. Military Specification No. MIL-T-52777(A)
 - d. Factory Mutual Systems approval J.I. IG4AO.AF
 - e. National Sanitation Foundation, Standard 14
 - f. National Fire Protection Association (NFPA-30), (NFPA-30A) Flammable and Combustible Liquid Code and (NFPA-31) Standard for Installation of Oil Burning Equipment.
 4. The tank shall be capable of the following loading conditions:
 - a. Internal load: Tank shall withstand 5 psi air pressure test with 5 to 1 safety factor. Contractor shall test prior to installation as this is to test for leakage. Maximum test pressure is 5 psi.
 - b. Vacuum Test: Every tank shall be tested to 11.5 inches (primary tank) and 9.5 inches (secondary tank) mercury vacuum by the tank manufacturer to assure structural integrity.
 - c. Surface Loads: Tank shall withstand surface H-20 axle load when properly installed according to current manufacturer's installation instruction (32,000 lbs.).
 - d. External hydrostatic pressure: Tank shall withstand 7' of overburden with the hole fully flooded with 7:1 safety factor against buckling.
 5. Provide glass fiber-reinforced plastic straps for the tank shown. Provide number and location of straps as specified by the manufacturer. Each strap shall be capable of withstanding the buoyancy load of 25,000 lbs. for 8' tank diameter. Straps shall be standard as supplied by the tank manufacturer. A concrete pad or concrete deadman must be used with anchor straps as recommended by tank manufacturer.
 6. The Contractor shall provide fiberglass piping sump with fittings as indicated. The piping sump shall be manufactured by Xerxes Corporation or approved equal and supplied with tanks.
 - a. The piping sump shall be installed so that it is suitable for monitoring the double-wall piping system and containment of its product. Piping sump shall be located on tanks 22" minimum manway.
 7. All tank fittings shall be standard (proofed tight) as supplied by the tank manufacturer. The tank shall have an opening for one each of the following:
 - a. Fill/Manual Gauging
 - b. Vent/Overfill/Stage One Vapor Recovery
 - c. Pump (pressure system) or supply and return (suction system)
 - d. In tank gauging automatic inventory control
 - e. Others as shown or required by the operating agency
 8. The tank shall have a factory filled brine interstitial and reservoir for continuous monitoring of both inner and outer walls.
 9. Tank to be installed per manufacturer installation instructions which will be inspected as it progresses.
- C. Spill Protection
1. Universal model 70CD, or approved equal, spill containment shall be used as containment basin for spills during filling. A manual valve, if so required, shall be used to return any spilled product back to tank.
- D. Overfill Prevention
1. Universal model 37, or approved equal, float valve is to be used for overfill prevention. The automatic shut off device must stop the flow of product being delivered when tank is 90% full. Access must be provided.
- E. Stage One Vapor Recovery
1. Stage one vapor recovery is incorporated into the access assembly of the overfill prevention access way. See drawing for details. (Less than 10,000 gals per month through flow)



- F. Stage Two Vapor Recover
1. Piping for stage two vapor recovery will be installed for future use. Required for gasoline motor fuel only. (More than 10,000 gales per month through flow)
- G. Tank Trim
1. Surface manholes shall have all cast iron rim and minimum 10" galvanized steel skirt. Tank trim shall have Universal Valve.
- H. Submersible Turbine Pump Specifications
1. General Pump Specifications: The pump shall be designed to pump gasoline, diesel, kerosene and jet fuel. The entire pumping assembly shall have UL listing and shall meet all requirements of UL79. The pump discharge head and manifold assembly shall be manufactured from ASTM A 48 Class 30 grey iron. The pump shall be available in 1/3, 3/4, and 1-1/2 hp sizes and shall be manufactured to the proper length as determined by the tank diameter, type of tank, and bury depth. The pump motor shall have a thermal over current overload protector with automatic reset. The pump motor assembly shall be clearly marked with pertinent information including Model, Horsepower, Voltage, Phase, and Manufacturer. The pump motor shall be a permanent split phase capacitor type, and shall incorporate a 15 mfd capacitor. The pumping unit shall not incorporate any flexible diaphragms and all sealing shall be accomplished with "o" ring or UL recognized fiber gaskets. The pump shall have a removable intake screen with openings no greater than 3/32 inch. The pump shall be manufactured by FE Petro, Inc., McFarland, WI. or approved equal as judged by the the Owner.
 2. Installation and Maintenance Specifications: The pump shall have a two-wire field connection and an easy access ground wire terminal, and shall incorporate a wire seal plug which will accommodate three wires. The pump shall incorporate a port for line pressure testing that shall be sealed with a 1/4 NPT pipe plug. The pump unit shall have a fully extractable head in order to permit removal of the pump motor assembly without disturbing the discharge piping or the electrical wiring. The product in the pipelines shall be held in place by a line check valve that shall have a minimum sealing of 170 lbs when the pump is not running. The line check valve shall be independent of the removable head and shall be easily accessible. The removal of the extractable portion of the pump shall not disturb product in the pipelines downstream of the check valve. During the removal of the extractable portion of the pump, product contained in the discharge manifold of the pump shall drain automatically into the storage tank. The pump motor shall be interchangeable by horsepower with different manufacturers' product.
 3. Operation Specifications: The pump shall have an air/vapor elimination system that returns air or vapors to the underground storage tank through a tube discharging near the top of the pump motor assembly. The pump unit shall contain a built-in expansion relief valve that relieves pressure above pumping pressure but below 50 psi. The pump motor shall utilize the product being pumped for lubrication of the motor bearings and for cooling the stator, and this fluid shall discharge into the underground storage tank at the top of the motor. The pump shall have siphon capability built into the pump as standard.
- I. Piping System
1. All piping fittings and adhesives shall be UL listed made of fiberglass double wall. Pipe shall be in compliance with ASTM D 2996 and classified by designation code RTRP-11AF-3111. Pipe shall be filament wind of continuous glass filament. Pipe must have a minimum bend radius of 50 feet on 2" primary (80 feet on 3" secondary) to allow settling of tank. Pipe shall have maximum tensile loads of 1160 lbs, compressive loads 2210 lbs at 75 degrees Fahrenheit on 2" primary. 3" pipe shall have tensile load of 2020 lbs at 75 degrees and compressive loads of 3850 lbs. Pipe to be factory proof tested at 1000 psig-2", 700 psig-3". Pipe shall be Smith Fiberglass Red thread II, or approved equal as judged by the Owner.
 2. Vent piping shall not have secondary containment. Vent shall not be sloped less than 1/4" per foot downward to tank.
 3. Product piping shall have secondary containment. Product piping shall not be sloped less than 1/8" per foot downward toward tank.
 4. All piping must slope back toward tank.



5. All piping must be installed as per manufacturer installation instructions. the Owner shall monitor each installation daily.

J. Leak Detection

1. Tank shall have a Pullulert FD241RRA, or approved equal, float probe mounted on the brine filled hydrostatic reservoir. The system shall monitor both the inner and outer walls of the tank.
 - a. Alarm Conditions:
 - 1) Hydrocarbons in hydrostatic reservoir
 - 2) A loss of fluid in reservoir
2. Piping shall have a Pollulert FD241RRA, or approved equal, float probe mounted in the piping sump. System shall monitor the piping sump compartment that has to be designed to catch any leaked product from the primary piping system. This probe shall distinguish the difference between water and hydrocarbons and alarm on any one or both conditions.
3. Remote monitoring piping sumps shall be installed only if piping can not be sloped toward tank. The Contractor shall use as many remote monitoring piping sumps as needed to assure that all sections of piping are monitored. All monitoring sumps shall have a Pollulert FD241RRA or approved equal probe for leak detection.
4. Control panel shall have probe status for wet, dry, or hydrocarbon. Alarm conditions are to be selectable. Control panel must have installed relay or provision for installing relays for remote alarms. Control panel shall have both visual and audible alarm. System shall have a two year warranty from date of manufacture. Ground water probes shall be adjustable 1/8" to 2" for product detection. Probes shall be wired by a single cable run. Systems must be UL listed for Class 1, Division 1, Group D locations and meet all existing EPA regulations. Leak detection shall be Pollulert systems or approved equal.
5. Submersible pump shall have a mechanical in-line leak detector with a free floating check valve. Leak detector shall be vaporless LD2000 or approved equal.

K. In Tank Gauging System

1. Gauging system shall provide inventory management designed to continuously monitor underground storage tanks. System must provide information on inventory, delivery of fuel, and product through-put. System must measure fuel levels, water level and fuel temperature. This is to ensure proper compensated level readings. System shall have five temperature sensors, two floats, one for product level, one for water interface. System shall have a 48 character LCD display and internal thermal printer. System shall utilize a magnetostrictive probe and have visual, audible alarm with automatic printout. The system shall be designed to have 16 input on/off devices, RS232 port full duplex with adjustable baud rate. Tank gauging system shall be Pollulert system or approved equal.

L. Test For Pipe

1. Test of the piping system shall be made per manufacturer's recommendations.
2. Furnish the Owner with a certificate stating that all piping has been tested as specified and has been shown to be tight.
3. The piping systems may be tested in sections if necessary, but a final test may be required of the entire piping system at the completion of the system. The final test shall be made while pipe is exposed to view where possible.
4. Both primary and secondary pipe must be tested.

M. Test For Tank

1. Pre-installation: All Xerxes or approved equal tanks shall be tested prior to shipment, but it is required that all tanks be tested by the Contractor prior to installation. After installation and before final backfilling to grade, the tank must be retested to assure that no damage occurred during installation.
2. Hose/Valve Assembly: In order to test the tank, the hose/valve assembly must be connected from the reservoir to a service fitting. The hose/valve assembly will already be connected from the reservoir to a service fitting when the tank is shipped. If the hose/valve assembly is not connected



- when the tank is delivered, contact the Customer Service Representative at the Xerxes or other plant nearest you, before attempting to test the tank.
3. Primary (Internal) Tank Test: Prior to installation, check to see that all service and monitor fittings are plugged and tightened, except the service fitting with a temporary plastic plug. Close the valve on the hose/valve assembly. Remove the temporary plastic plug and connect the pressure source to the service fitting. Pressure test the primary (internal) tank to 5 psig for 60 minutes.
 4. Secondary (External) Tank Test:
 - a. CAUTION: Never pressurize the secondary tank or (annular space) without connecting it to the primary tank. The secondary tank and primary tank will be properly connected if the hose/valve assembly is in place as shipped. Failure to have the secondary tank and primary tank properly connected could potentially result in tank failure and personal injury, and will void all warranties.
 - b. While the primary tank is still under pressure, open the valve on the hose/valve assembly until the pressure stabilizes. Once the pressure has stabilized, either add or subtract air pressure to stabilize the pressure at 5 psig. Observe the tank for any liquid on the exterior surface and check the gauge at the pressure source for any drop in pressure.
 - c. After completing the test, relieve the pressure at the source.
- N. Product Dispenser
1. A fiberglass containment box shall be installed with each product dispenser. Containment box shall be as manufactured by Petro Fiberglass or approved equal. Double wall pipe shall terminate inside containment box. A flex connector as manufactured by Dana Everflex or approved equal shall be used to connect product pipe to the shear valve within the containment box. The shear valve shall be air tested at the factory and shall not lose its seal when its top is removed for service. Shear valve shall be Universal model 521 or approved equal. Each product dispensing hose shall be equipped with a re-connectable breakaway featuring a pressure balancing chamber to prevent nuisance breaks and shall disconnect at 200 lbs. A hose coupling shall separate the breakaway and hose swivel. The nozzle shall have a means of automatically stopping flow if the nozzle is not at the proper dispensing angle. Nozzle shall be of die-cast construction UL listed and have a flow equalizer to maintain 10 GPM flow. Breakaway, hose coupling, hose swivel, and nozzle shall be as manufactured by Husky or approved equal. Dispenser shall be compatible with vapor recovery systems.

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SECTION 22 12 23 26a - FACILITY FUEL-OIL PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for facility fuel-oil piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes fuel-oil, fuel-oil and diesel-fuel-oil, and diesel-fuel-oil distribution systems and the following:
 - a. Pipes, tubes, and fittings.
 - b. Piping and tubing joining materials.
 - c. Piping specialties.
 - d. Valves.
 - e. Vertical, steel, fuel-oil ASTs.
 - f. Horizontal, steel, fuel-oil ASTs.
 - g. Containment-dike, steel, fuel-oil ASTs.
 - h. Insulated, steel, fuel-oil ASTs.
 - i. Concrete-vaulted, steel, fuel-oil ASTs.
 - j. Steel, fuel-oil USTs with STI-P3.
 - k. Composite, steel, fuel-oil USTs.
 - l. Jacketed, steel, fuel-oil USTs.
 - m. FRP fuel-oil USTs.
 - n. Fuel-oil AST accessories.
 - o. Fuel-oil UST accessories.
 - p. Fuel-oil storage tank piping specialties.
 - q. Fuel-oil storage tank pumps.
 - r. Fuel-transfer pumps.
 - s. Fuel maintenance system.
 - t. Liquid-level gage system.
 - u. Leak-detection and monitoring system.
 - v. Mechanical sleeve seals.
 - w. Grout.
 - x. Concrete bases.

C. Definitions

1. AST: Aboveground storage tank.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
5. FPM: Vinylidene fluoride-hexafluoropropylene copolymer rubber.
6. FRP: Glass-fiber-reinforced plastic.
7. UST: Underground storage tank.

D. Performance Requirements

1. Maximum Operating-Pressure Ratings: 3-psig (21-kPa) fuel-oil supply pressure at oil-fired appliances.



2. Delegated Design: Design restraint and anchors for fuel-oil piping, ASTs, and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Seismic Performance: Factory-installed support attachments for AST shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event, **as directed**."

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For facility fuel-oil piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
3. Delegated-Design Submittal: For fuel-oil piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of anchors and seismic restraints.
 - b. Design Calculations: Calculate requirements for selecting seismic restraints.
 - c. Detail fabrication and assembly of pipe anchors, hangers, supports for multiple pipes, and attachments of the same to building structure.
4. Seismic Qualification Certificates: For ASTs, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Brazing certificates.
6. Welding certificates.
7. Field quality-control reports.
8. Operation and Maintenance Data.
9. Warranty: Sample of special warranty.

F. Quality Assurance

1. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
2. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.
6. Comply with requirements of the EPA and of state and local authorities having jurisdiction. Include recording of fuel-oil storage tanks and monitoring of tanks and piping.

G. Delivery, Storage, And Handling

1. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.
2. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.



3. Store pipes and tubes with protective PE coating to avoid damaging the coating and to protect from direct sunlight.
4. Store PE pipes and valves protected from direct sunlight.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-oil storage tanks and flexible, double-containment piping and related equipment that fail in materials or workmanship within specified warranty period.
 - a. Storage Tanks:
 - 1) Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding 150 deg F (66 deg C):
 - a) Structural failures including cracking, breakup, and collapse.
 - b) Corrosion failure including external and internal corrosion of steel tanks.
 - 2) Warranty Period: 30 years from date of Final Completion.
 - b. Flexible, Double-Containment Piping and Related Equipment:
 - 1) Failures due to defective materials or workmanship for materials installed together, including piping, dispenser sumps, entry boots, and sump mounting adapters.
 - 2) Warranty Period: 10 **OR** 30, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. See Part 1.3 piping schedule articles for where pipes, tubes, fittings, and joining materials are applied in various services.
2. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - a. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - b. Wrought-Steel Welding Fittings: ASTM A 234/A 234M, for butt and socket welding.
 - c. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - d. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1) Material Group: 1.1.
 - 2) End Connections: Threaded or butt welding to match pipe.
 - 3) Lapped Face: Not permitted underground.
 - 4) Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
 - 5) Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.
 - e. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - 1) Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
3. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**.
 - a. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
 - b. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - 1) Gasket Material: Asbestos free, ASME B16.20, metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
 - 2) Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.
4. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**.
 - a. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
 - b. Flare Fittings: Comply with ASME B16.26 and SAE J513.
 - 1) Copper fittings with long nuts.
 - 2) Metal-to-metal compression seal without gasket.
 - 3) Dryseal threads complying with ASME B1.20.3.



B. Double-Containment Pipe And Fittings

1. Flexible, Double-Containment Piping: Comply with UL 971.
 - a. Pipe Materials: PVDF complying with ASTM D 3222 for carrier pipe with mechanical couplings to seal carrier, and PE pipe complying with ASTM D 4976 for containment piping.
 - b. Fiberglass **OR** PE, **as directed**, sumps.
 - c. Watertight sump entry boots, pipe adapters with test ports and tubes, coaxial fittings, and couplings.
 - d. Minimum Operating Pressure Rating: 10 psig (69 kPa).
 - e. Plastic to Steel Pipe Transition Fittings: Factory-fabricated fittings with plastic end matching or compatible with carrier piping, and steel pipe end complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - f. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.
2. Rigid, Double-Containment Piping: Comply with UL 971.
 - a. RTRP: ASTM D 2996 or ASTM D 2997 carrier and containment piping and mechanical couplings to seal carrier and containment piping or individually bonded joints.
 - 1) Minimum Operating-Pressure Rating for RTRP NPS 2 and NPS 3 (DN 50 and DN 80): 150 psig (1035 kPa).
 - 2) Minimum Operating-Pressure Rating for RTRP NPS 4 and NPS 6 (DN 100 and DN 150): 125 psig (860 kPa). Compliance with UL 971 is not required for NPS 6 (DN 150) and larger piping.
 - 3) Fittings: RTRF complying with ASTM D 2996 or ASTM D 2997, and made by RTRP manufacturer; watertight sump entry boots, termination, or other end fittings.
 - b. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

C. Piping Specialties

1. Flexible Connectors: Comply with UL 567.
 - a. Metallic Connectors:
 - 1) Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.
 - 2) Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
 - 3) Minimum Operating Pressure: 150 psig (1035 kPa).
 - 4) End Connections: Socket, flanged, or threaded end to match connected piping.
 - 5) Maximum Length: 30 inches (762 mm).
 - 6) Swivel end, 50-psig (345-kPa) maximum operating pressure.
 - 7) Factory-furnished anode.
 - b. Nonmetallic Connectors:
 - 1) Listed and labeled for underground applications by an NRTL acceptable to authorities having jurisdiction.
 - 2) PTFE bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
 - 3) Minimum Operating Pressure: 150 psig (1035 kPa).
 - 4) End Connections: Socket, flanged, or threaded end to match connected piping.
 - 5) Maximum Length: 30 inches (762 mm).
 - 6) Swivel end, 50-psig (345-kPa) maximum operating pressure.
 - 7) Factory-furnished anode.
2. Y-Pattern Strainers:
 - a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.



- c. Strainer Screen: 60 **OR** 80, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 125 psig (860 kPa).
 3. Basket Strainers:
 - a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: 60 **OR** 80, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 125 psig (860 kPa).
 4. T-Pattern Strainers:
 - a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
 - b. End Connections: Grooved ends.
 - c. Strainer Screen: 60 **OR** 80, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
 - d. CWP Rating: 750 psig (5170 kPa).
 5. Manual Air Vents:
 - a. Body: Bronze.
 - b. Internal Parts: Nonferrous.
 - c. Operator: Screwdriver or thumbscrew.
 - d. Inlet Connection: NPS 1/2 (DN 15).
 - e. Discharge Connection: NPS 1/8 (DN 6).
 - f. CWP Rating: 150 psig (1035 kPa).
 - g. Maximum Operating Temperature: 225 deg F (107 deg C).
- D. Joining Materials
 1. Joint Compound and Tape: Suitable for fuel oil.
 2. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
 3. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.
 4. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.
- E. Manual Fuel-Oil Shutoff Valves
 1. See valve schedule in Part 1.3 for where each valve type is applied in various services.
 2. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller for Liquid Service: Comply with UL 842.
 - a. CWP Rating: 125 psig (860 kPa).
 - b. Threaded Ends: Comply with ASME B1.20.1.
 - c. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 - d. Tamperproof Feature: Locking feature for valves indicated in the valve schedule.
 - e. Service Mark: Initials "WOG" shall be permanently marked on valve body.
 3. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with UL 842.
 - a. CWP Rating: 125 psig (860 kPa).
 - b. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 - c. Tamperproof Feature: Locking feature for valves indicated in the valve schedule.
 - d. Service Mark: Initials "WOG" shall be permanently marked on valve body.
 4. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated brass.
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE; blowout proof.
 - e. Packing: Separate packnut with adjustable-stem packing threaded ends.



- f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
 - g. CWP Rating: 600 psig (4140 kPa).
 - h. Service Mark: Initials "WOG" shall be permanently marked on valve body.
5. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
- a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated bronze.
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE; blowout proof.
 - e. Packing: Threaded-body packnut design with adjustable-stem packing.
 - f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
 - g. CWP Rating: 600 psig (4140 kPa).
 - h. Service Mark: Initials "WOG" shall be permanently marked on valve body.
6. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
- a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated bronze.
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE.
 - e. Packing: Threaded-body packnut design with adjustable-stem packing.
 - f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
 - g. CWP Rating: 600 psig (4140 kPa).
 - h. Service Mark: Initials "WOG" shall be permanently marked on valve body.

F. Specialty Valves

1. Pressure Relief Valves: Comply with UL 842.
 - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
 - b. Body: Brass, bronze, or cast steel.
 - c. Springs: Stainless steel, interchangeable.
 - d. Seat and Seal: Nitrile rubber.
 - e. Orifice: Stainless steel, interchangeable.
 - f. Factory-Applied Finish: Baked enamel.
 - g. Maximum Inlet Pressure: 150 psig (1035 kPa).
 - h. Relief Pressure Setting: 60 psig (414 kPa).
2. Oil Safety Valves: Comply with UL 842.
 - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
 - b. Body: Brass, bronze, or cast steel.
 - c. Springs: Stainless steel.
 - d. Seat and Diaphragm: Nitrile rubber.
 - e. Orifice: Stainless steel, interchangeable.
 - f. Factory-Applied Finish: Baked enamel.
 - g. Manual override port.
 - h. Maximum Inlet Pressure: 60 psig (414 kPa).
 - i. Maximum Outlet Pressure: 3 psig (21 kPa).
3. Emergency Shutoff Valves: Comply with UL 842.
 - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
 - b. Single **OR** Double, **as directed**, poppet valve.
 - c. Body: ASTM A 126, cast iron.
 - d. Disk: FPM.
 - e. Poppet Spring: Stainless steel.
 - f. Stem: Plated brass.
 - g. O-Ring: FPM.
 - h. Packing Nut: PTFE-coated brass.
 - i. Fusible link to close valve at 165 deg F (74 deg C).



- j. Thermal relief to vent line pressure buildup due to fire.
- k. Air test port.
- l. Maximum Operating Pressure: 0.5 psig (3.45 kPa).
- 4. Mechanical Leak Detector: Comply with UL 842.
 - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
 - b. Body: ASTM A 126, cast iron.
 - c. O-Rings: Elastomeric compatible with fuel oil.
 - d. Piston and Stem Seals: PTFE.
 - e. Stem and Spring: Stainless steel.
 - f. Piston Cylinder: Burnished brass.
 - g. Indicated Leak Rate: Maximum 3 gph (3 mL/s) at 10 psig (69 kPa).
 - h. Leak Indication: Reduced flow.
- G. Vertical, Steel, Fuel-Oil AST
 - 1. Description:
 - a. UL 142, single-wall, vertical, steel tank.
 - b. UL 142 and STI F921, **as directed**, double-wall, vertical, steel tank; with primary- and secondary-containment walls and interstitial space.
 - 2. Construction: Fabricated with welded, carbon steel suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and maintained temperature up to 150 deg F (66 deg C).
- H. Horizontal, Steel, Fuel-Oil AST
 - 1. Description:
 - a. UL 142, single-wall, horizontal, steel tank.
 - b. UL 142 and STI F921, **as directed**, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and interstitial space.
 - 2. Construction: Fabricated with welded, carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to 150 deg F (66 deg C).
 - 3. Supports:
 - a. Manufacturer's standard structural steel welded to tank.
 - b. Manufacturer's standard type and number, steel or cast-iron cradles, for field installation.
- I. Containment-Dike, Steel, Fuel-Oil AST
 - 1. Description: UL 142 and STI F911, single-wall, horizontal, steel tank; with open or enclosed **OR** enclosed, **as directed**, secondary-containment dike with capacity greater than tank capacity.
 - 2. Construction: Fabricated with welded, carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to 150 deg F (66 deg C).
- J. Insulated, Steel, Fuel-Oil AST
 - 1. Description: UL 142 and UL 2085 **OR** UL 142, UL 2085, and STI F941, **as directed**, thermally insulated and fire-resistant, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and insulation and with interstitial space.
 - 2. Construction: Fabricated with welded, carbon steel and insulation; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature according to UL 2085.
- K. Concrete-Vaulted, Steel, Fuel-Oil AST
 - 1. Description: UL 142 and UL 2085 **OR** UL 142, UL 2085, and STI F941, **as directed**; thermally insulated, fire-resistant and protected, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and insulation and with interstitial space.



2. Construction: Fabricated with welded, carbon steel and insulation and encased in concrete that will protect from bullets; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature according to UL 2085.
- L. Steel, Fuel-Oil UST With STI-P3
1. Description: UL 58 and STI P3, double-wall, horizontal, steel tank; with cathodic protection and electrical isolation.
 - a. Containment Method: STI-P3, Type I, with primary and secondary walls in contact **OR** Type II, with interstitial space, **as directed**.
 2. Construction: Fabricated with welded steel; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:
 - a. Depth of Bury: 3 feet (1 m) from top of tank to finished surface.
 - b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
 - c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).
 3. Corrosion-Protection System: Protect tank and factory-installed piping by engineered and installed corrosion-protection system according to STI P3, with means of monitoring cathodic protection.
- M. Composite, Steel, Fuel-Oil UST
1. Description: UL 58, double-wall, horizontal, composite tank; with coating complying with UL 1746 and STI F894.
 - a. Containment Method: STI F894, Type I, with primary and secondary walls in contact **OR** Type II, with interstitial space, **as directed**.
 2. Construction: Fabricated with welded steel and factory coating according to UL 1746 and STI F894; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:
 - a. Depth of Bury: 3 feet (1 m) from top of tank to finished surface.
 - b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
 - c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).
- N. Jacketed, Steel, Fuel-Oil UST
1. Description: Jacketed, horizontal, steel tank; complying with UL 58, and with plastic or fiberglass jacket and corrosion-protection system according to UL 1746 and STI F922, **as directed**.
 2. Construction: Tank fabricated with welded carbon steel, and jacket fabricated with plastic or fiberglass and vacuum-sealed interstitial space; suitable for operation at atmospheric pressure and with integral leak-detection device. Tank fabricated for the following loads:
 - a. Depth of Bury: 3 feet (1 m) from top of tank to finished surface.
 - b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
 - c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).
- O. FRP Fuel-Oil UST
1. Description: Horizontal, FRP UST; UL 1316, double wall, with interstitial space and integral, hydrostatic, leak-detection and monitoring system, **as directed**.
 2. Construction: Fabricated with fiberglass-reinforced polyester resins; suitable for operation at atmospheric pressure; fabricated for the following loads:
 - a. Depth of Bury: 3 feet (1 m) from top of tank to finished surface.
 - b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.



- c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).
- P. Shop Painting Of AST
1. Apply manufacturer's standard prime coat to exterior steel surface of AST and supports.
 2. Prepare exterior steel surface of AST and tank supports.
 3. Shop Cleaning: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3 **OR** SSPC-SP 10/NACE No. 2, **as directed**.
 4. After cleaning, remove dust or residue from cleaned surfaces.
 5. If surface develops rust before prime coat is applied, repeat surface preparation.
 6. Apply manufacturer's standard prime coat to shop-cleaned, dry surface same day as surface preparation.
 7. Apply manufacturer's standard two-component, epoxy finish coats.
- Q. Fuel-Oil AST Accessories
1. Tank Manholes (for horizontal tanks and some vertical tanks): 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed; centered on top of tank.
 2. Tank Manholes (for vertical tanks): 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed; on top and at side of tank.
 3. For Horizontal Tanks: Threaded pipe connection fittings on top of tank, for fill, supply, return, vent, sounding, and gaging. Include cast-iron plugs for shipping.
 4. For Vertical Tanks: Threaded pipe connection fittings on top or sides of tank as indicated, for fill, supply, return, vent, sounding, and gaging. Include cast-iron plugs for shipping.
 5. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.
 6. Lifting Lugs: For handling and installation.
 7. Ladders (for horizontal tanks and some vertical tanks): Carbon-steel ladder inside tank, anchored to top and bottom, and located as indicated. Include reinforcement of tank at bottom of ladder.
 8. Ladders (for vertical tanks): Carbon-steel ladder outside tank, anchored to top and side wall. Comply with requirements in Division 05 Section "Metal Fabrications" for exterior steel ladder.
 - a. Cage: Include welded steel cage around ladders for tanks 20 feet (6 m) high or higher.
 9. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).
 10. Sounding and Gage Tubes: Extension of fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).
- R. Fuel-Oil UST Accessories
1. Tank Manholes: 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed, with extension collar; for access to inside of tank.
 2. Steel Tank Masonry Supports: Two 6-by-6-by-3/8-inch (150-by-150-by-10-mm) steel angles, 72 inches (1800 mm) long, located longitudinally on tank on each side of manholes and continuously welded in place.
 3. Threaded pipe connection fittings on top of tank for fill, supply, return, vent, sounding, and gaging, in locations and of sizes indicated. Include cast-iron plugs for shipping.
 4. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.
 5. Lifting Lugs: For handling and installation.
 6. Ladders: Carbon-steel ladder inside tank, anchored to top and bottom. Include reinforcement of tank at bottom of ladder.
 7. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).
 8. Sounding and Gage Tubes: Extension of fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).
 9. Containment Sumps: Fiberglass **OR** PE, **as directed**, with sump base, add-on extension pieces as required, sump top, lid, and gasket-seal joints. Include sump entry boots for pipe penetrations through sidewalls.



10. Sump Entry Boots: Two-part pipe fitting for field assembly and of size required to fit over pipe. Include gaskets shaped to fit sump sidewall, sleeves, seals, and clamps as required for liquid-tight pipe penetrations.
11. Anchor Straps: Storage tank manufacturer's standard anchoring system, with straps, strap-insulating material, cables and turnbuckles, of strength at least one and one-half times maximum uplift force of empty tank without backfill in place.
12. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total weight of 3 oz./sq. yd. (101.7 g/sq. m).
13. Overfill Prevention Valves: Factory fabricated or shop or field assembled from manufacturer's standard components. Include drop tube, cap, fill nozzle adaptor, check valve mechanism or other devices, and vent if required to restrict flow at 95 percent of tank capacity and to provide complete shutoff of filling at 98 **OR** 99, **as directed**, percent of tank capacity.

S. Fuel-Oil Storage Tank Piping Specialties

1. Fitting Materials: Cast iron, malleable iron, brass, or corrosion-resistant metal; suitable for fuel-oil service.
 - a. Surface, Flush-Mounted Fittings: Waterproof and suitable for truck traffic.
 - b. Aboveground-Mounted Fittings: Weatherproof.
2. Spill-Containment Fill Boxes: Flush mounting, with drainage feature to drain oil into tank, threaded fill-pipe connection, and wrench operation.
3. Fill Boxes: Flush mounting, with threaded fill-pipe connection and wrench operation.
4. Locking Fill Boxes: Flush mounting, with locking-type inner fill cap for standard padlock and threaded fill-pipe connection.
5. Supply and Sounding Drop Tubes: Fuel-oil supply piping or fitting, inside tank, terminating 6 inches (150 mm) above bottom of tank, and with end cut at a 45-degree angle (1:1 slope).
6. Pipe Adapters and Extensions: Compatible with piping and fittings.
7. Suction Strainers and Check Valves: Bronze or corrosion-resistant metal components.
8. Foot Valves and Antisiphon Valves: Poppet-type, bronze or corrosion-resistant metal components.
9. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.
10. Metal Manholes: 22-inch- (560-mm-) minimum diameter frame and cover. Furnish manhole units of adequate size for access to fittings if size is not indicated.
11. Monitoring Well Caps: Locking pipe plug and manhole.

T. Submersible Fuel-Oil Pumps

1. Description: Comply with UL 79, UL 87, and UL 343.
 - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
 - b. Impeller: Turbine.
 - c. Housing and Volute: Cast iron.
 - d. Bearings: Bronze, self-lubricating.
 - e. Seals: Mechanical.
 - f. Shaft: Polished steel.
 - g. Suspension Piping: Telescoping to accommodate tank diameter and depth of bury.
 - h. Base: Steel.
 - i. Pressure Relief: Built in.
 - j. Discharge Check Valve: Built in.
 - k. Drive: Direct, close coupled.
2. Controls: Pump controller panel complying with UL 353 and UL 508C and with interlock and terminals for connections to fuel-oil-burning equipment **OR** diesel-driven fire pumps **OR** diesel-driven emergency generators **OR** diesel-fuel-oil dispenser, **as directed**.
 - a. Run pumps to maintain minimum manifold pressure with outdoor-air temperature less than 60 deg F (16 deg C).



- b. Run pumps on seven-day schedule.
 - c. Stage pumps on pressure at a common supply manifold.
 - d. Alternate pumps to equalize run time.
 - e. Alarm motor failure.
 - f. Manual reset dry-run protection. Stop pumps if fuel level falls below pump suction.
 - g. Deenergize and alarm pump locked rotor condition.
 - h. Alarm open circuit, high and low voltage.
 - i. Indicating lights for power on, run, and off normal conditions.
 - j. Interface with automatic control system is specified in Division 23 Section "Instrumentation And Control For Hvac" to control and indicate the following:
 - 1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
 - 2) Operating status.
 - 3) Alarm off-normal status.
3. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Thermal-Overload Protection: Motor-winding temperature sensor.
 - c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

U. Simplex Fuel-Oil Transfer Pumps

1. Description: Comply with UL 343, and HI M109.
 - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
 - b. Type: Positive-displacement, rotary type.
 - c. Impeller: Steel gear with crescent **OR** Carbon vane, **as directed**.
 - d. Housing: Cast-iron foot mounted.
 - e. Bearings: Bronze, self-lubricating.
 - f. Shaft: Polished steel.
 - g. Seals: Mechanical.
 - h. Base: Steel.
 - i. Pressure Relief: Built in.
 - j. Discharge Check Valve: Built in.
2. Drive: V-belt with guard; gear reducer; or direct, close coupled **OR** V-belt with guard **OR** Gear reducer **OR** Direct, close coupled, **as directed**.
3. Controls:
 - a. Run pump to maintain minimum manifold pressure with outdoor-air temperature less than 60 deg F (16 deg C).
 - b. Run pump on seven-day schedule.
 - c. Alarm motor failure.
 - d. Manual reset dry-run protection. Stop pump if fuel level falls below pump suction.
 - e. Deenergize and alarm pump locked rotor condition.
 - f. Alarm open circuit, high and low voltage.
 - g. Indicating lights for power on, run, and off normal conditions.
 - h. Interface with automatic control system is specified in Division 23 Section "Instrumentation And Control For Hvac" to control and indicate the following:
 - 1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
 - 2) Operating status.
 - 3) Alarm off-normal status.
4. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".



- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

V. Duplex **OR** Triplex, **as directed**, Fuel-Oil Transfer Pump Sets

1. Description: Comply with HI M109.
 - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
 - b. Type: Positive-displacement, rotary type.
 - c. Impeller: Steel gear with crescent **OR** Carbon vane, **as directed**.
 - d. Housing: Cast-iron foot mounted.
 - e. Bearings: Bronze, self-lubricating.
 - f. Shaft: Polished steel.
 - g. Seals: Mechanical.
 - h. Base: Steel.
 - i. Pressure Relief: Built in.
 - j. Discharge Check Valve: Built in.
2. Drive: V-belt with guard, gear reducer, or direct close coupled **OR** V-belt with guard **OR** Gear reducer **OR** Direct close coupled, **as directed**.
3. Controls:
 - a. Run pumps to maintain minimum manifold pressure with outdoor-air temperature less than 60 deg F (16 deg C).
 - b. Run pumps on seven-day schedule.
 - c. Stage pumps on pressure at a common supply manifold.
 - d. Alternate pumps to equalize run time.
 - e. Alarm motor failure.
 - f. Manual reset dry-run protection. Stop pumps if fuel level falls below pump suction.
 - g. Deenergize and alarm pump locked rotor condition.
 - h. Alarm open circuit, high and low voltage.
 - i. Indicating lights for power on, run, and off normal conditions.
 - j. Interface with automatic control system is specified in Division 23 Section "Instrumentation And Control For Hvac" to control and indicate the following:
 - 1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
 - 2) Operating status.
 - 3) Alarm off-normal status.
4. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
5. Piping Furnished with Pumps: Steel with ferrous fittings and threaded or welded joints.
6. Strainers Furnished with Pumps: Duplex, basket type with corrosion-resistant-metal-screen baskets.

W. Fuel Maintenance System

1. Description: Factory fabricated and wired fuel maintenance system for fuel-oil filtration; with enclosure, filter, fuel-oil pump, and controls; FMG approved, listed, and labeled by an NRTL acceptable to authorities having jurisdiction.
 - a. Enclosure: NEMA 250, Type 3R, painted steel containing pumps, filters, accessories, and controls. Hinged door on the front of enclosure.



- b. Pump: Comply with HI M109, steel-gear-with-crescent, positive-displacement, direct-coupled, rotary-type.
 - c. Materials: Cast-iron housing; bronze bearings; steel shaft; mechanical seals; and built-in, pressure relief bypass valve.
 - d. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
 - e. Piping: Steel with malleable-iron fittings and threaded joints or wrought-steel fittings and welded joints.
 - f. Multistage Filter: Spin-on, replaceable types.
 - 1) Stage 1: 100-mesh strainer.
 - 2) Stage 2: Centrifuge to separate particulates and water from oil.
 - 3) Stage 3: Coalescing water and particulate filter.
 - 4) Stage 4: 30-micron particulate removal.
 - 5) Stage 5: 10-micron particulate removal.
 - 6) Stage 6: Minimum 99.5 percent water removal with see-through bowl and water-sensor probe.
 - 7) Stage 7: 1.5 **OR** 3, **as directed**, -micron particulate removal.
 - g. Multiple-Tank Manifolds:
 - 1) Manifold fabricated of Schedule 80, black steel pipe and threaded nipples for two **OR** three **OR** four, **as directed**, tanks.
 - 2) Solenoid valves for supply and return piping to each tank.
 - 3) Strainers for each tank supply connection.
 - h. Programmable Logic Controller:
 - 1) Alarm on maximum 15-in. Hg (51-kPa) vacuum at pump suction indicating plugged filter.
 - 2) Alarm on high water level in filter.
 - 3) Alarm leak in enclosure.
 - 4) Touch screen; with minimum 2-line, 20-character, backlit, LCD display.
 - 5) Controller strip heater with thermostat.
 - i. Interface with automatic control system is specified in Division 23 Section "Instrumentation And Control For Hvac" to control and indicate the following:
 - 1) Start/stop system when required by schedule.
 - 2) Operating status.
 - 3) Alarm off-normal status.
- X. Liquid-Level Gage System
- 1. Description: Calibrated, liquid-level gage system complying with UL 180 with floats **OR** UL 1238 with probes, **as directed**, or other sensors and remote annunciator panel.
 - 2. Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (liters), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
 - 3. Controls: Electrical, operating on 120-V ac.
- Y. Leak-Detection And Monitoring System
- 1. Cable and Sensor System: Comply with UL 1238.
 - a. Calibrated, leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping.
 - b. Include fittings and devices required for testing.
 - c. Controls: Electrical, operating on 120-V ac.
 - d. Calibrated, liquid-level gage complying with UL 180 with floats **OR** UL 1238 with probes, **as directed**, or other sensors and remote annunciator panel.



- e. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (liters), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
 - f. Controls: Electrical, operating on 120-V ac.
 - 2. Hydrostatic System: Comply with UL 1238.
 - a. Calibrated, leak-detection and monitoring system with brine antifreeze solution, reservoir sensor, and electronic control panel to monitor leaks in inner and outer tank walls.
 - b. Include fittings and devices required for testing.
 - c. Controls: Electrical, operating on 120-V ac.
 - d. Calibrated, liquid-level gage complying with UL 180 with floats **OR** UL 1238 with probes, **as directed**, or other sensors and remote annunciator panel.
 - e. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (liters), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
 - f. Controls: Electrical, operating on 120-V ac.
- Z. Fuel Oil
- 1. Fuel Oil: ASTM D 396, Grade No. 1 **OR** No. 2, **as directed**.
 - 2. Diesel Fuel Oil: ASTM D 975, Grade Low Sulfur **OR** No. 1-D, special-purpose **OR** No. 2-D, general-purpose, **as directed**, high volatility.
- AA. Sleeves
- 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
 - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- BB. Mechanical Sleeve Seals
- 1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.
- CC. Escutcheons
- 1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube and with OD that completely covers opening.
 - 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn brass with polished chrome-plated finish.
 - 3. One-Piece, Cast-Brass Escutcheons: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 - 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 - 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 - 6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 - 7. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.
 - 8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.
- DD. Grout
- 1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.



- a. Characteristics: Posthardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
- b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- c. Packaging: Premixed and factory packaged.

EE. Labeling And Identifying

1. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (152 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (762 mm) deep; colored yellow.

FF. Concrete Manholes

1. Precast Concrete Manhole Sections: ASTM C 478 (ASTM C 478M), base and concentric-cone sections with integral ladder or steps.
2. Cast-Iron Frame and Cover: Heavy-duty, water-resistant, cast-iron manhole frame, gasket, and bolted cover; 24-inch- (609-mm-) diameter, inside opening dimension; 8-inch (203-mm) frame riser height.

GG. Source Quality Control

1. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, according to ASME and the following:
 - a. Vertical **OR** Horizontal, **as directed**, Single-Wall Steel ASTs: UL 142.
 - b. Vertical **OR** Horizontal, **as directed**, Double-Wall Steel ASTs: UL 142, STI F921, and STI R931.
 - c. Horizontal, Containment-Dike, Steel ASTs: UL 142 and STI F911.
 - d. Horizontal, Concrete-Vaulted **OR** Concrete-Vaulted and Insulated **OR** Insulated, **as directed**, Steel ASTs: UL 142 and UL 2085.
 - e. Horizontal, Steel USTs with the STI-P3 Corrosion-Protection System: UL 58 and STI P3.
 - f. Composite **OR** Composite and Jacketed **OR** Jacketed, **as directed**, Steel USTs: UL 58.
 - g. FRP USTs: UL 1316.
2. Affix standards organization's code stamp.

1.3 EXECUTION

A. Earthwork

1. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Preparation

1. Close equipment shutoff valves before turning off fuel oil to premises or piping section.
2. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

C. Outdoor Piping Installation

1. Install underground fuel-oil piping buried at least 18 inches (457 mm) below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 - a. If fuel-oil piping is installed with less than 12 inches (305 mm) of cover to finished grade, install in containment piping.
2. Steel Piping with Protective Coating:
 - a. Apply joint cover kits to pipe after joining, to cover, seal, and protect joints.
 - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer. Review protective coating damage prior to repair.
OR
Replace pipe having damaged PE coating with new pipe.



3. Install double-containment, fuel-oil pipe at a minimum slope of 1 percent downward toward fuel-oil storage tank sump.
4. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.
5. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.
6. Install metal pipes and tubes, fittings, valves, and flexible connectors at piping connections to AST and UST.
7. Install fittings for changes in direction in rigid pipe.
8. Install system components with pressure rating equal to or greater than system operating pressure.
9. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Install sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
10. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
11. Mechanical Sleeve Seal Installation: Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
12. Install pressure gage on suction **OR** suction and discharge, **as directed**, from each pump. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".

D. Indoor Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
3. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping free of sags and bends.
7. Install fittings for changes in direction and branch connections.
8. Install escutcheons for penetrations of walls, ceilings, and floors.
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 2) Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
OR
Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - 3) Piping at Ceiling Penetrations in Finished Spaces: One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
OR
Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
 - 4) Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR



- Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
- 5) Piping in Equipment Rooms: One-piece, cast-brass type.
OR
Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
- 6) Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
9. Existing Piping:
- 1) Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
OR
Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
- 2) Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
OR
Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
- 3) Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
- 4) Piping in Equipment Rooms: Split-casting, cast-brass type.
OR
Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
- 5) Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
10. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
11. Verify final equipment locations for roughing-in.
12. Comply with requirements for equipment specifications in Division 14 AND Division 21 for roughing-in requirements.
13. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.
14. Prohibited Locations:
- a. Do not install fuel-oil piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
- b. Do not install fuel-oil piping in solid walls or partitions.
15. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
16. Connect branch piping from top or side of horizontal piping.
17. Install unions in pipes NPS 2 (DN 50) and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.
18. Do not use fuel-oil piping as grounding electrode.
19. Install Y-pattern **OR** basket **OR** T-pattern, **as directed**, strainer on inlet side of fuel-oil pump.

E. Valve Installation

1. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.
2. Install valves in accessible locations.
3. Protect valves from physical damage.
4. Install metal tag attached with metal chain indicating fuel-oil piping systems.
5. Identify valves as specified in Division 23 Section "Identification For Hvac Piping And Equipment".
6. Install oil safety valves at inlet of each oil-fired appliance.



7. Install pressure relief valves in distribution piping between the supply and return lines.
8. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping.
9. Install manual air vents at high points in fuel-oil piping.
10. Install emergency shutoff valves at dispensers (for systems with fuel-oil or diesel-fuel-oil dispensers).

F. Piping Joint Construction

1. Ream ends of pipes and tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
4. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.
 - a. Bevel plain ends of steel pipe.
 - b. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
6. Flanged Joints: Install gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.
7. Flared Joints: Comply with SAE J513. Tighten finger tight, then use wrench according to fitting manufacturer's written recommendations. Do not overtighten.
8. Fiberglass-Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

G. Fuel-Oil AST Installation

1. Install tank bases and supports.
2. Connect piping and vent fittings.
3. Install ground connections.
4. Install tank leak-detection and monitoring devices.
5. Install steel ASTs according to STI R912.
6. Install insulated and concrete-vaulted, steel ASTs according to STI R942.
7. Fill storage tanks with fuel oil.

H. Fuel-Oil UST Installation

1. Excavate to sufficient depth for a minimum of 3 feet (1 m) of earth cover from top of tank to finished grade. Allow for cast-in-place, concrete-ballast base plus 6 inches (150 mm) of sand or pea gravel between ballast base and tank. Extend excavation at least 12 inches (300 mm) around perimeter of tank.
2. Set tie-down eyelets for hold-down straps in concrete-ballast base and tie to reinforcing steel.
3. Place 6 inches (152 mm) of clean sand or pea gravel on top of concrete-ballast base.
4. Set tank on fill materials and install hold-down straps.
5. Connect piping.
6. Install tank leak-detection and monitoring devices.
7. Install containment sumps.
8. Backfill excavation with clean sand or pea gravel in 12-inch (305-mm) lifts and tamp backfill lift to consolidate.
9. Install filter mat between top of backfill material and earth fill.
10. Install steel USTs with the STI-P3 corrosion-protection system according to STI R821 and STI R891. Protect anodes during tank placement and backfilling operations.



11. Install composite, steel USTs according to STI R913 and STI R891.
12. Install jacketed, steel USTs according to STI R923 and STI R891.
13. Install FRP USTs with FRP hold-down straps, manhole extensions, and manhole risers.
14. Fill storage tanks with fuel oil.

I. Hanger And Support Installation

1. Pipe hanger and support and equipment support materials and installation requirements are specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
2. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - a. NPS 1-1/4 (DN 32) and Smaller: Maximum span, 84 inches (2130 mm); minimum rod size, 3/8 inch (10 mm).
 - b. NPS 1-1/2 (DN 40): Maximum span, 108 inches (2740 mm); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 1/2 inch (13 mm).
 - e. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).
 - f. NPS 4 (DN 100): Maximum span, 13 feet (4 m); minimum rod size, 5/8 inch (16 mm).
3. Support vertical steel pipe at each floor and at spacing not greater than 15 feet (4.5 m).
4. Install hangers for horizontal, drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
 - a. NPS 3/4 (DN 20) and Smaller: Maximum span, 60 inches (1524 mm); minimum rod size, 3/8 inch (10 mm).
 - b. NPS 1 (DN 25): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 1-1/4 (DN 32): Maximum span, 84 inches (2130 mm); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).
 - e. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2740 mm); minimum rod size, 1/2 inch (13 mm).
 - f. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
 - g. NPS 4 (DN 100): Maximum span, 11 feet (3.4 m); minimum rod size, 5/8 inch (16 mm).
5. Support vertical copper tube at each floor and at spacing not greater than 10 feet (3 m).

J. Fuel-Oil Pump Installation

1. Submersible Pumps:
 - a. Suspend pumps from supply piping and anchored to bottom of tank.
2. Transfer Pumps:
 - a. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
 - b. Set pumps on and anchor to concrete base.
3. Install two-piece, full-port ball valves at suction and discharge of pumps.
4. Install mechanical leak-detector valves at pump discharge.
5. Install Y-pattern **OR** basket **OR** T-pattern, **as directed**, strainer on inlet side of simplex fuel-oil pumps.
6. Install check valve on discharge of simplex fuel-oil pumps.
7. Install suction piping with minimum fittings and change of direction.
8. Install vacuum and pressure gage, upstream and downstream respectively, at each pump to measure the differential pressure across the pump. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".

K. Fuel Maintenance System Installation

1. Install suction line, with foot valve, at one end of storage tank, 1 inch (25 mm) from the bottom of tank.
2. Install return line at the opposite end of storage tank from suction line.



- L. Liquid-Level Gage System Installation
1. Install liquid-level gage system. Locate panel inside building where indicated.
- M. Leak-Detection And Monitoring System Installation
1. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.
 - a. Double-Wall, Fuel-Oil Storage Tanks: Install probes **OR** Install probes or use factory-installed integral probes **OR** Use factory-installed integral probes, **as directed**, in interstitial space.
 - b. Single-Wall, Fuel-Oil Storage Tanks: Install probes as indicated.
 - c. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes in fuel-oil storage tank containment sumps and at low points in piping **OR** cable probes in interstitial space of double-containment piping, **as directed**.
 - d. Install liquid-level gage.
- N. Connections
1. Install piping adjacent to equipment to allow service and maintenance.
 2. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.
 3. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
 4. Connect piping to equipment with ball valve and union. Install union between valve and equipment.
 5. Install flexible piping connectors at final connection to burners or oil-fired appliances that must be moved for maintenance access.
- O. Labeling And Identifying
1. Nameplates, pipe identification, and signs are specified in Division 23 Section "Identification For Hvac Piping And Equipment".
OR
Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.
 - a. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
 2. Install detectable warning tape directly above fuel-oil piping, 12 inches (304 mm) below finished grade, except 6 inches (152 mm) below subgrade under pavements and slabs. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign.
 - a. Piping: Over underground fuel-oil distribution piping.
 - b. Fuel-Oil Storage Tanks: Over edges of each UST.
- P. Field Painting Of AST
1. If shop painting AST, prepare and touch up damaged exterior surface of AST and supports, **as directed**, as specified in "Shop Painting of AST" Article.
 2. If field painting AST, prepare exterior steel surface of AST and tank supports, **as directed**.
 3. Field Cleaning: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3 **OR** SSPC-SP 10/NACE No. 2, **as directed**.
 4. After cleaning, remove dust or residue from cleaned surfaces.
 5. If surfaces develop rust before prime coat is applied, repeat surface preparation.
 6. Prepare surface of AST and supports, **as directed**, and apply painting systems according to specifications in Division 09 Section "High-performance Coatings" for severe **OR** moderate **OR** mild, **as directed**, environment high-gloss **OR** semigloss, **as directed**, finish for ferrous metal.
- Q. Field Painting Of Aboveground Piping
1. Comply with requirements in Division 07 for painting interior and exterior fuel-oil piping.



2. Paint exposed, exterior metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
 - a. Alkyd System: MPI EXT 5.1D.
 - 1) Prime Coat: Alkyd anticorrosive metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Exterior alkyd enamel matching topcoat.
 - 3) Topcoat: Exterior alkyd enamel (flat) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **as directed**.
3. Paint exposed, interior metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
 - a. Latex Over Alkyd Primer System: MPI INT 5.1Q.
 - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Interior latex matching topcoat.
 - 3) Topcoat: Interior latex (flat) **OR** (low sheen) **OR** (eggshell) **OR** (satin) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **as directed**.
 - b. Alkyd System: MPI INT 5.1E.
 - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Interior alkyd matching topcoat.
 - 3) Topcoat: Interior alkyd (flat) **OR** (eggshell) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **as directed**.
4. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

R. Concrete Bases

1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (457-mm) centers around the full perimeter of the base.
 - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Use 3000-psig (20.7-MPa), **unless directed otherwise**, 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

S. Field Quality Control

1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:
 - 1) Single-Wall Tanks: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa).
 - 2) Double-Wall Tanks:
 - a) Inner Tanks: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa).
 - b) Interstitial Space: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa), or 5.3-in. Hg (18-kPa) vacuum.



- 3) Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than 10 psig (69 kPa), hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
- 4) Maintain the test pressure for one hour.
- b. Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:
 - 1) Fuel-Oil Distribution Piping: Minimum 5 psig (34.5 kPa) for minimum 30 minutes.
 - 2) Fuel-Oil, Double-Containment Piping:
 - a) Carrier Pipe: Minimum 5 psig (34.5 kPa) for minimum 30 minutes.
 - b) Containment Conduit: Minimum 5 psig (34.5 kPa) for minimum 60 minutes.
 - 3) Suction Piping: Minimum 20-in. Hg (68 kPa) for minimum 30 minutes.
 - 4) Isolate storage tanks if test pressure in piping will cause pressure in storage tanks to exceed 10 psig (69 kPa).
- c. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.
- d. Test liquid-level gage for accuracy by manually measuring fuel-oil levels at not less than three **OR** four **OR** five, **as directed**, different depths while filling tank and checking against gage indication.
- e. Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication.
- f. Start fuel-oil transfer pumps to verify for proper operation of pump and check for leaks.
- g. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- h. Bleed air from fuel-oil piping using manual air vents.
3. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

T. Outdoor Piping Schedule

1. Underground fuel-oil piping shall be one of the following. Size indicated is carrier-pipe size.
 - a. Flexible, double-containment piping.
 - b. Rigid, double-containment piping.
2. Underground fuel-oil-tank fill and vent piping shall be one of the following:
 - a. NPS 2 (DN 50) and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints. Coat pipe and fittings with protective coating for steel piping.
 - b. NPS 2-1/2 (DN 65) and Larger: Steel pipe, steel welding fittings, and welded joints. Coat pipe and fittings with protective coating for steel piping.
3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
4. Aboveground fuel-oil piping shall be one of the following:
 - a. NPS 2 (DN 50) and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints.
 - b. NPS 2-1/2 (DN 65) and Larger: Steel pipe, steel welding fittings, and welded joints.
 - c. Annealed **OR** Drawn, **as directed**,-temper copper tube with wrought-copper fittings and brazed joints.

U. Indoor Piping Schedule

1. Aboveground fuel-oil piping shall be one of the following:
 - a. NPS 1/2 (DN 15) and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints **OR** Annealed-temper copper pipe, wrought copper fittings, and brazed or flared joints, **as directed**.
 - b. NPS 5/8 to NPS 2 (DN 18 to DN 50): Steel pipe, steel or malleable-iron threaded fittings, and threaded joints **OR** Drawn temper copper pipe, wrought copper fittings, and brazed joints, **as directed**.



- c. NPS 2-1/2 (DN 65) and Larger: Steel pipe, steel fittings, and welded or flanged joints **OR** Drawn temper copper pipe, wrought copper fittings, and brazed or flanged joints, **as directed**.
 - d. Steel pipe with malleable-iron fittings and threaded joints.
 - e. Steel pipe with wrought-steel fittings and welded joints.
 - f. Annealed-temper copper tube, brass fittings, and flared joints.
 - g. Drawn-temper copper tubing, copper fittings, and brazed joints.
- V. Aboveground Manual Fuel-Oil Shutoff Valve Schedule
- 1. Distribution piping valves for pipe NPS 2 (DN 50) and smaller shall be one of the following:
 - a. One-piece, bronze ball valve with bronze trim.
 - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - 2. Distribution piping valves for pipe NPS 2-1/2 (DN 65) and larger shall be one of the following:
 - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - b. Bronze, nonlubricated **OR** lubricated, **as directed**, plug valve.
 - 3. Valves in branch piping for single appliance shall be one of the following:
 - a. One-piece, bronze ball valve with bronze trim.
 - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.

END OF SECTION 22 12 23 26a



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Task	Specification	Specification Description
22 12 23 26	22 05 23 00	Piped Utilities Basic Materials And Methods
22 13 16 00	22 05 23 00	Piped Utilities Basic Materials And Methods
22 13 16 00	22 11 23 23	Water Supply Wells
22 13 16 00	22 05 76 00	Sanitary Sewerage
22 13 16 00	07 63 00 00	Common Work Results for Fire Suppression
22 13 16 00	07 63 00 00a	Common Work Results for Plumbing
22 13 16 00	07 63 00 00b	Common Work Results for HVAC
22 13 16 00	22 11 16 00a	Sanitary Waste And Vent Piping
22 13 16 00	22 11 16 00b	Storm Drainage Piping



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**SECTION 22 13 19 13 - HIGH-EFFICIENCY PARTICULATE FILTRATION****1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for high-efficiency particulate filtration. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. HEPA rigid-cell box filters.
 - b. HEPA V-bank cell filters.
 - c. HEPA filter diffusers.
 - d. HEPA filter fan modules.
 - e. ULPA filters.
 - f. 95 percent DOP filters.
 - g. Front- and rear-access filter frames.
 - h. Side-service housings.
 - i. Filter gages.

C. Submittals

1. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
2. LEED Submittals:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment."
3. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
 - a. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
 - b. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
 - c. Wiring Diagrams: For power, signal, and control wiring.
4. Field quality-control reports.
5. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended use.
2. ASHRAE Compliance:
 - a. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Comply with IEST-RP-CC001.3.
4. Comply with UL 586.
5. Comply with IEST-RP-CC007.1.
6. Comply with NFPA 90A and NFPA 90B.

E. Coordination

1. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.



1.2 PRODUCTS

A. HEPA Rigid-Cell Box Filters

1. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow and with holding frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.
 - a. Internal Separators: None **OR** Aluminum in media folds, **as directed**.
 - b. Gasket Material: None **OR** Neoprene **OR** Blue gel, **as directed**.
 - c. Gasket Location: None **OR** Upstream **OR** Upstream and Downstream **OR** Downstream, **as directed**.
 - d. Faceguard Material: Aluminum **OR** Stainless steel, **as directed**.
 - e. Faceguard Location: None **OR** Upstream **OR** Upstream and Downstream **OR** Downstream, **as directed**.
4. Filter-Media Frames:
 - a. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - b. Materials: Stainless steel **OR** Fire-retardant plywood **OR** Fabricated aluminum **OR** Fire-retardant particleboard **OR** Galvanized sheet **OR** Non-fire-retardant particleboard, **as directed**.
 - c. Style: Box **OR** Double-turned flange **OR** Deep channel **OR** Double-turned flange, one side, **as directed**.
5. Mounting Frames: Welded galvanized steel with gaskets and fasteners; suitable for bolting together into built-up filter banks.

B. HEPA V-Bank Cell Filters

1. Description: Factory-fabricated, disposable, packaged air filters with media at an angle to airflow and with holding frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.
 - a. Internal Separators: None **OR** Aluminum in media folds, **as directed**.
 - b. Gasket Material: None **OR** Neoprene **OR** Blue gel, **as directed**.
 - c. Gasket Location: None **OR** Upstream **OR** Upstream and Downstream **OR** Downstream, **as directed**.
 - d. Faceguard Material: Aluminum **OR** Stainless steel, **as directed**.
 - e. Faceguard Location: None **OR** Upstream **OR** Upstream and Downstream **OR** Downstream, **as directed**.
4. Filter-Media Frames:
 - a. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - b. Materials: Stainless steel **OR** Fire-retardant plywood **OR** Fabricated aluminum **OR** Fire-retardant particleboard **OR** Galvanized sheet **OR** Non-fire-retardant particleboard, **as directed**.
 - c. Style: Box **OR** Double-turned flange **OR** Deep channel **OR** Double-turned flange, one side, **as directed**.
5. Mounting Frames: Welded galvanized steel with gaskets and fasteners; suitable for bolting together into built-up filter banks.

C. HEPA Filter Diffusers

1. Description: Factory-fabricated, individually ducted, HEPA filter-holding ceiling modules.
2. Media: Fibrous glass, constructed of continuous sheets with closely spaced pleats with glass filament separators.
 - a. Media to Module Side Bond: Urethane sealant.



- b. Media to Frame Side Bond: Polyurethane foam **OR** Silicone **OR** Neoprene adhesive **OR** Fiberglass-mat packing **OR** Thermosetting sealant **OR** Knife edge in fluid-filled channel, **as directed**.
 - c. Application: Class 100 **OR** Class 10 **OR** Class 1, **as directed**, clean room.
 - 3. Casing:
 - a. Configuration: Ducted inlet **OR** Plenum inlet **OR** Plenum inlet with prefilter, **as directed**.
 - b. Module Material: Extruded aluminum, 16 gage with mill finish.
 - c. Suspension: Ceiling grid.
 - 4. Accessories:
 - a. Diffusion damper.
 - b. Diffusion-damper adjustment port.
 - c. Filter test port.
- D. HEPA Filter Fan Modules
- 1. Description: Factory-fabricated, HEPA filter ceiling module with fan.
 - 2. Casing:
 - a. Configuration: Ducted inlet **OR** Plenum inlet **OR** Plenum inlet with prefilter, **as directed**.
 - b. Module Material: Extruded aluminum, 16 gage with mill finish.
 - c. Suspension: Ceiling grid **OR** Independent, **as directed**.
 - 3. Media: Fibrous glass, constructed of continuous sheets with closely spaced pleats with aluminum separators **OR** vinyl-coated aluminum separators **OR** separators of ribbons of filter media, **as directed**.
 - a. Frame Material: 3/4-inch- (19-mm-) thick, fire-retardant plywood **OR** 3/4-inch- (19-mm-) thick, fire-retardant particleboard **OR** 3/4-inch- (19-mm-) thick plywood **OR** 3/4-inch- (19-mm-) thick particleboard **OR** Galvanized steel **OR** Aluminized steel **OR** Cadmium-plated steel **OR** Stainless steel **OR** Aluminum, **as directed**.
 - b. Media to Frame Side Bond: Polyurethane foam **OR** Silicone **OR** Neoprene adhesive **OR** Fiberglass-mat packing **OR** Thermosetting sealant **OR** Knife edge in fluid-filled channel, **as directed**.
 - c. Face Gasket: Neoprene expanded rubber **OR** Ceramic fiber **OR** Silicone, **as directed**.
 - d. Faceguard: Plastic **OR** Stainless steel, **as directed**.
 - 4. Accessories: Filter test port.
 - 5. Control: Variable speed.
 - 6. Motor:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
 - c. Type: Permanent-split capacitor with SCR for speed adjustment **OR** Electronically commutated motor, **as directed**.
 - d. Fan-Motor Assembly Isolation: Rubber isolators.
 - e. Enclosure: Open dripproof **OR** Totally enclosed, fan cooled **OR** Totally enclosed, air over **OR** Open, externally ventilated **OR** Totally enclosed, nonventilated **OR** Severe duty **OR** Explosion proof **OR** Dust-ignition-proof machine, **as directed**.
 - f. Enclosure Materials: Cast iron **OR** Cast aluminum **OR** Rolled steel, **as directed**.
 - g. Motor Bearings: **<Insert special requirements>**.
 - h. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg F (deg C)>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - i. Efficiency: Premium efficient.
 - j. NEMA Design: **<Insert designation>**.
 - k. Service Factor: **<Insert value>**.
 - l. Motor Speed: Single speed **OR** Multispeed, **as directed**.
 - 1) Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.



E. ULPA Filters

1. Description: Factory-fabricated, ULPA filters with holding casing.
2. Media: Fibrous glass, constructed of continuous sheets with closely spaced pleats with aluminum separators **OR** vinyl-coated aluminum separators **OR** separators of ribbons of filter media, **as directed**.
3. Frame Material: 3/4-inch- (19-mm-) thick, fire-retardant plywood **OR** 3/4-inch- (19-mm-) thick, fire-retardant particleboard **OR** 3/4-inch- (19-mm-) thick plywood **OR** 3/4-inch- (19-mm-) thick particleboard **OR** Galvanized steel **OR** Aluminized steel **OR** Cadmium-plated steel **OR** Stainless steel **OR** Aluminum, **as directed**.
4. Media to Frame Side Bond: Polyurethane foam **OR** Silicone **OR** Neoprene adhesive **OR** Fiberglass-mat packing **OR** Thermosetting sealant **OR** Knife-edge in fluid-filled channel, **as directed**.
5. Face Gasket: Neoprene expanded rubber **OR** Ceramic fiber **OR** Silicone, **as directed**.
6. Mounting Frames: Construct downstream corners of holding device with cushion pads to protect media. Provide bolted filter-sealing mechanism to mount and continuously seal each individual filter.

F. 95 Percent DOP Filters

1. Description: Factory-fabricated, 95 percent DOP filters with holding casing.
2. Media: Fibrous glass, constructed of continuous sheets with closely spaced pleats with aluminum separators **OR** vinyl-coated aluminum separators **OR** separators of ribbons of filter media, **as directed**.
3. Frame Material: 3/4-inch- (19-mm-) thick, fire-retardant plywood **OR** 3/4-inch- (19-mm-) thick, fire-retardant particleboard **OR** 3/4-inch- (19-mm-) thick plywood **OR** 3/4-inch- (19-mm-) thick particleboard **OR** Galvanized steel **OR** Aluminized steel **OR** Cadmium-plated steel **OR** Stainless steel **OR** Aluminum, **as directed**.
4. Frame Style: Box single header **OR** Double header **OR** Double turned flange **OR** 3/4-inch- (19-mm-) deep channel, **as directed**.
5. Media to Frame Side Bond: Polyurethane foam **OR** Silicone **OR** Neoprene adhesive **OR** Fiberglass-mat packing **OR** Thermosetting sealant **OR** Knife edge in fluid-filled channel, **as directed**.
6. Face Guard Material: Galvanized **OR** Aluminum, **as directed**, mesh.
7. Face Guard Location: Upstream **OR** Upstream and Downstream **OR** Downstream, **as directed**.
8. Gasket Material: Neoprene expanded rubber **OR** Ceramic fiber **OR** Silicone, **as directed**.
9. Gasket Location: Upstream **OR** Upstream and Downstream **OR** Downstream, **as directed**.
10. Mounting Frames: Construct downstream corners of holding device with cushion pads to protect media. Provide bolted filter-sealing mechanism to mount and continuously seal each individual filter.

G. Front- And Rear-Access Filter Frames

1. Framing System: Aluminum framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
2. Prefilters: Incorporate a separate track, removable from front or back.
3. Sealing: Factory-installed, positive-sealing device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.
4. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

H. Side-Service Housings

1. Description: Factory-assembled, side-service housings, constructed of 0.064-inch- (1.6-mm-) thick, galvanized steel **OR** stainless steel **OR** double-wall casing with 1-inch (25-mm) insulation, **as directed**, to hold filters. Side servicing is through gasketed access doors on one side, and



housings are capable of connection to other housings. Equip housings with metal slide channel tracks with clamping mechanisms to hold filters, and the following:

- a. Pressure tap and fitting.
 - b. DOP/freon test ports.
 - c. Decontamination ports.
 - d. Isolation dampers.
 - e. Lifting lugs.
2. Prefilters: Integral tracks to accommodate 2-, 4-, and 6-inch- (50-, 100-, and 150-mm-) thick, disposable filters.
 3. Access Doors: Continuous gaskets on perimeter and positive-locking swivel, **as directed**, devices. Provide ribbed bagging rim behind access door and PVC bags for bag-in, bag-out arrangement, **as directed**. Arrange so filter cartridges can be loaded from an access door for each tier and section of the following:
 - a. Combination prefilter and HEPA filter.
OR
Prefilter.
OR
HEPA filter.
 - b. Upstream and downstream test section.
 4. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.
 5. Accessories:
 - a. Filter change-out trays.
 - b. Document-storage pocket.
 - c. Filter removal rod.
 6. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

I. Filter Gages

1. Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 - a. Diameter: 4-1/2 inches (115 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
 - c. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
 - d. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
 - e. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
 - f. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).
2. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage; graduated to read from 0- to 3.0-inch wg (0 to 750 Pa) and accurate within 3 percent of full-scale range.
3. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

1.3 EXECUTION

A. Installation

1. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
2. Install filters in position to prevent passage of unfiltered air.
3. Install filter gage for each filter bank.



4. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters that were used during construction and testing with new, clean filters.
5. Install filter-gage static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
6. Coordinate filter installations with duct and air-handling unit installations.

B. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Operate automatic roll filters to demonstrate compliance with requirements.
 - b. Test for leakage of unfiltered air while system is operating.
 - c. HEPA Filters: Pressurize housing to a minimum of 3.0-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
 - d. HEPA Filters: Pressurize housing to a minimum of 3.0-inch wg (750 Pa) or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter for air leaks according to pressure-decay method in ASME N510.
3. Air filter will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

C. Cleaning

1. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 22 13 19 13



SECTION 22 13 19 26 - INTERCEPTORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for interceptors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Grease interceptors.
 - b. Oil interceptors.
 - c. Sand interceptors.

C. Definitions

1. FRP: Fiberglass-reinforced plastic.
2. PP: Polypropylene plastic.

D. Submittals

1. Product Data: For each type of metal and plastic interceptor indicated. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.
2. Shop Drawings: For each type and size of precast-concrete interceptor indicated.
 - a. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.
3. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, based on input from Installers of the items involved:
 - a. Interceptors.
 - b. Piping connections. Include size, location, and elevation of each.
 - c. Interface with underground structures and utility services.

E. Project Conditions

1. Interruption of Existing Sewer Services: Do not interrupt services to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sewer services according to requirements indicated:
 - a. Notify the Owner no fewer than seven days in advance of proposed interruption of service.
 - b. Do not proceed with interruption of sewer services without the Owner's written permission.

1.2 PRODUCTS

A. Grease Interceptors

1. Grease Interceptors: Precast concrete complying with ASTM C 913.
 - a. Include rubber-gasketed joints, vent connections (if required), manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow, unless directed otherwise.
 - b. Structural Design Loads:
 - 1) Light-Traffic Load: Comply with ASTM C 890, A-8 (ASSHTO HS10-44).
 - 2) Medium-Traffic Load: Comply with ASTM C 890, A-12 (ASSHTO HS15-44).
 - 3) Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).
 - 4) Walkway Load: Comply with ASTM C 890, A-03.



- c. Resilient Pipe Connectors (if required): ASTM C 923 (ASTM C 923M), cast or fitted into interceptor walls, for each pipe connection.
- d. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of interceptor to finished grade is less than 60 inches (1500 mm).
- e. Grade Rings (if required): Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.
- f. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover.
 - 1) Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
 - 2) Gray Iron: ASTM A 48, Class 35, unless otherwise indicated.
 - 3) Include indented top design with lettering cast into cover, using wording equivalent to "INTERCEPTOR," or "GREASE INTERCEPTOR," or "SANITARY SEWER."

B. Oil Interceptors

1. Oil Interceptors: Precast concrete comply with ASTM C 913.
 - a. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.
 - b. Structural Design Loads:
 - 1) Light-Traffic Load: Comply with ASTM C 890, A-8 (ASSHTO HS10-44).
 - 2) Medium-Traffic Load: Comply with ASTM C 890, A-12 (ASSHTO HS15-44).
 - 3) Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).
 - 4) Walkway Load: Comply with ASTM C 890, A-03.
 - c. Resilient Pipe Connectors (if required): ASTM C 923 (ASTM C 923M), cast or fitted into interceptor walls, for each pipe connection.
 - d. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of interceptor to finished grade is less than 60 inches (1500 mm).
 - e. Grade Rings (if required): Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.
 - f. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover.
 - 1) Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
 - 2) Gray Iron: ASTM A 48, Class 35, unless otherwise indicated.
 - 3) Include indented top design with lettering cast into cover, using wording equivalent to "INTERCEPTOR," or "OIL INTERCEPTOR," or "SANITARY SEWER."
 - g. Waste-oil storage tank and piping are specified in Division 23 Section "Facility Fuel-oil Piping".
2. Oil Interceptors: Factory-fabricated, cast-iron or steel body; with removable sediment bucket or strainer, baffles, vents, and flow-control fitting on inlet.
 - a. Inlet, Outlet, Vent, and Waste-Oil Outlet Piping Connections: Hub, hubless, or threaded, unless otherwise indicated.
 - b. Extension (if required): Cast-iron or steel shroud, full size of interceptor, extending from top of interceptor to grade.



- c. Cover: Cast iron or steel, with steel reinforcement to provide ASTM C 890, A-03, walkway load, **as directed**.
 - d. Comply with requirements in Division 23 Section "Facility Fuel-oil Piping" for waste-oil storage tank and piping
3. Oil Interceptors: Plastic body; with removable sediment bucket or strainer, baffles, vents, and flow-control fitting on inlet.
- a. Inlet, Outlet, Vent, and Waste-Oil Outlet Piping Connections: Hub, hubless, or threaded, unless otherwise indicated.
 - b. Extension (if required): Plastic shroud, full size of interceptor, extending from top of interceptor to grade.
 - c. Cover: Plastic with steel reinforcement to provide ASTM C 890, A-03, walkway load, **as directed**.
 - d. Waste-oil storage tank and piping are specified in Division 23 Section "Facility Fuel-oil Piping".
- C. Sand Interceptors
1. Description: Factory-fabricated, cast-iron or steel body and inlet grate; with settlement chamber and removable basket or strainer.
 2. Outlet Piping Connection: Hub, hubless, or threaded, unless otherwise indicated.
 3. Grate: Cast iron or steel with reinforcement to provide ASTM C 890, A-03, walkway load, **as directed**.
- D. Precast-Concrete Manhole Risers
1. Precast-Concrete Manhole Risers: ASTM C 478 (ASTM C 478M) **OR** ASTM C 913, **as directed**, with rubber-gasket joints.
 - a. Structural Design Loads:
 - 1) Light-Traffic Load: Comply with ASTM C 890, A-8 (ASSHTO HS10-44).
 - 2) Medium-Traffic Load: Comply with ASTM C 890, A-12 (ASSHTO HS15-44).
 - 3) Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).
 - 4) Walkway Load: Comply with ASTM C 890, A-03.
 - b. Length: From top of underground concrete structure to grade.
 - c. Riser Sections: 3-inch (75-mm) minimum thickness and 36-inch (915-mm) diameter.
 - d. Top Section: Eccentric cone, unless otherwise indicated. Include top of cone to match grade ring size.
 - e. Gaskets: ASTM C 443 (ASTM C 443M), rubber.
 - f. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals.
 2. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, diameter matching manhole frame and cover, and height as required to adjust the manhole frame and cover to indicated elevation and slope.
 3. Manhole Frames and Covers (if required): Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover.
 - a. Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
 - b. Gray Iron: ASTM A 48, Class 35, unless otherwise indicated.
 - c. Include indented top design with lettering cast into cover, using wording equivalent to the following:
 - 1) Grease Interceptors in Sanitary Sewerage System: "INTERCEPTOR" **OR** "GREASE INTERCEPTOR" **OR** "SANITARY SEWER", **as directed**.
 - 2) Oil Interceptors in Sanitary Sewerage System: "INTERCEPTOR" **OR** "OIL INTERCEPTOR" **OR** "SANITARY SEWER", **as directed**.



1.3 EXECUTION

A. Earthwork

1. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Installation

1. Install precast-concrete interceptors according to ASTM C 891. Set level and plumb.
2. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.
3. Set tops of manhole frames and covers flush with finished surface in pavements. Set tops 3 inches (75 mm) above finish surface elsewhere, unless otherwise indicated.
4. Set tops of grating frames and grates flush with finished surface.
5. Set metal and plastic interceptors level and plumb.
6. Set tops of metal interceptor covers flush with finished surface in pavements. Set tops 3 inches (75 mm) above finish surface elsewhere, unless otherwise indicated.
7. Install piping and oil storage tanks according to Division 23 Section "Facility Fuel-oil Piping".

C. Connections

1. Piping installation requirements are specified in other Division 22. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Make piping connections between interceptors and piping systems.

D. Identification

1. Identification materials and installation are specified in Division 31 Section "Earth Moving". Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
 - a. Use warning tapes or detectable warning tape over ferrous piping.
 - b. Use detectable warning tape over nonferrous piping and over edges of underground structures.

END OF SECTION 22 13 19 26

**SECTION 22 13 19 33 - GENERAL-DUTY VALVES FOR HVAC PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of general-duty valves for HVAC piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Bronze angle valves.
 - b. Brass ball valves.
 - c. Bronze ball valves.
 - d. Iron ball valves.
 - e. Iron, single-flange butterfly valves.
 - f. Iron, grooved-end butterfly valves.
 - g. High-performance butterfly valves.
 - h. Bronze lift check valves.
 - i. Bronze swing check valves.
 - j. Iron swing check valves.
 - k. Iron swing check valves with closure control.
 - l. Iron, grooved-end swing-check valves.
 - m. Iron, center-guided check valves.
 - n. Iron, plate-type check valves.
 - o. Bronze gate valves.
 - p. Iron gate valves.
 - q. Bronze globe valves.
 - r. Iron globe valves.
 - s. Lubricated plug valves.
 - t. Eccentric plug valves.
 - u. Chainwheels.

C. Definitions

1. CWP: Cold working pressure.
2. EPDM: Ethylene propylene copolymer rubber.
3. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
4. NRS: Nonrising stem.
5. OS&Y: Outside screw and yoke.
6. RS: Rising stem.
7. SWP: Steam working pressure.

D. Submittals

1. Product Data: For each type of valve indicated.

E. Quality Assurance

1. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
2. ASME Compliance:
 - a. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - b. ASME B31.1 for power piping valves.
 - c. ASME B31.9 for building services piping valves.



F. Delivery, Storage, And Handling

1. Prepare valves for shipping as follows:
 - a. Protect internal parts against rust and corrosion.
 - b. Protect threads, flange faces, grooves, and weld ends.
 - c. Set angle, gate, and globe valves closed to prevent rattling.
 - d. Set ball and plug valves open to minimize exposure of functional surfaces.
 - e. Set butterfly valves closed or slightly open.
 - f. Block check valves in either closed or open position.
2. Use the following precautions during storage:
 - a. Maintain valve end protection.
 - b. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
3. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.2 PRODUCTS

A. General Requirements For Valves

1. Refer to HVAC valve schedule articles for applications of valves.
2. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
3. Valve Sizes: Same as upstream piping unless otherwise indicated.
4. Valve Actuator Types:
 - a. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
 - b. Handwheel: For valves other than quarter-turn types.
 - c. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller except plug valves, **as directed**.
 - d. Wrench: For plug valves with square heads. Furnish the Owner with 1 wrench for every 5 **OR 10, as directed**, plug valves, for each size square plug-valve head.
 - e. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
5. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
 - a. Gate Valves: With rising stem.
 - b. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - c. Butterfly Valves: With extended neck.
6. Valve-End Connections:
 - a. Flanged: With flanges according to ASME B16.1 for iron valves.
 - b. Grooved: With grooves according to AWWA C606.
 - c. Solder Joint: With sockets according to ASME B16.18.
 - d. Threaded: With threads according to ASME B1.20.1.
7. Valve Bypass and Drain Connections: MSS SP-45.

B. Bronze Angle Valves

1. Class 125, Bronze Angle Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded.
 - 5) Stem and Disc: Bronze.
 - 6) Packing: Asbestos free.
 - 7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.



2. Class 125, Bronze Angle Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: PTFE or TFE.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
 3. Class 150, Bronze Angle Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem and Disc: Bronze.
 - 6) Packing: Asbestos free.
 - 7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
 4. Class 150, Bronze Angle Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: PTFE or TFE.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
- C. Brass Ball Valves
1. One-Piece, Reduced-Port, Brass Ball Valves with Brass Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Design: One piece.
 - 4) Body Material: Forged brass.
 - 5) Ends: Threaded.
 - 6) Seats: PTFE or TFE.
 - 7) Stem: Brass.
 - 8) Ball: Chrome-plated brass.
 - 9) Port: Reduced.
 2. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Brass.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Full.
 3. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
 - a. Description:



- 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Full.
4. Two-Piece, Regular-Port, Brass Ball Valves with Brass Trim:
- a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Brass.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Regular.
5. Two-Piece, Regular-Port, Brass Ball Valves with Stainless-Steel Trim:
- a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Brass or bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Regular.
6. Three-Piece, Full-Port, Brass Ball Valves with Brass Trim:
- a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Three piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Brass.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Full.
7. Three-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
- a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Three piece.
 - 5) Body Material: Forged brass.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.



- 8) Stem: Stainless steel.
- 9) Ball: Stainless steel, vented.
- 10) Port: Full.

D. Bronze Ball Valves

1. One-Piece, Reduced-Port, Bronze Ball Valves with Bronze Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) CWP Rating: 400 psig (2760 kPa).
 - 3) Body Design: One piece.
 - 4) Body Material: Bronze.
 - 5) Ends: Threaded.
 - 6) Seats: PTFE or TFE.
 - 7) Stem: Bronze.
 - 8) Ball: Chrome-plated brass.
 - 9) Port: Reduced.
2. One-Piece, Reduced-Port, Bronze Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) CWP Rating: 600 psig (4140 kPa).
 - 3) Body Design: One piece.
 - 4) Body Material: Bronze.
 - 5) Ends: Threaded.
 - 6) Seats: PTFE or TFE.
 - 7) Stem: Stainless steel.
 - 8) Ball: Stainless steel, vented.
 - 9) Port: Reduced.
3. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Bronze.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Full.
4. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Full.
5. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).



- 4) Body Design: Two piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Bronze.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Regular.
6. Two-Piece, Regular-Port, Bronze Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Two piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Regular.
 7. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Three piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Bronze.
 - 9) Ball: Chrome-plated brass.
 - 10) Port: Full.
 8. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
 - a. Description:
 - 1) Standard: MSS SP-110.
 - 2) SWP Rating: 150 psig (1035 kPa).
 - 3) CWP Rating: 600 psig (4140 kPa).
 - 4) Body Design: Three piece.
 - 5) Body Material: Bronze.
 - 6) Ends: Threaded.
 - 7) Seats: PTFE or TFE.
 - 8) Stem: Stainless steel.
 - 9) Ball: Stainless steel, vented.
 - 10) Port: Full.

E. Iron Ball Valves

1. Class 125, Iron Ball Valves:
 - a. Description:
 - 1) Standard: MSS SP-72.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Split body.
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Ends: Flanged.
 - 6) Seats: PTFE or TFE.
 - 7) Stem: Stainless steel.
 - 8) Ball: Stainless steel.



9) Port: Full.

F. Iron, Single-Flange Butterfly Valves

1. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 150 psig (1035 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Aluminum bronze.
2. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 150 psig (1035 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: NBR.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Aluminum bronze.
3. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 150 psig (1035 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
4. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 150 psig (1035 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: NBR.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
5. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 150 psig (1035 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Stainless steel.
6. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.



- 2) CWP Rating: 150 psig (1035 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: NBR.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Stainless steel.
7. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
- a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Aluminum bronze.
8. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:
- a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: NBR.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Aluminum bronze.
9. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:
- a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
10. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:
- a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: NBR.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
11. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:
- a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: EPDM.



- 6) Stem: One- or two-piece stainless steel.
- 7) Disc: Stainless steel.
12. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - 5) Seat: NBR.
 - 6) Stem: One- or two-piece stainless steel.
 - 7) Disc: Stainless steel.
- G. Iron, Grooved-End Butterfly Valves
 1. 175 CWP, Iron, Grooved-End Butterfly Valves:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) CWP Rating: 175 psig (1200 kPa).
 - 3) Body Material: Coated, ductile iron.
 - 4) Stem: Two-piece stainless steel.
 - 5) Disc: Coated, ductile iron.
 - 6) Seal: EPDM.
 2. 300 CWP, Iron, Grooved-End Butterfly Valves:
 - a. Description:
 - 1) Standard: MSS SP-67, Type I.
 - 2) NPS 8 (DN 50) and Smaller CWP Rating: 300 psig (2070 kPa).
 - 3) NPS 10 (DN 250) and Larger CWP Rating: 200 psig (1380 kPa).
 - 4) Body Material: Coated, ductile iron.
 - 5) Stem: Two-piece stainless steel.
 - 6) Disc: Coated, ductile iron.
 - 7) Seal: EPDM.
- H. High-Performance Butterfly Valves
 1. Class 150, Single-Flange, High-Performance Butterfly Valves:
 - a. Description:
 - 1) Standard: MSS SP-68.
 - 2) CWP Rating: 285 psig (1965 kPa) at 100 deg F (38 deg C).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
 - 5) Seat: Reinforced PTFE or metal.
 - 6) Stem: Stainless steel; offset from seat plane.
 - 7) Disc: Carbon steel.
 - 8) Service: Bidirectional.
 2. Class 300, Single-Flange, High-Performance Butterfly Valves:
 - a. Description:
 - 1) Standard: MSS SP-68.
 - 2) CWP Rating: 720 psig (4965 kPa) at 100 deg F (38 deg C).
 - 3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 4) Body Material: Carbon steel, cast iron, or ductile iron.
 - 5) Seat: Reinforced PTFE or metal.
 - 6) Stem: Stainless steel; offset from seat plane.
 - 7) Disc: Carbon steel.
 - 8) Service: Bidirectional.

**I. Bronze Lift Check Valves**

1. Class 125, Lift Check Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Vertical flow.
 - 4) Body Material: ASTM B 61 or ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: Bronze.
2. Class 125, Lift Check Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Vertical flow.
 - 4) Body Material: ASTM B 61 or ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: NBR, PTFE, or TFE.

J. Bronze Swing Check Valves

1. Class 125, Bronze Swing Check Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 3.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Horizontal flow.
 - 4) Body Material: ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: Bronze.
2. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 4.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Design: Horizontal flow.
 - 4) Body Material: ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: PTFE or TFE.
3. Class 150, Bronze Swing Check Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 3.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Design: Horizontal flow.
 - 4) Body Material: ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: Bronze.
4. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 4.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Design: Horizontal flow.
 - 4) Body Material: ASTM B 62, bronze.
 - 5) Ends: Threaded.
 - 6) Disc: PTFE or TFE.

K. Iron Swing Check Valves

1. Class 125, Iron Swing Check Valves with Metal Seats:
 - a. Description:



- 1) Standard: MSS SP-71, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Design: Clear or full waterway.
 - 5) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 6) Ends: Flanged.
 - 7) Trim: Bronze.
 - 8) Gasket: Asbestos free.
2. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Design: Clear or full waterway.
 - 5) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 6) Ends: Flanged.
 - 7) Trim: Composition.
 - 8) Seat Ring: Bronze.
 - 9) Disc Holder: Bronze.
 - 10) Disc: PTFE or TFE.
 - 11) Gasket: Asbestos free.
 3. Class 250, Iron Swing Check Valves with Metal Seats:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Design: Clear or full waterway.
 - 5) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 6) Ends: Flanged.
 - 7) Trim: Bronze.
 - 8) Gasket: Asbestos free.
- L. Iron Swing Check Valves With Closure Control
1. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Design: Clear or full waterway.
 - 5) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 6) Ends: Flanged.
 - 7) Trim: Bronze.
 - 8) Gasket: Asbestos free.
 - 9) Closure Control: Factory-installed, exterior lever and spring.
 2. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:
 - a. Description:
 - 1) Standard: MSS SP-71, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Design: Clear or full waterway.
 - 5) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 6) Ends: Flanged.
 - 7) Trim: Bronze.
 - 8) Gasket: Asbestos free.
 - 9) Closure Control: Factory-installed, exterior lever and weight.



- M. Iron, Grooved-End Swing Check Valves
1. 300 CWP, Iron, Grooved-End Swing Check Valves:
 - a. Description:
 - 1) CWP Rating: 300 psig (2070 kPa).
 - 2) Body Material: ASTM A 536, ductile iron.
 - 3) Seal: EPDM.
 - 4) Disc: Spring operated, ductile iron or stainless steel.
- N. Iron, Center-Guided Check Valves
1. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Style: Compact wafer.
 - 6) Seat: Bronze.
 2. Class 125, Iron, Globe, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Style: Globe, spring loaded.
 - 6) Ends: Flanged.
 - 7) Seat: Bronze.
 3. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Style: Compact wafer.
 - 6) Seat: Bronze.
 4. Class 150, Iron, Globe, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Style: Globe, spring loaded.
 - 6) Ends: Flanged.
 - 7) Seat: Bronze.
 5. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Style: Compact wafer, spring loaded.
 - 6) Seat: Bronze.
 6. Class 250, Iron, Globe, Center-Guided Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).



- 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Style: Globe, spring loaded.
 - 6) Ends: Flanged.
 - 7) Seat: Bronze.
7. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Style: Compact wafer, spring loaded.
 - 6) Seat: Bronze.
8. Class 300, Iron, Globe, Center-Guided Check Valves with Metal Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Style: Globe, spring loaded.
 - 6) Ends: Flanged.
 - 7) Seat: Bronze.
9. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Style: Compact wafer.
 - 6) Seat: EPDM **OR** BR, **as directed**.
10. Class 125, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Style: Globe, spring loaded.
 - 6) Ends: Flanged.
 - 7) Seat: EPDM **OR** NBR, **as directed**.
11. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Style: Compact wafer.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
12. Class 150, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Style: Globe, spring loaded.
 - 6) Ends: Flanged.
 - 7) Seat: EPDM **OR** NBR, **as directed**.



13. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Style: Compact wafer, spring loaded.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
 14. Class 250, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 126, gray iron.
 - 5) Style: Globe, spring loaded.
 - 6) Ends: Flanged.
 - 7) Seat: EPDM **OR** NBR, **as directed**.
 15. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Style: Compact wafer, spring loaded.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
 16. Class 300, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
 - a. Description:
 - 1) Standard: MSS SP-125.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
 - 4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 5) Style: Globe, spring loaded.
 - 6) Ends: Flanged.
 - 7) Seat: EPDM **OR** NBR, **as directed**.
- O. Iron, Plate-Type Check Valves
1. Class 125, Iron, Dual-Plate Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Design: Wafer, spring-loaded plates.
 - 5) Body Material: ASTM A 126, gray iron.
 - 6) Seat: Bronze.
 2. Class 150, Iron, Dual-Plate Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: API 594.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
 - 4) Body Design: Wafer, spring-loaded plates.
 - 5) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 6) Seat: Bronze.
 3. Class 250, Iron, Dual-Plate Check Valves with Metal Seat:
 - a. Description:
 - 1) Standard: API 594.



- 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Design: Wafer, spring-loaded plates.
 - 5) Body Material: ASTM A 126, gray iron.
 - 6) Seat: Bronze.
4. Class 300, Iron, Dual-Plate Check Valves with Metal Seat:
- a. Description:
 - 1) Standard: API 594.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
 - 4) Body Design: Wafer, spring-loaded plates.
 - 5) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 6) Seat: Bronze.
5. Class 125, Iron, Single-Plate Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: API 594.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Design: Wafer, spring-loaded plate.
 - 5) Body Material: ASTM A 126, gray iron.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
6. Class 125, Iron, Dual-Plate Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: API 594.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Design: Wafer, spring-loaded plates.
 - 5) Body Material: ASTM A 126, gray iron.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
7. Class 150, Iron, Dual-Plate Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: API 594.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
 - 4) Body Design: Wafer, spring-loaded plates.
 - 5) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
8. Class 250, Iron, Wafer, Single-Plate Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: API 594.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Design: Wafer, spring-loaded plate.
 - 5) Body Material: ASTM A 126, gray iron.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
9. Class 250, Iron, Dual-Plate Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: API 594.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Design: Wafer, spring-loaded plates.
 - 5) Body Material: ASTM A 126, gray iron.
 - 6) Seat: EPDM **OR** NBR, **as directed**.
10. Class 300, Iron, Dual-Plate Check Valves with Resilient Seat:
- a. Description:
 - 1) Standard: API 594.



- 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
- 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
- 4) Body Design: Wafer, spring-loaded plates.
- 5) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
- 6) Seat: EPDM **OR** NBR, **as directed**.

P. Bronze Gate Valves

1. Class 125, NRS Bronze Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded or solder joint, **as directed**.
 - 5) Stem: Bronze.
 - 6) Disc: Solid wedge; bronze.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, RS Bronze Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded or solder joint, **as directed**.
 - 5) Stem: Bronze.
 - 6) Disc: Solid wedge; bronze.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, NRS Bronze Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: Solid wedge; bronze.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
4. Class 150, RS Bronze Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: Solid wedge; bronze.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

Q. Iron Gate Valves

1. Class 125, NRS, Iron Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-70, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.



- 5) Ends: Flanged.
- 6) Trim: Bronze.
- 7) Disc: Solid wedge.
- 8) Packing and Gasket: Asbestos free.
2. Class 125, OS&Y, Iron Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-70, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 5) Ends: Flanged.
 - 6) Trim: Bronze.
 - 7) Disc: Solid wedge.
 - 8) Packing and Gasket: Asbestos free.
3. Class 250, NRS, Iron Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-70, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 5) Ends: Flanged.
 - 6) Trim: Bronze.
 - 7) Disc: Solid wedge.
 - 8) Packing and Gasket: Asbestos free.
4. Class 250, OS&Y, Iron Gate Valves:
 - a. Description:
 - 1) Standard: MSS SP-70, Type I.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 5) Ends: Flanged.
 - 6) Trim: Bronze.
 - 7) Disc: Solid wedge.
 - 8) Packing and Gasket: Asbestos free.

R. Bronze Globe Valves

1. Class 125, Bronze Globe Valves with Bronze Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 1.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded or solder joint, **as directed**.
 - 5) Stem and Disc: Bronze.
 - 6) Packing: Asbestos free.
 - 7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, Bronze Globe Valves with Nonmetallic Disc:
 - a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - 4) Ends: Threaded or solder joint, **as directed**.
 - 5) Stem: Bronze.
 - 6) Disc: PTFE or TFE.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, Bronze Globe Valves with Nonmetallic Disc:



- a. Description:
 - 1) Standard: MSS SP-80, Type 2.
 - 2) CWP Rating: 300 psig (2070 kPa).
 - 3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - 4) Ends: Threaded.
 - 5) Stem: Bronze.
 - 6) Disc: PTFE or TFE.
 - 7) Packing: Asbestos free.
 - 8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

S. Iron Globe Valves

- 1. Class 125, Iron Globe Valves:
 - a. Description:
 - 1) Standard: MSS SP-85, Type I.
 - 2) CWP Rating: 200 psig (1380 kPa).
 - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 4) Ends: Flanged.
 - 5) Trim: Bronze.
 - 6) Packing and Gasket: Asbestos free.
- 2. Class 250, Iron Globe Valves:
 - a. Description:
 - 1) Standard: MSS SP-85, Type I.
 - 2) CWP Rating: 500 psig (3450 kPa).
 - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
 - 4) Ends: Flanged.
 - 5) Trim: Bronze.
 - 6) Packing and Gasket: Asbestos free.

T. Lubricated Plug Valves

- 1. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type II.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 5) Pattern: Regular or short **OR Venturi, as directed**.
 - 6) Plug: Cast iron or bronze with sealant groove.
- 2. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type II.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 5) Pattern: Regular or short **OR Venturi, as directed**.
 - 6) Plug: Cast iron or bronze with sealant groove.
- 3. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type IV.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 5) Pattern: Regular or short **OR Venturi, as directed**.



- 6) Plug: Cast iron or bronze with sealant groove.
4. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type IV.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - 4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 5) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 6) Plug: Cast iron or bronze with sealant groove.
5. Class 250, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type II.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 5) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 6) Plug: Cast iron or bronze with sealant groove.
6. Class 250, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type II.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 5) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 6) Plug: Cast iron or bronze with sealant groove.
7. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type IV.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - 5) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 6) Plug: Cast iron or bronze with sealant groove.
8. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:
 - a. Description:
 - 1) Standard: MSS SP-78, Type IV.
 - 2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 - 3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 - 4) Body Material: ASTM A 48/A 48M or ASTM A 126, Grade 40 cast iron with lubrication-sealing system.
 - 5) Pattern: Regular or short **OR** Venturi, **as directed**.
 - 6) Plug: Cast iron or bronze with sealant groove.

U. Eccentric Plug Valves

1. 175 CWP, Eccentric Plug Valves with Resilient Seating.
 - a. Description:
 - 1) Standard: MSS SP-108.
 - 2) CWP Rating: 175 psig (1200 kPa) minimum.
 - 3) Body and Plug: ASTM A 48/A 48M, gray iron; ASTM A 126, gray iron; or ASTM A 536, ductile iron.
 - 4) Bearings: Oil-impregnated bronze or stainless steel.
 - 5) Ends: Flanged.



- 6) Stem-Seal Packing: Asbestos free.
- 7) Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

V. Chainwheels

1. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
 - a. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
 - b. Attachment: For connection to ball **OR** butterfly **OR** plug, **as directed**, valve stems.
 - c. Sprocket Rim with Chain Guides: Ductile iron **OR** Cast iron **OR** Aluminum **OR** Bronze, **as directed**, of type and size required for valve. Include zinc coating, **as directed**.
 - d. Chain: Hot-dip, galvanized steel **OR** Brass **OR** Stainless steel, **as directed**, of size required to fit sprocket rim.

1.3 EXECUTION

A. Valve Installation

1. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
2. Locate valves for easy access and provide separate support where necessary.
3. Install valves in horizontal piping with stem at or above center of pipe.
4. Install valves in position to allow full stem movement.
5. Install chainwheels on operators for ball **OR** butterfly **OR** gate **OR** globe **OR** plug, **as directed**, valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.
6. Install check valves for proper direction of flow and as follows:
 - a. Swing Check Valves: In horizontal position with hinge pin level.
 - b. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
 - c. Lift Check Valves: With stem upright and plumb.

B. Adjusting

1. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

C. General Requirements For Valve Applications

1. If valve applications are not indicated, use the following:
 - a. Shutoff Service: Ball, butterfly **OR** gate **OR** plug, **as directed**, valves.
 - b. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 - c. Throttling Service except Steam: Globe **OR** angle **OR** ball **OR** butterfly, **as directed**, valves.
 - d. Throttling Service, Steam: Globe **OR** angle **OR** butterfly, **as directed**, valves.
 - e. Pump-Discharge Check Valves:
 - 1) NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze **OR** nonmetallic, **as directed**, disc.
 - 2) NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal **OR** resilient, **as directed**,-seat check valves.
2. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
3. Select valves, except wafer types, with the following end connections:
 - a. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 - b. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.



- c. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
- d. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
- e. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
- f. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
- g. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

D. Chilled-Water Valve Schedule

- 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
 - b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**, bronze.
 - f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
- 2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
 - c. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - d. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): 150 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - e. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 175 **OR** 300, **as directed**, CWP.
 - f. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
 - g. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - h. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
 - i. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
 - j. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.
 - k. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
 - l. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
 - m. Iron Globe Valves: Class 125 **OR** Class 250, **as directed**.
 - n. Lubricated Plug Valves: Class 125 **OR** Class 250, **as directed**, regular gland **OR** cylindrical, **as directed**, threaded **OR** flanged, **as directed**.
 - o. Eccentric Plug Valves: 175 CWP, resilient seating.

E. Condenser-Water Valve Schedule

- 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.



- b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
 - f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
- a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
 - c. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - d. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): 150 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - e. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 175 **OR** 300, **as directed**, CWP.
 - f. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
 - g. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - h. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
 - i. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
 - j. Iron, Center-Guided Check Valves, NPS 2-1/2 to NPS 24 (DN 65 to DN 600): Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, metal **OR** resilient, **as directed**, seat.
 - k. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
 - l. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
 - m. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.
 - n. Lubricated Plug Valves: Class 125 **OR** Class 250, **as directed**, regular gland **OR** cylindrical, **as directed**, threaded **OR** flanged, **as directed**.
- F. Heating-Water Valve Schedule
- 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
 - b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
 - f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - 2. Pipe NPS 2-1/2 (DN 65) and Larger:



- a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
 - c. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - d. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): 150 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
 - e. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 175 **OR** 300, **as directed**, CWP.
 - f. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
 - g. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - h. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
 - i. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
 - j. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.
 - k. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
 - l. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
 - m. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.
- G. Low-Pressure Steam Valve Schedule (15 psig (104 kPa) Or Less)
1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - c. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - d. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
 - e. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
 - c. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
 - d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - e. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
 - f. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
 - g. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.
- H. High-Pressure Steam Valve Schedule (More Than 15 psig (104 kPa))
1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.



- b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - c. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - d. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**, bronze.
 - e. Globe Valves: Class 125 **OR** 150, **as directed**, bronze, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe Sizes NPS 2-1/2 (DN 65) and Larger:
- a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150, iron.
 - c. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
 - d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - e. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
 - f. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
 - g. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.
- I. Steam-Condensate Valve Schedule
1. Pipe NPS 2 (DN 50) and Smaller:
- a. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
 - c. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
 - d. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
 - e. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
- a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
 - c. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
 - d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
 - e. Iron Swing Check Valves with Closure Control: Class 125, lever and spring **OR** weight, **as directed**.
 - f. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
 - g. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.
 - h. Lubricated Plug Valves: Class 125 **OR** Class 250, **as directed**, regular gland **OR** cylindrical, **as directed**, threaded **OR** flanged, **as directed**.

END OF SECTION 22 13 19 33



Task	Specification	Specification Description
22 13 19 33	22 05 23 00	Piped Utilities Basic Materials And Methods
22 13 19 33	22 05 76 00	Sanitary Sewerage
22 13 19 33	22 05 23 00a	General-Duty Valves for Plumbing Piping
22 13 23 00	22 13 19 26	Interceptors



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**SECTION 22 13 29 13 - PACKAGED SEWAGE PUMPING STATIONS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for packaged sewage pumping stations. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes dry-well, packaged pumping stations with dry-well or vacuum-primed sewage pumps.
2. This Section includes wet-well, packaged pumping stations with submersible or submersible grinder or wet-well-mounting sewage pumps.

C. Performance Requirements

1. Pressure Rating of Sewage Pumps and Discharge Piping Components: At least equal to sewage pump discharge pressure, but not less than 125 psig (860 kPa).
2. Pressure Rating of Other Piping Components: At least equal to system operating pressure.

D. Submittals

1. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
2. Shop Drawings: Show fabrication and installation details for each packaged pumping station. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Product Certificates: For sewage pumps, signed by product manufacturer.
4. Manufacturer Seismic Qualification Certification
5. Field quality-control test reports.
6. Maintenance Data: For packaged pumping stations to include in maintenance manuals.

E. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Testing Agency Qualifications: Nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. Comply with HI 1.1-1.2, "Centrifugal Pumps for Nomenclature and Definitions"; HI 1.3, "Centrifugal Pumps for Design and Application"; and HI 1.4, "Centrifugal Pumps for Installation, Operation and Maintenance," for sewage and sump pumps.
5. Comply with UL 778, "Motor-Operated Water Pumps," for sewage and sump pumps.

F. Project Conditions

1. Interruption of Existing Sanitary Sewer Service: Do not interrupt sanitary sewer service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sanitary sewer service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of sanitary sewer service.



- b. Do not proceed with interruption of sanitary sewer service without the Owner's written permission.

1.2 PRODUCTS

A. Dry-Well, Packaged Sewage Pumping Stations

1. Dry-Well, Packaged Sewage Pumping Stations with Dry-Well Sewage Pumps:

- a. Description: Factory fabricated, assembled, and tested with wet well for comminutor and collection of sanitary sewage and with dry equipment chamber for sewage pumps, controls, and accessories.
- 1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.
 - 2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.
 - 3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
 - 4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).
 - 5) Comminutor: Full size of sewage inlet pipe.
 - 6) Sewage Pumps: Two **OR** Three, **as directed**, dry-well-type, nonclog sewage pumps with controls and piping. Include ASTM A 48/A 48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; mechanical or stuffing-box seals; and pedestal-mounted motor.

2. Dry-Well, Packaged Sewage Pumping Stations with Vacuum-Primed Sewage Pumps:

- a. Description: Factory fabricated, assembled, and tested with wet well for comminutor and collection of sanitary sewage and with dry equipment chamber for sewage pumps, vacuum pumps, controls, and accessories.
- 1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.
 - 2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.
 - 3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
 - 4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).
 - 5) Comminutor: Full size of sewage inlet pipe.
 - 6) Sewage Pumps: Two **OR** Three, **as directed**, dry-chamber-mounting, vacuum-primed, nonclog sewage pumps located in dry compartment above wet pit, with controls and piping. Include ASTM A 48/A 48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; mechanical or stuffing-box seals; pedestal-mounted motor; and suction piping extending to bottom of wet pit.
 - 7) Vacuum Pumps: Duplex arrangement with controls, vacuum piping, and vent piping of size and capacity required for system. Include automatic alternator, with manual disconnect switch, to change sequence of lead-lag vacuum pumps at completion of each cycle.

B. Wet-Well, Packaged Sewage Pumping Stations

1. Wet-Well, Packaged Sewage Pumping Stations with Submersible Sewage Pumps:

- a. Description: Factory fabricated, assembled, and tested with wet well for comminutor, sewage pumps and collection of sanitary sewage and with sewage pumps and dry equipment chamber for controls and accessories.



- 1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.
 - 2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.
 - 3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
 - 4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).
 - 5) Comminutor: Full size of sewage inlet pipe.
 - 6) Sewage Pumps: Two **OR** Three, **as directed**, submersible-type sewage pumps, with guide rail, quick-disconnect system, controls, and piping. Include ASTM A 48/A 48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; and hermetically sealed motor with moisture-sensing probe, mechanical seals, and waterproof power cable.
2. Wet-Well, Packaged Sewage Pumping Stations with Submersible Grinder Sewage Pumps:
- a. Description: Factory fabricated, assembled, and tested with wet well for sewage pumps and collection of sanitary sewage and with dry equipment chamber for controls and accessories.
 - 1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.
 - 2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.
 - 3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
 - 4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).
 - 5) Sewage Pumps: Two **OR** Three, **as directed**, submersible grinder-type sewage pumps, with guide rail, quick-disconnect system, controls, and piping. Include stainless-steel grinder impeller and hermetically sealed motor with moisture-sensing probe, mechanical seals, and waterproof power cable.
 - a) If Project has more than one wet-well, packaged sewage pumping station with submersible grinder sewage pumps,
3. Wet-Well, Packaged Sewage Pumping Stations with Wet-Well-Mounting Sewage Pumps:
- a. Description: Factory fabricated, assembled, and tested with wet well for comminutor, sewage pumps and collection of sanitary sewage and with suspended sewage pumps and dry equipment chamber for pump motors, controls, and accessories.
 - 1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.
 - 2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.
 - 3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
 - 4) Cathodic Protection: as directed by XXXXcontractingpositiontheXXX, exterior magnesium anode(s).
 - 5) Comminutor: Full size of sewage inlet pipe.
 - 6) Sewage Pumps: Two **OR** Three, **as directed**, wet-well-mounting-type, nonclog sewage pumps suspended from dry-compartment floor, with controls and piping. Include ASTM A 48/A 48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; grease-lubricated bearings and stuffing-box seal; shaft coupling; and pedestal-mounted motor.

C. Comminutors:

1. Description: Motor-operated, single- or twin-shaft, cutter- or grinder-design unit with controls; for pipeline installation.
 - a. Body: Stainless steel or ductile iron with flanged ends and access plate.



- b. Cutting Elements: Motor-driven rotor and stationary cutters or grinders of hardened stainless or heat-treated steel.
- c. Motor: Explosion proof, directly connected to body.
- d. Control Panel: NEMA 250, Type 12 enclosure for installation in dry equipment chamber.

D. Controls

1. Control Sequence of Operation: Cycle each sewage pump on and off automatically to maintain wet-well sewage level. Automatic control operates both pumps in parallel if wet-well level rises above starting point of low-level pump, until shutoff level is reached. Automatic alternator, with manual disconnect switch, changes sequence of lead-lag sewage pumps at completion of each pumping cycle.
2. Self-Purging, Air-Bubbler System: Senses variations of sewage level in wet well. Include duplex-arrangement oilless air compressors to furnish bubbler air; filters; air-storage reservoir; piping; airflow meter with needle valve adjustment for airflow regulation; sewage depth gage; air-bubbler piping to wet well; and pressure-sensing, dustproof mercury switches.
3. Electrode **OR** Float-Switch **OR** Pressure-Switch **OR** Ultrasonic, **as directed**, System: Senses variations of sewage level in wet well. Include high and low adjustments capable of operating on 6-inch (150-mm) minimum differential of liquid level.
4. Motor Controllers: Magnetic, full voltage, nonreversing. Include undervoltage release, thermal-overload heaters in each phase, manual reset buttons, and hand-automatic selector switches. Include circuit breakers to provide branch-circuit protection for each controller.
5. 120-V accessory controls with 15-A, single-phase circuit breakers or fuses for each item.
6. Control Panel: Enclosure complying with UL 508A and with UL 508A, Supplement SB, **as directed**, with separate compartments and covers for controllers, circuit breakers, transformers, alternators, and single-phase controls. Include 20-A duplex receptacle in NEMA WD 1, Configuration 5-20R mounted on exterior of control panel.
 - a. Mounting: Inside, on dry-chamber wall **OR** Outside, on pedestal, at grade, **as directed**.
 - b. Enclosure: NEMA 250, Type 1 **OR** 4 **OR** 4X, **as directed**.
7. Install labels on panel face to identify switches and controls.
8. Wiring: Tin-copper wiring.
9. Connection for Portable Generator: Nonautomatic (manual) transfer switch with receptacle matching generator electrical power requirements. Nonautomatic transfer switches are specified in Division 26 Section "Transfer Switches" and receptacles are specified in Division 26 Section "Wiring Devices".

E. Accessories

1. Lighting: Minimum of 2, UL 1571, heavy-duty, cast-metal, wet-location-type fixtures with 100-W bulbs and guards in service area. Locate switches, with pilot lights, at chamber entrance.
2. Submersible Sump Pump:
 - a. Discharge Size: NPS 1-1/4 (DN 32) minimum.
 - b. Pump End Bell and Motor Shell: Cast iron.
 - c. Motor: 1/3 hp, 1750-rpm, hermetically sealed, capacitor-start, with built-in overload protection.
 - d. Impeller: ASTM B 584, cast bronze or ASTM B 36/B 36M, brass.
 - e. Shaft: Stainless steel.
 - f. Bearings: Grease-lubricated, factory-sealed ball bearings.
 - g. Seals: Mechanical.
 - h. Accessories: Inlet strainer.
 - i. Controls: Float switch.
3. Dehumidifier: Electric refrigeration system, adjustable humidistat, reverse-acting thermostat for low-temperature cutoff controls, and condensate pump with drain piping to sump.
 - a. Dehumidification system capacity adequate to remove at least 15 pints (7 L) of water per day from service area air that is 80 deg F (27 deg C) with a relative humidity of 60 percent.
4. Ventilation: Electrically powered ventilation system. Include centrifugal blower with 4-inch- (100-mm-) round exhaust vent designed to keep out rain, insects, and other foreign matter; limit switch



- to start blower if entrance door or lid is opened; 0- to 15-minute timer; and separate manual switch.
- a. Ventilating system capacity to change air in dry equipment chamber every two minutes.
5. Heater: Electric, 1.5 kW minimum, with fan and thermostat control.
 6. High-Water Audio Alarm: Horn for audio indication of station high-water level, energized by separate level-detecting device. Include alarm silencer switch and relay in station.
 7. Remote Alarm Circuit: Include contacts for connection to remote alarm panel.
- F. Motors
1. General requirements for motors are specified in Division 22 Section "Common Motor Requirements For Plumbing Equipment".
- G. Miscellaneous Materials
1. Structural Steel: ASTM A 6/A 6M, W or HP shapes, or ASTM A 36/A 36M, plates or beams.
 2. Grout: ASTM C 1107, Grade B, nonshrink cement grout.
 - a. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 3. Concrete: Concrete is specified in Division 03 Section "Cast-in-place Concrete".
- H. Packaged Sewage Pumping Station Fabrication
1. Fabricate shell from structural-steel plate with continuous welds to make watertight and gastight construction.
 - a. Walls: 1/4-inch (6.4-mm) minimum thickness.
 - b. Top and Bottom Heads: 3/8-inch (9.5-mm) minimum thickness. Weld reinforcing steel to top and bottom heads.
 - c. Entrance-Tube Walls: 1/4-inch (6.4-mm) minimum thickness.
 - d. Weld steel access ladder and air vent to shell and entrance tube, **as directed**.
 - e. Apply three coats of epoxy resin to interior and exterior surfaces.
 - f. Include at least two **OR** four, **as directed**, exterior magnesium anode(s) for cathodic protection.
 2. Fabricate shell from fiberglass with structural-steel reinforcement.
 - a. Attach structural-steel reinforcement to top and bottom heads.
 - b. Fabricate shell with continuous joints to make watertight and gastight construction.
 - c. Attach air vent to pump chamber and entrance tube, **as directed**.
 - d. Ladder: Steel **OR** Fiberglass, **as directed**.
 3. Install sump, 18 inches (450 mm) in diameter by 10 inches (254 mm) deep in dry-chamber floor. Slope floor toward sump and fasten rubber mat to floor walkway with cement.
 4. Entrance tube may be furnished separately for field installation.
 5. Entrance Cover: Waterproof and corrosion resistant, with lock. Include way to open cover from inside tube if cover is locked.
 6. Air Vent: Duct fabricated from corrosion-resistant material, extended to above grade, outlet turned down, and with insect screen in outlet.
 7. Factory fabricate piping between unit components.
 - a. Use galvanized-steel pipe and cast-iron fittings or ductile-iron pipe and fittings.
 - b. Use fittings for changes in direction and branch connections.
 - c. Flanged and union joints may be used instead of joints specified.
 - d. Use dielectric fittings for connections between ferrous- and copper-alloy piping.
 8. Piping Connections: Unless otherwise indicated, make the following piping connections:
 - a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment having NPS 2 (DN 50) or smaller threaded pipe connection.
 - b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
 9. Valves: Ferrous alloy.
 - a. Sewage Pump Piping: Include gate valve on each pump inlet and gate and check valves on each discharge pipe.
 - b. Sump Pump Piping: Include ball or gate and check valves on discharge pipe.



- c. Compressed-Air Piping: Include ball and check valves on discharge pipe from each air compressor.
 - d. Vacuum Piping: Include ball and check valves on inlet pipe to each vacuum pump.
10. Wiring: Tin-coated copper.
- I. Source Quality Control
- 1. Test and inspect sewage and sump, **as directed**, pumps according to HI 1.6, "Centrifugal Pump Tests." Include test recordings that substantiate correct performance of pumps at design head, capacity, suction lift, speed, and horsepower.
 - 2. Test accessories and controls through complete cycle. Include test recordings that substantiate correct performance.

1.3 EXECUTION

A. Earthwork

- 1. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Installation

- 1. Install packaged sewage pumping station components where indicated, according to specific equipment and piping arrangement indicated.
- 2. Shell Base Supports: Form from structural-steel beams, of number and lengths required to support bottom of shell and to anchor beams to concrete foundation.
 - a. Use elevator blocks attached to bottom of shell to slope station floor 1 inch in 10 feet (25.4 mm in 3 m) down toward sump.
- 3. Grout under and around shell. Ensure that there are no voids between foundation slab and underslab of pumping station.
- 4. Fill voids between shell sidewalls, sleeves, and piping and make watertight seal with grout.
- 5. Connect anode conductors to grounding lugs on steel housing.
- 6. Join separate sections of housing by field welding.
- 7. Field weld entrance tube to housing.

C. Connections

- 1. Sanitary sewer piping installation requirements are specified in Division 22 Section "Facility Sanitary Sewers". Drawings indicate general arrangement of piping.
- 2. Install piping adjacent to machine to allow service and maintenance.
- 3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
- 4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

D. Identification

- 1. Install identifying labels permanently attached to equipment.
- 2. Install operating instruction signs permanently attached to equipment or on pumping station wall near equipment.
- 3. Arrange for installing green warning tape or detectable warning tape over outside edges of underground packaged sewage pumping stations. Tape materials and their installation are specified in Division 31 Section "Earth Moving".

E. Painting

- 1. Prepare and paint ferrous piping in wet wells, structural-steel supports, and anchor devices with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.
- 2. Paint field-welded areas to match factory coating.

F. Field Quality Control



1. Testing Agency: Engage a qualified testing agency to perform field tests and inspections and prepare test reports.
 2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.. Report results in writing.
 3. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 4. Tests and Inspections:
 - a. After installing packaged sewage pumping stations and after electrical circuitry has been energized, test for compliance with requirements. Furnish water required for pump tests.
 - b. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 5. Remove and replace packaged sewage pumping stations that do not pass tests and inspections and retest as specified above.
- G. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Adjust pump, accessory, and control settings, and safety and alarm devices.
- H. Demonstration
1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain packaged sewage pumping stations.

END OF SECTION 22 13 29 13



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**SECTION 22 13 29 13a - LIFT STATION****1.1 GENERAL****A. Description Of Work**

1. This Specification covers the furnishing and installation of sewage lift stations. Work includes but is not limited to earthwork, installation of watertight precast concrete sump basin, basin access cover, submersible sewage pumps, pump guide rail system, pump control system, valves and piping and electrical connections as required. Specific sizes of basins, pumps, and piping shall be as follows or as directed by the Owner.

B. Submittals

1. Product Data: For each type of product indicated.
 - a. Pipe and fittings
 - b. Check valves
 - c. Gate valves
 - d. Submersible sewage grinder pumps
 - e. Pump motor
 - f. Flexible flanged coupling
2. Operation and Maintenance Data: Include pumps, alarms, and motors. Data for submersible sewage grinder pump station data shall include all information on all equipment, alarm panel and controls, pumps and pump performance curves, and station layout.

C. Delivery, Storage, and Handling of Materials

1. Delivery and Storage: Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials in enclosures or under protective covering. Store rubber gaskets not to be installed immediately under cover, out of direct sunlight. Do not store materials directly on the ground. Keep interior of pipes and fittings free of dirt and debris.
2. Handling: Handle pipe, fittings, valves, and other accessories in such manner as to ensure delivery to the trench in sound, undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make satisfactory repairs if coatings or linings are damaged. Carry pipe to the trench; do not drag it.

1.2 PRODUCTS**A. Precast Concrete Sump Basin(s)**

1. Precast Concrete Sump Basin shall be constructed in conformance with Division 26 Section "Underground Ducts And Raceways For Electrical Systems". Basin shall have an integral bottom base section.
2. Joint Sealant: Seal all joints with EZ Stik Butyl Gasket as manufactured by Concrete Products Supply Co., or approved equal. Install in accordance with manufacturer's recommendations.
3. Pipe Opening Seals.
4. Waterproofing: Waterproof interior of concrete sump with one coat of Koppers Coal Tar Bitumastic Black or approved equal. Repair all damaged coating before final backfill. Do not coat cover of basin.
5. Access Hatch - Aluminum Hinged Frame and Cover Model EC-3HD by Syracuse Castings, Cicero, NY (315) 699-2601, or approved equal. Frame and cover shall be heavy duty, rated for H-20 Loadings. Frame shall be angle style frame. Material shall be 6061-T6 aluminum for bars, angles and extrusions. 1/4" diamond plate shall be 5086 aluminum. Unit designed heavy duty, for H-20 wheel loads where not subject to high density traffic. Unit supplied with a heavy duty pneu-spring, for ease of operation when opening cover. Each hatch shall be equipped with a hold open arm. Door shall lock open in the 90 degree position. Hinges shall be of heavy duty design. Material shall be a brass alloy with a 65,000 psi tensile strength. Each hinge shall have



a Grade 316 Stainless Steel, 3/8" diameter hinge pin. Exterior of frame, which comes in contact with concrete shall have one coat black bituminous paint. Unit supplied with a recessed stainless steel slamlock. Angle frame must be completely encased in concrete. Both bearing plates must be fully supported by a bed of concrete.

6. The unit shall be supplied with aluminum safety grate. Safety Grate shall be made of 6061-T6 aluminum with a minimum ultimate strength of 38,000 psi and a minimum yield strength of 35,000 psi as per ASTM B221. Grate design shall use safety factors as defined in the "Specifications for Aluminum Structures", by the Aluminum Association, Inc., 5th edition, DEC. 1986 for "Bridge Type Structures."
 - a. Grating shall be designed to withstand a minimum live load of 300 pounds per square foot. Deflection shall not exceed 1/150th of the span.
 - b. Grate openings shall be 4" x 4", which will allow for visual inspection of the pit once the access hatch is open.
 - c. Each grate shall be provided with a stainless steel, safety check chain. Chain will prevent the grating from falling into the pit.
 - d. Welding shall be in accordance with ANSI/AWS D1.2 "Structural Welding Code for Aluminum."

B. Submersible Sewage Pump System

1. Submersible sewage effluent pumps shall be sized as directed by the Owner and specified herein. Pump shall be heavy duty cast iron with stainless steel fasteners. The impeller shall be semi-open, non-clog, engineered plastic capable of passing 3/4" solids. Pump motor shall be oil filled. Pumps shall be equal to SHEF Series as manufactured by Hydromatic or approved equal. Specific pump performance data shall conform to the following:

1/2 HP Pumps 230 volt/single phase/60 Hz/2" NPT/ 3450 rpm
 40 gpm @ 42 ft. TDH
 50 gpm @ 32 ft. TDH
 60 gpm @ 18 ft. TDH

1 HP Pumps 230 volt/single phase/60 Hz/2" NPT/3450 rpm
 20 gpm @ 80 ft. TDH
 30 gpm @ 76 ft. TDH
 40 gpm @ 71 ft. TDH
 50 gpm @ 65 ft. TDH

C. Duplex Guide Rail System: Complete package system shall be as manufactured by Moran Manufacturing Inc., or approved equal, as follows.

1. The guide rail assembly shall be constructed of Type 304 stainless steel and shall consist of a minimum of two rails, a bottom base plate, a minimum of one cross brace every 18 inches between the rails and a wall brace, all welded together to provide the maximum structural integrity. The rails shall be round to provide a non-binding surface during installation and removal of the pump. The guide rail assembly shall be installed as a one piece unit and shall be bolted with stainless anchor bolts to the basin bottom and the basin wall a minimum of two places each.
2. The pump bracket assembly shall consist of a top bracket and a bottom bracket. The brackets shall be fabricated of 1/4" steel material and shall be painted with coal tar epoxy paint at such rate as to provide a minimum 10 mil thickness. The top bracket shall be attached to the discharge piping above the pump disconnect and shall be constructed in such a manner that pump cannot be removed from the guide rail assembly except when removing pump out the top of the sump basin. The bottom bracket shall be attached to the pump at the discharge connection and shall guide the pump along the guide rail assembly to ensure proper alignment of the pump.



3. A 3/16" min. (7 x 9) stainless steel lifting cable, 10 ft. longer than the sump depth, shall be furnished for lifting and lowering the pump in the sump basin. The stainless steel lifting cable shall be of the 18-8 type 302/304 stainless steel and shall have minimum nominal breaking strength of 15 times the weight of the pump. It shall be substantially attached to the top of the pump and shall have a formed loop at the other end.
4. The discharge piping shall include a cast iron ball check valve, with a natural rubber ball and clean out port with plug for easy access, a brass quick disconnect fitting, with an O-ring stem brass gate valve, per pump. All other piping shall be schedule 40 stainless steel.
5. The station shall have a gate valve extension handle per valve which will allow the gate valve to be operated from a maximum of 6" below the basin cover. The handle shall be constructed of a minimum of 3/8" dia. Type 304 stainless steel. The handle shall be held in place by being attached to the gate valve and by the guide rail wall brace.
6. All internal metal parts that are not brass, galvanized steel, or stainless steel shall be painted with coal-tar epoxy paint to resist corrosion, unless otherwise noted.
7. Mercury level control switches shall be provided for lead pump on, lag pump on and high level alarm, pumps off and low level alarm.
8. The mercury switch shall be encapsulated in polyurethane foam for corrosion and shock resistance. Level switches shall be weighted to hold position in the sump. The cord connecting the control shall be No. 16-2, rated for 13 amps, and shall be type C-SJO. To ensure optimum longevity, mercury contacts shall be of the mercury-to-mercury type and encapsulated in a glass tube and shall be rated for 20 amps at 115 VAC.
9. The manufacturer of the lift station shall furnish a limited warranty for 18 months from the date of shipment or 12 months from start-up (whichever occurs first), that all equipment shall be free from defects in design, materials and workmanship. The lift station manufacturer shall furnish replacement parts for any component proven defective whether of its or other manufacturer during the warranty period, excepting only those items which are normally consumed in service, such as (but not limited to) light bulbs, oil, grease, packing, etc.
10. Installation instructions shall be furnished with the station.

D. Control System

1. This system shall be controlled and protected by a packaged system as manufactured by Rombus, or approved equal. The control shall provide automatic start, stop and alternation of 2 pumps, and shall provide an audible alarm as well as visual indication of high level conditions.
2. The control panel shall be pre-wired in a NEMA 3R weatherproof enclosure, and all necessary components including the following: single phase lightning arrester for protection of the pumps, NEMA rated contractor and thermal magnetic circuit breaker for each pump, a main control/alarm circuit fused disconnect switch, separately fused control and alarm circuits, panel mounted duplex alternating relays, control relays, and terminal blocks for the connection on all external wiring. Provide a 20 amp/115v convenience outlet in each panel on its own GFCI circuit breaker. Multi-colored circuitry is to be used within the control panel to facilitate trouble shooting.
3. Mounted inside the enclosure shall be hand-off-auto switches and run pilot lights for each pump circuit; normal-off-test switch and alarm pilot light for high level alarm; float test toggle switches for each float to override floats to simulate operation; non-resettable elapsed time meters for each pump.
4. Mounted remotely from the Control Panel shall be a 4" 120V alarm bell and a flashing alarm light.

E. System Operation: As the level in the sump rises to the lead pump on level, the pump selected as lead by the alternator will come on line, and will pump the level down to the pump off level. The pump will then turn off, and the alternator will cycle, selecting the other pump as lead for the next cycle. If, with the lead pump running, the level in the tank continues to rise to the lag pump on level, the lag pump will come on line, alarms will sound, and will run with the lead pump until the pumps off level has been reached. The pumps will then be turned off, and the alternator will cycle. If level continues to drop to the low level alarm float, alarm circuits will be activated.

1. Placing the T-O-N switch into the off position will de-energize the alarm bell and flashing light, but the alarm pilot light will remain illuminated until the alarm condition has been cleared. When the



alarm pilot light is extinguished, the T-O-N switch may be reset to the normal position, and the alarm will stand ready for the next alarm.

1.3 EXECUTION

- A. The Contractor shall excavate the station site to the elevations as required to meet project requirements. Compact the subgrade and install crushed stone.
- B. Install lift station in accordance with manufacturer's recommendations. Perform additional exterior waterproofing as required to repair original coating and to achieve a watertight sump basin. The discharge piping shall be extended and connected to the sewage force mains. Backfill material shall be approved by the Owner. No backfill material shall have any dimension greater than 6". Backfill material within 15" of basin shall not have a dimension greater than 2".
- C. The Lift Station control panel shall be mounted to the building nearby and shall have sufficient cord supplied by the Lift Station manufacturer to avoid any splices. All necessary electrical connections between pumps, flow controls and control panel shall be made in accordance with manufacturer's recommendations. No splices shall be made in the basin. Lightning protection shall be provided in the panel.
- D. Install pump power conductors in rigid steel conduit between Lift Station and Control Panel.
- E. Upon completion, the Lift Station shall be tested to assure there is no leakage and that the pumps, controls and alarm are operating satisfactorily. The Lift Station manufacturer's representative shall be present during initial start up and testing. Three (3) Lift Station operation and maintenance manuals shall be provided.

END OF SECTION 22 13 29 13a



SECTION 22 13 29 13b - SEWAGE PUMPS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for sewage pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Submersible effluent pumps.
 - b. Submersible sewage pumps.
 - c. Wet-pit-volute sewage pumps.
 - d. Sewage-pump, reverse-flow assemblies.
 - e. Sewage-pump basins and basin covers.
 - f. Progressing-cavity sewage pumps.
 - g. Packaged, submersible sewage-pump units.
 - h. Packaged wastewater-pump units.

C. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. UL Compliance: Comply with UL 778 for motor-operated water pumps.

E. Delivery, Storage, And Handling

1. Retain shipping flange protective covers and protective coatings during storage.
2. Protect bearings and couplings against damage.
3. Comply with pump manufacturer's written rigging instructions for handling.

F. Coordination

1. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.2 PRODUCTS

A. Submersible Effluent Pumps

1. Submersible, Fixed-Position, Single-Seal Effluent Pumps:
 - a. Description: Factory-assembled and -tested effluent-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal effluent pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as**



- directed**, and stainless steel, **as directed**, closed or semiopen design for clear wastewater, and keyed and secured to shaft.
- e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seal: Mechanical.
 - g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - h. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - i. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - j. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
2. Submersible, Fixed-Position, Double-Seal Effluent Pumps:
- a. Description: Factory-assembled and -tested effluent-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal effluent pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, closed or semiopen design for clear wastewater, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seals: Mechanical.
 - g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
 - h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - i. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.



- 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
- 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
- 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
- j. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
- k. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
3. Submersible, Quick-Disconnect, Single-Seal Effluent Pumps:
 - a. Description: Factory-assembled and -tested effluent-pump unit with guide-rail supports.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal effluent pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, closed or semiopen design for clear wastewater, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seal: Mechanical.
 - g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - h. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - i. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.



- 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
- j. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
- k. Guide-Rail Supports:
 - 1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
 - 2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
 - 3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
 - 4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
 - 5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
 - 6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
 - 7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.
4. Submersible, Quick-Disconnect, Double-Seal Effluent Pumps:
 - a. Description: Factory-assembled and -tested effluent-pump unit with guide-rail supports.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal effluent pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, closed or semiopen design for clear wastewater, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seals: Mechanical.
 - g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
 - h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - i. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - j. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.



- 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - k. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
 - l. Guide-Rail Supports:
 - 1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
 - 2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
 - 3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
 - 4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
 - 5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
 - 6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
 - 7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.
- B. Submersible Sewage Pumps
1. Submersible, Fixed-Position, Single-Seal Sewage Pumps:
 - a. Description: Factory-assembled and -tested sewage-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seal: Mechanical.
 - g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - h. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - i. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.



- 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
- 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
- 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
- j. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
2. Submersible, Fixed-Position, Double-Seal Sewage Pumps:
 - a. Description: Factory-assembled and -tested sewage-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seals: Mechanical.
 - g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
 - h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - i. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - j. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - k. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.



- b) Alarm status.
3. Submersible, Quick-Disconnect, Single-Seal Sewage Pumps:
- a. Description: Factory-assembled and -tested sewage-pump unit with guide-rail supports.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seal: Mechanical.
 - g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - h. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - i. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - j. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
 - k. Guide-Rail Supports:
 - 1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
 - 2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
 - 3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
 - 4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
 - 5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
 - 6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
 - 7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.



4. Submersible, Quick-Disconnect, Double-Seal Sewage Pumps:
 - a. Description: Factory-assembled and -tested sewage-pump unit with guide-rail supports.
 - b. Pump type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seals: Mechanical.
 - g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
 - h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - i. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - j. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - k. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
 - l. Guide-Rail Supports:
 - 1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
 - 2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
 - 3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
 - 4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
 - 5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
 - 6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.



- 7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.
5. Submersible, Quick-Disconnect, Grinder Sewage Pumps:
- a. Description: Factory-assembled and -tested, grinder sewage-pump unit with guide-rail supports.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail supports.
 - d. Impeller: Bronze or stainless steel; statically and dynamically balanced, with stainless-steel cutter, grinder, or slicer assembly; capable of handling solids; and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seal: Mechanical.
 - g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - h. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - i. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - j. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
 - k. Guide-Rail Supports:
 - 1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
 - 2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
 - 3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
 - 4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
 - 5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
 - 6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
 - 7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.



6. Submersible, Quick-Disconnect, Progressing-Cavity, Grinder Sewage Pumps:
- a. Description: Factory-assembled and -tested progressing-cavity, grinder sewage-pump unit with guide-rail supports.
 - b. Pump Type: Submersible, progressing-cavity, single-screw rotary, grinder sewage pump as defined in HI 3.1-3.5.
 - c. Pump Body: Cast iron.
 - d. Pump Bearings: Radial and thrust types.
 - e. Pump Shaft: Steel.
 - f. Rotor: Stainless steel.
 - g. Stator: Buna-N **OR** Natural rubber, **as directed**.
 - h. Seal: Packing gland and mechanical types.
 - i. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - j. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - k. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - l. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
 - m. Guide-Rail Supports:
 - 1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
 - 2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
 - 3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
 - 4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
 - 5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
 - 6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
 - 7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.

C. Wet-Pit-Volute Sewage Pumps

1. Description: Factory-assembled and -tested sewage-pump unit.



2. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
 3. Pump Casing: Cast iron, with open inlet and threaded or flanged connection for discharge piping.
 4. Pump Shaft: Stainless-steel **OR** steel, **as directed**.
 5. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
 6. Sleeve Bearings: Bronze. Include oil-lubricated, intermediate sleeve bearings at 48-inch (1200-mm) maximum intervals if basin depth is more than 48 inches (1200 mm), and grease-lubricated, ball-type thrust bearings.
 7. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
 8. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.1, Class 125, cast-iron flanges and flanged fittings or ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
 - a. Modify piping configuration to accommodate reverse-flow assembly.
 9. Support Plate: Cast iron or coated steel and strong enough to support pumps, motors, and controls. Refer to Part 1.2 "Sewage-Pump Basins and Basin Covers" Article for requirements.
 10. Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.
 11. Motor: Single-speed; grease-lubricated ball bearings and mounted on vertical, cast-iron pedestal.
 12. Controls (rod-and-float type):
 - a. Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 13. Controls (float- and pressure-switch types):
 - a. Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - b. Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 14. Control-Interface Features:
 - a. Remote Alarm Contacts: For remote alarm interface.
 - b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.
- D. Sewage-Pump, Reverse-Flow Assemblies
1. Description: Factory-fabricated, sewage pump reverse-flow assembly for factory or field assembly and installation in sewage pump basin. Include the following corrosion-resistant-metal components:
 - a. Inlet Fitting: One combination inlet-overflow strainer fitting.
 - b. Valves: Two shutoff valves and two check valves.
 - c. Strainers: Two strainer housings with reverse-flow, self-flushing strainers.
 - d. Pipe and Fittings: Size and configuration required to connect to sewage pumps and piping.

E. Sewage-Pump Basins And Basin Covers



1. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
 - a. Material: Cast iron **OR** Fiberglass **OR** Polyethylene, **as directed**.
 - b. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports if used, and accessories.
 - c. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.
2. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
 - a. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

F. Progressing-Cavity Sewage Pumps

1. Description: Factory-assembled and -tested progressing-cavity, single-screw rotary pump as defined in HI 3.1-3.5.
2. Pump Body: Cast iron with feet for base or floor installation.
3. Pump Bearings: Radial and thrust types.
4. Pump Shaft: Steel.
5. Rotor: Chrome-plated steel.
6. Stator: Buna-N **OR** Natural rubber, **as directed**.
7. Seals: Packing gland and mechanical types.
8. Coupling: Flexible.
9. Motor: Single-speed; grease-lubricated ball bearings.

G. Packaged, Submersible Sewage-Pump Units

1. Packaged, Submersible, Grinder, Sewage-Pump Units:
 - a. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, grinder, sewage-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron.
 - d. Impeller: Stainless-steel grinder, cutter, or slicer type with shredding ring.
 - e. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - f. Control (for simplex pump unit): Manufacturer's standard panel for one pump.
 - g. Controls (for duplex pump unit): Automatic, with mechanical- or mercury-float switches and alternator.
 - h. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
 - i. Basin: Watertight plastic, **as directed**, and of size required for pumps, with inlet pipe connection and gastight cover with pump discharge and vent connections.
2. Packaged, Submersible, Nonclog, Sewage-Pump Units:
 - a. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, sewage-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron.
 - d. Impeller: Brass or cast iron; statically and dynamically balanced, non-clog design, and capable of handling 2-inch (50-mm) diameter solids.
 - e. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.



- f. Control (for simplex pump units): Manufacturer's standard panel for one pump.
 - g. Controls (for duplex pump unit): Automatic, with mechanical- or mercury-float switches and alternator.
 - h. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
 - i. Basin: Watertight plastic, **as directed**, and of size required for pumps, with inlet pipe connection and gastight cover with pump discharge and vent connections.
- H. Packaged Wastewater-Pump Units
- 1. Packaged, Wet-Pit-Volute, Wastewater-Pump Units:
 - a. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, effluent-pump unit.
 - b. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Body and Impeller: Corrosion-resistant materials.
 - d. Motor: With built-in overload protection and mounted vertically on basin cover.
 - e. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches (1830 mm) and with grounding plug and cable-sealing assembly for connection at pump.
 - f. Control: Float switch.
 - g. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
 - h. Basin: Watertight, aluminum, plastic, or coated steel with inlet pipe connection and gastight cover with vent and pump discharge connections.
 - 2. Packaged, Submersible Wastewater-Pump Units:
 - a. Description: Factory-assembled and -tested, automatic-operation, effluent-pump unit with basin.
 - b. Pump Type: Submersible, end-suction, single-stage, overhung-impeller, centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Body and Impeller: Corrosion-resistant materials.
 - d. Pump Seals: Mechanical.
 - e. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection.
 - f. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches (1830 mm) and with grounding plug and cable-sealing assembly for connection at pump.
 - g. Control: Float switch.
 - h. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
 - i. Basin: Watertight plastic with inlet pipe connection and gastight cover with vent and pump discharge connections.
- I. Motors
- 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "Common Motor Requirements For Plumbing Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
 - 2. Motors for submersible pumps shall be hermetically sealed.



1.3 EXECUTION

A. Earthwork

1. Excavation and filling are specified in Division 31 Section "Earth Moving".

B. Examination

1. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

C. Installation

1. Pump Installation Standards:
 - a. Comply with HI 1.4 for installation of centrifugal pumps.
 - b. Comply with HI 3.1-3.5 for installation of progressing-cavity sewage pumps.
2. Equipment Mounting (for equipment supported on slabs-on-grade): Install progressing-cavity sewage pumps on concrete base using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install progressing-cavity sewage pumps using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
4. Equipment Mounting: Install progressing-cavity sewage pumps on vibration isolation equipment base. Comply with requirements specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
5. Wiring Method (for pumps with wall-mounted controls): Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
6. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Connections

1. Comply with requirements for piping specified in Division 22 Section "Sanitary Waste And Vent Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment to allow service and maintenance.

E. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Perform each visual and mechanical inspection.
 - b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pumps and controls will be considered defective if they do not pass tests and inspections.



-
4. Prepare test and inspection reports.
 - F. Startup Service
 1. Engage a factory-authorized service representative to perform **OR** Perform, **as directed**, startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - G. Adjusting
 1. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
 2. Adjust control set points.
 - H. Demonstration
 1. Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 22 13 29 13b



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Task	Specification	Specification Description
22 13 29 16	22 13 29 13b	Sewage Pumps
22 13 29 33	01 22 16 00	No Specification Required



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SECTION 22 14 29 13 - SUMP PUMPS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for sump pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Submersible sump pumps.
 - b. Wet-pit-volute sump pumps.
 - c. Sump-pump basins and basin covers.
 - d. Packaged drainage-pump units.

C. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. UL Compliance: Comply with UL 778 for motor-operated water pumps.

E. Delivery, Storage, And Handling

1. Retain shipping flange protective covers and protective coatings during storage.
2. Protect bearings and couplings against damage.
3. Comply with pump manufacturer's written rigging instructions for handling.

1.2 PRODUCTS

A. Submersible Sump Pumps

1. Submersible, Fixed-Position, Single-Seal Sump Pumps:
 - a. Description: Factory-assembled and -tested sump-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, semiopen, **as directed**, design for clear wastewater handling, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seal: Mechanical.



- g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - h. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - i. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - j. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
2. Submersible, Fixed-Position, Double-Seal Sump Pumps:
- a. Description: Factory-assembled and -tested sump-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
 - d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, semiopen, **as directed**, design for clear wastewater handling, and keyed and secured to shaft.
 - e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
 - f. Seals: Mechanical.
 - g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
 - h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - 1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
 - i. Controls (rod-and-float type):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - 2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).



- 5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - j. Controls (float- and pressure-switch types):
 - 1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - 2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - 3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - 4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - k. Control-Interface Features:
 - 1) Remote Alarm Contacts: For remote alarm interface.
 - 2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a) On-off status of pump.
 - b) Alarm status.
- B. Wet-Pit-Volute Sump Pumps
1. Description: Factory-assembled and -tested sump-pump unit.
 2. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
 3. Pump Casing: Cast iron, with strainer inlet and threaded connection for NPS 2 (DN 50) and smaller and flanged connection for NPS 2-1/2 (DN 65) and larger discharge piping.
 4. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, semiopen, **as directed**, design for clear wastewater handling, and keyed and secured to shaft.
 5. Sleeve Bearings: Bronze. Include oil-lubricated, intermediate sleeve bearings at 48-inch (1200-mm) maximum intervals if basin depth is more than 48 inches (1200 mm), and grease-lubricated, ball-type thrust bearings.
 6. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
 7. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.1, Class 125, cast-iron flanges and flanged fittings or ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
 8. Support Plate: Cast iron or coated steel and strong enough to support pumps, motors, and controls. Refer to Part 1.2 "Sump-Pump Basins and Basin Covers" Article for requirements.
 9. Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.
 10. Motor: Single-speed; grease-lubricated ball bearings and mounting on vertical, cast-iron pedestal.
 11. Controls (rod-and-float type):
 - a. Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
 - b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 - e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 12. Controls (float- and pressure-switch types):
 - a. Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
 - b. Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.



- c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
13. Control-Interface Features:
- a. Remote Alarm Contacts: For remote alarm interface.
 - b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.
- C. Sump-Pump Basins And Basin Covers
1. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
 - a. Material: Cast iron **OR** Fiberglass **OR** Polyethylene, **as directed**.
 - b. Reinforcement: Mounting plates for pumps, fittings, and accessories.
 - c. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.
 2. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
 - a. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.
- D. Packaged Drainage-Pump Units
1. Packaged Pedestal Drainage-Pump Units:
 - a. Description: Factory-assembled and -tested, automatic-operation, freestanding, sump-pump unit.
 - b. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Pump Casing: Corrosion-resistant material, with strainer inlet, design that permits flow into impeller, and vertical discharge for piping connection.
 - d. Impeller: Aluminum, brass, or plastic.
 - e. Motor: With built-in overload protection and mounted vertically on sump pump column.
 - f. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches (1830 mm), with grounding plug and cable-sealing assembly for connection at pump.
 - g. Control: Float switch.
 2. Packaged Submersible Drainage-Pump Units:
 - a. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, sump-pump unit.
 - b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
 - c. Casing: Metal.
 - d. Impeller: Brass.
 - e. Pump Seal: Mechanical.
 - f. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection.
 - g. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches (1830 mm), with grounding plug and cable-sealing assembly for connection at pump.
 - h. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
 - i. Control: Motor-mounted float switch.



j. Basin: Plastic.

E. Motors

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "Common Motor Requirements For Plumbing Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
2. Motors for submersible pumps shall be hermetically sealed.

1.3 EXECUTION

A. Earthwork

1. Excavation and filling are specified in Division 31 Section "Earth Moving".

B. Examination

1. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

C. Installation

1. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

D. Connections

1. Comply with requirements for piping specified in Division 22 Section "Facility Storm Drainage Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment to allow service and maintenance.

E. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Perform each visual and mechanical inspection.
 - b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pumps and controls will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

F. Startup Service

1. Engage a factory-authorized service representative to perform **OR** Perform, **as directed**, startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.

G. Adjusting

1. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
2. Adjust control set points.

H. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.



END OF SECTION 22 14 29 13



Task	Specification	Specification Description
22 14 29 13	22 05 23 00	Piped Utilities Basic Materials And Methods



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**SECTION 22 15 13 00 - GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for general-service packaged air compressors and receivers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Lubricated, reciprocating air compressors.
 - b. Oil-free, reciprocating air compressors.
 - c. Oilless, reciprocating air compressors.
 - d. Oil-free, rotary-screw air compressors.
 - e. Oil-flooded, rotary-screw air compressors.
 - f. Oil-free, rotary, sliding-vane air compressors.
 - g. Oil-sealed, rotary, sliding-vane air compressors.
 - h. Inlet-air filters.
 - i. Air-cooled, compressed-air aftercoolers.
 - j. Water-cooled, compressed-air aftercoolers.
 - k. Refrigerant compressed-air dryers.
 - l. Desiccant compressed-air dryers.
 - m. Computer interface cabinet.

C. Definitions

1. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm (actual L/s).
2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
3. Standard Air: Free air at 68 deg F (20 deg C) and 1 atmosphere (29.92 in. Hg) before compression or expansion and measured in scfm (standard L/s).

D. Performance Requirements

1. Delegated Design: Design compressed-air equipment mounting, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Compressed-air equipment shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated.
 - a. Wiring Diagrams: For power, signal, and control wiring.
2. Delegated-Design Submittal: For compressed-air equipment mounting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of supports.
 - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.



3. Seismic Qualification Certificates: For compressed-air equipment, accessories, and components, from manufacturers.
4. Operation and Maintenance Data.

F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

1.2 PRODUCTS

A. General Requirements For Packaged Air Compressors And Receivers

1. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.
2. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
 - a. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
 - b. Motor Controllers: Full-voltage, combination magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 - c. Control Voltage: 120-V ac or less, using integral control power transformer.
 - d. Motor Overload Protection: Overload relay in each phase.
 - e. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 - f. Automatic control switches to alternate lead-lag compressors for duplex **OR** sequence lead-lag compressors for multiplex, **as directed**, air compressors.
 - g. Instrumentation: Include discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.
 - h. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
3. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - a. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
 - b. Interior Finish: Corrosion-resistant coating.
 - c. Accessories: Include safety valve, pressure gage, drain, and pressure-reducing valve.
4. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

B. Lubricated, Reciprocating Air Compressors

1. Compressor(s): Lubricated, reciprocating-piston type with lubricated compression chamber and crankcase.
 - a. Submerged gear-type oil pump.
 - b. Oil filter.
 - c. Combined high discharge-air temperature and low lubrication-oil pressure switch.
 - d. Belt guard totally enclosing pulleys and belts.

C. Oil-Free, Reciprocating Air Compressors

1. Compressor(s): Oil-free, reciprocating-piston type with nonlubricated compression chamber, lubricated crankcase, and of construction that prohibits oil from entering compression chamber.



- a. Submerged gear-type oil pump.
 - b. Oil filter.
 - c. Combined high discharge-air temperature and low lubrication-oil pressure switch.
 - d. Belt guard totally enclosing pulleys and belts.
- D. Oilless, Reciprocating Air Compressors
- 1. Compressor(s): Oilless (nonlubricated), reciprocating-piston type, with sealed oil-free bearings, that will deliver air of quality equal to intake air.
 - a. High discharge-air temperature switch.
 - b. Belt guard totally enclosing pulleys and belts.
- E. Oil-Free, Rotary-Screw Air Compressors
- 1. Compressor(s): Oil-free, rotary-screw type with nonlubricated helical screws and lubricated gear box, and of construction that prohibits oil from entering compression chamber.
 - a. Coupling: Nonlubricated, flexible type.
 - b. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package prepiped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
 - c. Air Filter: Dry type, with maintenance indicator and cleanable replaceable filter element.
 - d. Air/Coolant Receiver and Separation System: 150-psig- (1035-kPa-) rated steel tank with ASME safety valve, coolant-level gage, multistage air-coolant separator element, minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.
 - e. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between 50 and 100 psig (345 and 690 kPa). Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.
- F. Oil-Flooded, Rotary-Screw Air Compressors
- 1. Compressor(s): Oil-flooded, rotary-screw type with lubricated helical screws and lubricated gear box.
 - a. Coupling: Nonlubricated, flexible type.
 - b. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package prepiped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
 - c. Air Filter: Dry type, with maintenance indicator and cleanable replaceable filter element.
 - d. Air/Coolant Receiver and Separation System: 150-psig- (1035-kPa-) rated steel tank with ASME safety valve, coolant-level gage, multistage air-coolant separator element, minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.
 - e. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between 50 and 100 psig (345 and 690 kPa). Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.
- G. Oil-Free, Rotary, Sliding-Vane Air Compressors
- 1. Compressor(s): Oil-free, nonpulsating, rotary, sliding-vane type with nonlubricated sliding vanes.
 - a. Cleanable inlet screens.
 - b. Outlet silencers on discharge connections.
- H. Oil-Sealed, Rotary, Sliding-Vane Air Compressors
- 1. Compressor(s): Nonpulsating, rotary, sliding-vane type with oil-sealed sliding vanes.
 - a. Cleanable inlet screens.
 - b. Outlet silencers and oil-mist separators on discharge connections.
- I. Inlet-Air Filters



1. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.
 - a. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
 - b. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.
 2. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.
 - a. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
 - b. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.
- J. Air-Cooled, Compressed-Air Aftercoolers
1. Description: Electric-motor-driven, fan-operation, finned-tube unit; rated at 250 psig (1725 kPa) and leak tested at 350-psig (2415-kPa) minimum air pressure; in capacities indicated. Size units to cool compressed air in compressor-rated capacities to 10 deg F (6 deg C) above summertime maximum ambient temperature. Include moisture separator and automatic drain.
- K. Water-Cooled, Compressed-Air Aftercoolers
1. Description: Shell and tube unit, rated at 250 psig (1725 kPa) and leak tested at 350-psig (2415-kPa) minimum air pressure, in capacities indicated. Include moisture separator and automatic drain.
- L. Refrigerant Compressed-Air Dryers
1. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 35 deg F (2 deg C), 100-psig (690-kPa) air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.
- M. Desiccant Compressed-Air Dryers
1. Description: Twin-tower unit with purge system, mufflers, and capability to deliver plus 10 deg F (minus 12 deg C), 100-psig (690-kPa) air at dew point. Include dew point controlled purge, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.
- N. Computer Interface Cabinet
1. Description:
 - a. Wall mounting.
 - b. Welded steel with white enamel finish.
 - c. Gasketed door.
 - d. Grounding device.
 - e. Factory-installed, signal circuit boards.
 - f. Power transformer.
 - g. Circuit breaker.
 - h. Wiring terminal board.
 - i. Internal wiring capable of interfacing 20 alarm signals.
- O. Motors
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "Common Motor Requirements For Plumbing Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.



- b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

1.3 EXECUTION

A. Equipment Installation

1. Equipment Mounting:

- a. Install air compressors, aftercoolers, and air dryers on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
 - 1) Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - 2) Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 3) For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4) Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5) Install anchor bolts to elevations required for proper attachment to supported equipment.
 - b. Install air compressors, aftercoolers, and air dryers using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
 - 1) Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - c. Install air compressors, aftercoolers, and air dryers on vibration isolation inertia bases. Comply with requirements specified in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
 - d. Install air compressors, aftercoolers, and air dryers on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
 - 1) Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2) For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3) Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4) Install anchor bolts to elevations required for proper attachment to supported equipment.
 - e. Install water-cooled, compressed-air aftercoolers and desiccant compressed-air dryers on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
 - 1) Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2) For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3) Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4) Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Install compressed-air equipment anchored to substrate.
 3. Arrange equipment so controls and devices are accessible for servicing.



4. Maintain manufacturer's recommended clearances for service and maintenance.
 5. Install the following devices on compressed-air equipment:
 - a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
 - b. Pressure Regulators: Install downstream from air compressors and dryers.
 - c. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.
- B. Connections
1. Comply with requirements for piping specified in Division 22 Section "General-service Compressed-air Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to machine to allow service and maintenance.
- C. Identification
1. Identify general-service air compressors and components. Comply with requirements for identification specified in Division 22 Section "Identification For Plumbing Piping And Equipment".
- D. Startup Service
1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Check for lubricating oil in lubricated-type equipment.
 - c. Check belt drives for proper tension.
 - d. Verify that air-compressor inlet filters and piping are clear.
 - e. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
 - f. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure but not higher than rating of system components.
 - g. Check for proper seismic restraints.
 - h. Drain receiver tanks.
 - i. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - j. Test and adjust controls and safeties.
- E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain air compressors, aftercoolers, and air dryers.

END OF SECTION 22 15 13 00



Task	Specification	Specification Description
22 15 13 00	23 09 00 00	HVAC Instrumentation And Controls
22 15 19 13	22 15 13 00	General-Service Packaged Air Compressors and Receivers
22 15 19 13	23 09 00 00	HVAC Instrumentation And Controls
22 15 19 19	22 15 13 00	General-Service Packaged Air Compressors and Receivers
22 15 19 19	23 09 00 00	HVAC Instrumentation And Controls



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SECTION 22 31 16 00 - WATER SOFTENERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for water softeners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes household and commercial water softeners.
 - a. Chemicals.
 - b. Water testing kits.

C. Definitions

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. FRP: Fiberglass-reinforced plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

D. Submittals

1. Product Data: For each type of water softener and water testing kit indicated.
2. Shop Drawings: Include plans, elevations, sections, details, and connections to piping systems.
 - a. Include wiring diagrams.
3. Manufacturer Seismic Qualification Certification
4. Field quality-control test reports.
5. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.
6. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.
3. ASME Compliance for FRP Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, where indicated.

F. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of water softener that fail in materials or workmanship within Five years from date of Final Completion.

1.2 PRODUCTS

A. Household Water Softeners

1. Description: Factory-assembled, fully-automatic, pressure-type water softener.
 - a. Configuration: Unit with one mineral tank and one brine tank or cabinet-style, combination mineral and brine tank unit with equivalent characteristics.
 - b. Mineral Tank: Steel or FRP, with coating or liner suitable for potable-water service and 125-psig (860-kPa) minimum pressure rating.



- c. Comply with NSF 61, "Drinking Water System Components--Health Effects."
- d. Controls: For fully automatic operation.
- e. Brine Tank: Combination measuring and wet-salt storing system.
 - 1) Tank and Cover Material: FRP or molded PE.
 - 2) Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
 - 3) Size: Large enough for at least two regenerations at full salting.
- f. Factory-Installed Accessories:
 - 1) Piping, valves, tubing, and drains.
 - 2) Sampling cock.
 - 3) Main-operating-valve position indicator.

B. Commercial Water Softeners

1. Description: Factory-assembled, pressure-type water softener.
 - a. Comply with NSF 61, "Drinking Water System Components--Health Effects."
 - b. Configuration: Single unit with one mineral tank **OR** Twin unit with two mineral tanks **OR** Triple unit with three mineral tanks, **as directed**, and one brine tank, factory mounted on skids, **unless directed otherwise**.
 - c. Mineral Tanks: FRP, pressure-vessel quality.
 - 1) Construction: Non-ASME code **OR** Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels," **as directed**.
 - 2) Pressure Rating: 100 psig (690 kPa) **OR** 125 psig (860 kPa), **as directed**, minimum.
 - 3) Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C) **OR** 40 to at least 120 deg F (5 to at least 49 deg C) **OR** 40 to at least 150 deg F (5 to at least 66 deg C), **as directed**.
 - 4) Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
 - 5) Support Legs or Skirt: Constructed of structural steel, welded to tank before testing and labeling.
 - 6) Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
 - 7) Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, nonclogging plastic strainers; arranged for even flow distribution through resin bed.
 - 8) Liner: PE, ABS, or other material suitable for potable water.
 - d. Mineral Tanks: Steel **OR** Stainless steel, **as directed**, electric welded; pressure-vessel quality.
 - 1) Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
 - 2) Construction: Non-ASME code **OR** Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," **as directed**.
 - 3) Pressure Rating: 100 psig (690 kPa) **OR** 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, minimum.
 - 4) Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C) **OR** 40 to at least 120 deg F (5 to at least 49 deg C) **OR** 40 to at least 150 deg F (5 to at least 66 deg C), **as directed**.
 - 5) Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
 - 6) Handholes: 4 inches (102 mm) round or 4 by 6 inches (102 by 152 mm) elliptical, in top head and lower sidewall of tanks 30 inches (762 mm) and smaller in diameter.
 - 7) Manhole: 11 by 15 inches (280 by 380 mm) in top head of tanks larger than 30 inches (762 mm) in diameter.



- 8) Support Legs or Skirt: Constructed of structural steel, welded to tank before testing and labeling.
- 9) Finish: Hot-dip galvanized on exterior and interior of tank after fabrication, unless tank is stainless steel.
- 10) Finish: Exterior of tank spray painted with rust-resistant prime coat, 2- to 3-mil (0.051- to 0.076-mm) dry film thickness. Interior sandblasted and lined with epoxy-polyamide coating, 8- to 10-mil (0.203- to 0.254-mm) dry film thickness.
- 11) Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
- 12) Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even flow distribution through resin bed.
- 13) Liner: PE, ABS, or other material suitable for potable water.
- e. Controls: Automatic; factory mounted on unit and factory wired.
 - 1) Adjustable duration of various regeneration steps.
 - 2) Push-button start and complete manual operation.
 - 3) Electric time clock and switch for automatic operation, except for manual return to service.
 - 4) Sequence of Operation: Program multiport pilot-control valve to automatically pressure-actuate main operating valve through steps of regeneration.
 - 5) Pointer on pilot-control valve shall indicate cycle of operation.
 - 6) Means of manual operation of pilot-control valve if power fails.
- f. Controls: Fully automatic; factory mounted on unit and factory wired.
 - 1) Adjustable duration of various regeneration steps.
 - 2) Push-button start and complete manual operation.
 - 3) Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
 - 4) Sequence of Operation: Program multiport pilot-control valve to automatically pressure-actuate main operating valve through steps of regeneration and return to service.
 - 5) Pointer on pilot-control valve shall indicate cycle of operation.
 - 6) Means of manual operation of pilot-control valve if power fails.
 - 7) Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
 - a) Slow opening and closing, nonslam operation.
 - b) Diaphragm guiding on full perimeter from fully open to fully closed.
 - c) Isolated dissimilar metals within valve.
 - d) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
 - e) Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
 - f) Sampling cocks for soft water.
 - g) Special tools are not required for service.
 - 8) Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressures, and that does not require field adjustments.
 - a) Meter Control: Equip each mineral tank with signal-register-head water meter that will produce electrical signal indicating need for regeneration on reaching hand-set total in gallons (liters). Design so signal will continue until reset.
 - b) Demand-Initiated Control:
 - i. Equip single mineral-tank units with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons (liters). Design so head automatically resets to preset total in gallons (liters) for next service run.
 - ii. Equip each mineral tank of twin mineral-tank units with automatic-reset-head water meters that electrically activate cycle controllers to initiate regeneration at preset total in gallons (liters). Design so heads



automatically reset to preset total in gallons (liters) for next service run. Include electrical lockout to prevent simultaneous regeneration of both tanks.

- iii. Equip each mineral tank of twin mineral-tank units with automatic-reset-head water meter in common outlet header that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons (liters) and divert flow to other tank. Set to repeat with other tank. Include electrical lockout to prevent simultaneous regeneration of both tanks.
 - iv. Equip each mineral tank of multiple mineral-tank units with automatic-reset-head water meters that electrically activate cycle controllers to automatically regenerate at preset total in gallons (liters). Design so heads automatically reset to preset total in gallons (liters) for next service run. Include electrical lockouts to prevent simultaneous regeneration of more than one tank.
 - v. Equip each mineral tank of multiple mineral-tank units with automatic-reset-head water meter in common outlet header that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons (liters) and divert flow to other tanks. Set to repeat with other tanks. Include electrical lockouts to prevent simultaneous regeneration of more than one tank.
- g. Brine Tank: Combination measuring and wet-salt storing system.
- 1) Tank and Cover Material: Fiberglass, 3/16 inch (4.8 mm) thick; or molded PE, 3/8 inch (9.5 mm) thick.
 - 2) Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
 - 3) Size: Large enough for at least four regenerations at full salting.
- h. Factory-Installed Accessories:
- 1) Piping, valves, tubing, and drains.
 - 2) Sampling cocks.
 - 3) Main-operating-valve position indicators.
 - 4) Water meters.
2. Capacity and Characteristics:
- a. Service: Cold **OR** Hot, **as directed**, water.
 - b. Number of Mineral Tanks: One **OR** Two, **as directed**.

C. Chemicals

- 1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.
 - a. Exchange Capacity: 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.
- 2. Salt for Brine Tanks: High-purity sodium chloride; free of dirt and foreign material. Rock and granulated forms are not acceptable.
 - a. Form: Processed, food-grade salt pellets **OR** plain salt pellets **OR** crystallized solar salt from shallow ponds and milled into irregular particles **OR** plain, brine block salt, **as directed**.

D. Water Testing Sets

- 1. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

1.3 EXECUTION

A. Concrete Bases



1. Install concrete bases of dimensions indicated for commercial water softeners. Refer to Division 22 Section "Common Work Results For Plumbing".
- B. Water Softener Installation
1. Install household water softeners on floor. Anchor water softener and brine tanks to substrate.
 2. Install commercial water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
 3. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure.
 4. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.
 5. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.
 6. Install water testing sets mounted on wall, unless otherwise indicated, and near water softeners.
- C. Connections
1. Piping installation requirements are specified in other Division 14.. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to equipment to allow service and maintenance.
 3. Make piping connections between water-softener-unit headers and dissimilar-metal water piping with dielectric fittings. Dielectric fittings are specified in Division 22 Section "Common Work Results For Plumbing".
 4. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.
 - a. Metal general-duty valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
 - b. Plastic valves are specified in Division 22 Section "Domestic Water Piping".
 - c. Exception: Water softeners with factory-installed shutoff valves at locations indicated.
 5. Install pressure gages on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gages are specified in Division 22 Section "Meters And Gages For Plumbing Piping".
 - a. Exception: Water softeners with factory-installed pressure gages at locations indicated.
 - b. Exception: Household water softeners.
 - c. Exception: Water softeners in hot-water service.
 6. Install valved bypass water piping around water softeners.
 - a. Metal general-duty valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
 - b. Plastic valves are specified in Division 22 Section "Domestic Water Piping".
 - c. Water piping is specified in Division 22 Section "Domestic Water Piping".
 - d. Exception: Household water softeners.
 - e. Exception: Water softeners in hot-water service.
 7. Install drains as indirect wastes to spill into open drains or over floor drains.
 8. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- D. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
 2. Perform the following field tests and inspections and prepare test reports:
 - a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.



- b. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
- c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning water softeners that do not pass tests and inspections and retest as specified above.

E. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
2. Add water to brine tanks and fill with salt.
 - a. Household Water Softeners: Processed food-grade salt pellets **OR** plain salt pellets **OR** crystallized solar salt, **as directed**.
 - b. Commercial Water Softeners: Plain salt pellets **OR** Crystallized solar salt **OR** Plain, brine block salt **OR** Food-grade salt pellets, **as directed**.
3. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics. Comply with the following:
 - a. ASTM D 859, "Test Method for Silica in Water."
 - b. ASTM D 1067, "Test Methods for Acidity or Alkalinity of Water."
 - c. ASTM D 1068, "Test Methods for Iron in Water."
 - d. ASTM D 1126, "Test Method for Hardness in Water."
 - e. ASTM D 1129, "Terminology Relating to Water."
 - f. ASTM D 3370, "Practices for Sampling Water from Closed Conduits."

F. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial water softeners.

END OF SECTION 22 31 16 00



Task	Specification	Specification Description
22 33 00 00	22 12 23 13	Electric, Domestic Water Heaters
22 33 30 13	22 12 23 13	Electric, Domestic Water Heaters
22 33 30 16	22 12 23 13	Electric, Domestic Water Heaters
22 33 30 16	22 12 23 13a	Fuel-Fired, Domestic Water Heaters
22 33 33 00	22 12 23 13	Electric, Domestic Water Heaters
22 34 00 00	22 12 23 13a	Fuel-Fired, Domestic Water Heaters



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**SECTION 22 34 36 00 - WATER-TUBE BOILERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for water-tube boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, finned water-tube boilers, trim, and accessories for generating hot water.
2. This Section includes packaged, water-tube boilers, trim, and accessories for generating hot water or steam with the following configurations, burners, and outputs:
 - a. Factory and Field assembled.
 - b. Atmospheric gas, Forced-draft gas, Oil, and Combination gas and oil burner.

C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
 - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.
8. Other Informational Submittals:
 - a. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
 - b. Startup service reports.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."



5. I=B=R Compliance: Boilers shall be tested and rated according to HI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.
6. UL Compliance: Test boilers for compliance with UL 726, "Oil-Fired Boiler Assemblies" **OR** UL 726, "Oil-Fired Boiler Assemblies" and UL 795, "Commercial-Industrial Gas Heating Equipment" **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

E. Warranty

1. Special Warranty for Finned Water-Tube Boilers: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchangers damaged by thermal shock and vent dampers of boilers that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Heat Exchangers: 20 years from date of Final Completion.
 - b. Warranty Period for Vent Dampers: Five years from date of Final Completion.
2. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace drums, tubes, headers, cabinets, atmospheric gas burners, and pressure vessels of boilers that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Drums, Tubes, Headers, Cabinets, and Atmospheric Gas Burner: Five years from date of Final Completion, pro rata.
 - b. Warranty Period for Pressure Vessel: 20 years from date of Final Completion, for thermal shock.

1.2 PRODUCTS

A. Finned Water-Tube Boilers

1. Description: Factory-fabricated, -assembled, and -tested boiler with tubes sealed into headers pressure tight, and set on a steel base; including insulated jacket, flue-gas vent, combustion-air intake connections, water supply and return connections, and controls.
2. Heat Exchanger:
 - a. Finned copper **OR** steel **OR** copper-nickel, **as directed**, tubing with stainless-steel baffles.
 - b. Bronze **OR** Cast-iron **OR** Steel, **as directed**, headers.
 - c. Single-pass **OR** Two-pass, **as directed**, horizontal **OR** vertical **OR** coil, **as directed**, configuration.
 - d. Tubes shall be sealed in header with silicone O-ring gaskets **OR** by welding **OR** by mechanically rolling tubes in header, **as directed**.
3. Combustion Chamber Internal Insulation: Interlocking panels of refractory insulation, high-temperature cements, mineral fiber, and ceramic refractory tile for service temperatures to 2000 deg F (1100 deg C).
4. Casing:
 - a. Jacket: Sheet metal **OR** Stainless steel, **as directed**, with snap-in or interlocking closures.
 - b. Control Compartment Enclosure: NEMA 250, Type 1A.
 - c. Finish: Baked enamel over primer **OR** Baked enamel over galvanizing **OR** Powder coated, **as directed**.
 - d. Insulation: Minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, mineral-fiber insulation surrounding the heat exchanger.
 - e. Draft Hood: Integral **OR** External, **as directed**.
 - f. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
 - g. Mounting base to secure boiler with accessory for mounting on combustible surface, **as directed**.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And



Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

5. Burner:
 - a. Burner Tubes and Orifices: Stainless steel, for natural **OR** propane, **as directed**, gas. Mount burner tubes in a slide-out burner drawer for ease of inspection, **as directed**.
 - 1) Sealed Combustion: Factory-mounted centrifugal fan to draw outside air into boiler and discharge into burner compartment.
 - 2) Direct Vent: Factory-mounted centrifugal fan to draw flue gas out of boiler and discharge into boiler vent.
 - b. Vertical Burner:
 - 1) High-temperature stainless steel **OR** Ceramic, **as directed**, to fire in a 360-degree pattern.
 - 2) Burner shall have a viewing port for observation of burner operation and a factory-mounted centrifugal fan to supply room **OR** outside, **as directed**, air through a replaceable 99 percent efficient (1-micrometer particles) filter, **as directed**, to boiler burner.
 - 3) Fan shall be controlled to prepurge and postpurge the combustion chamber before firing.
 - c. Gas Train for Commercial Boilers: Control devices and full-modulation **OR** on-off **OR** low-high-low **OR** proportional, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**. In addition to these requirements, include shutoff cock, pressure regulator, and control valve.
 - d. Gas Train for Residential Boilers: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
 - e. Pilot: Standing **OR** Intermittent-electric-spark **OR** Hot-surface, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
 - f. Flue-Gas Recirculation Fans: Centrifugal fans on burner assembly to recirculate flue gas to decrease oxides of nitrogen emissions to less than 30 ppm.
 - g. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
6. Trim:
 - a. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
 - b. Safety Relief Valve: ASME rated.
 - c. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
 - d. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
 - e. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
 - f. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.
7. Controls:
 - a. Refer to Division 23 Section "Instrumentation And Control For Hvac".
OR
Boiler operating controls shall include the following devices and features:
 - 1) Control transformer.
 - 2) Motorized Vent Damper: Interlocked with burner to open before burner starts. If damper fails to open, stop burner operation.
 - 3) Set-Point Adjust: Set points shall be adjustable.
 - 4) Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.**OR**



Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).

- 5) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
 - b. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
 - 1) High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature.
 - 2) Water Flow Switch: Automatic-reset paddle-switch shall prevent burner operation on low water flow.
 - 3) Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
 - 4) Rollout Safety Switch: Factory mounted on boiler combustion chamber.
 - 5) Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
 - c. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
 - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
 - 2) Control: On/off operation, hot water supply temperature set-point adjustment, **as directed**.
 - 3) A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.
- B. Steel **OR** Flexible, **as directed**, Water-Tube Boilers
1. Description: Factory-fabricated and assembled **OR** Field-assembled, **as directed**, water-tube boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, supply and return connections, and controls.
 2. Heat-Exchanger Design: Straight steel tubes rolled into steel headers.
 - a. Accessible head plates at both ends.
 - b. Handholes or couplings, **as directed**, in headers for water-side inspections.
 - c. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 - d. Lifting lugs on top of boiler.
 - e. Built-in air separator.
 3. Heat-Exchanger Design: Bent steel tubes swaged **OR** welded, **as directed**, into steel headers with membrane waterwall design, **as directed**.
 - a. Limit tube configurations to two **OR** four, **as directed**.
 - b. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 - c. Accessible inspection ports in drum, mud legs, and tube manifolds.
 - d. Lifting lugs on top of boiler.
 - e. Built-in air separator.
 4. Combustion Chamber: Equipped with minimum 2-1/2-inch (64-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, 2700 deg F (1482 deg C) poured refractory on floor and minimum 2-inch (50-mm) **OR** 3-1/2-inch (89-mm), **as directed**, lap-jointed cast refractory with fiber-blanket joint seals on side walls. Combustion chamber shall have flame observation ports in front and back **OR** back, **as directed**.
 5. Casing:
 - a. Insulation: Minimum 2-inch (50-mm) thick, lightweight refractory; 1-inch (25-mm) thick insulating board; galvanized-steel membrane, and 2-inch (50-mm) thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber **OR** 2-inch (50-mm)



- thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber, **as directed**.
- b. Top Flue Connection: Constructed of aluminized steel **OR** stainless steel, **as directed**.
 - c. Jacket: Mirror-finish stainless steel, with screw-fastened closures.
OR
Jacket: Sheet metal **OR** Galvanized sheet metal, **as directed**, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
 - d. Mounting base to secure boiler to concrete base.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
 - e. Control Compartment Enclosure: NEMA 250, Type 1A.
6. Draft Diverter **OR** Barometric Damper, **as directed**: Galvanized-steel assembly with flue-gas thermometer.
7. Burner - Atmospheric Gas Burners:
- a. Burner and Orifices: Stainless steel **OR** Cast iron, **as directed**, for natural **OR** propane, **as directed**, gas.
 - b. Gas Train for Commercial Boilers: Control devices and full-modulation **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 - c. Gas Train for Residential Boilers: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
 - d. Pilot: Standing **OR** Intermittent-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
8. Burner - Forced-Draft Gas Burners:
- a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for natural **OR** propane, **as directed**, gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
 - b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - 1) Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 - d. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
 - e. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - 1) Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
9. Burner - Oil Burners:
- a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
 - b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - 1) Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.



- 1) Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
 - 2) Oil Piping Specialties:
 - a) Suction-line, manual, gate valve.
 - b) Removable-mesh oil strainer.
 - c) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
 - d) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
 - e) Nozzle-line, solenoid-safety-shutoff oil valve.
 - d. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid using cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
 - e. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - 1) Maximum Oxides of Nitrogen Emissions: 30 ppm.
10. Burner - Combination Gas and Oil Burners:
- a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and natural **OR** propane, **as directed** gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
 - b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - 1) Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI, **as directed**.
 - 1) Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
 - 2) Oil Piping Specialties:
 - a) Suction-line, manual, gate valve.
 - b) Removable-mesh oil strainer.
 - c) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
 - d) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
 - e) Nozzle-line, solenoid-safety-shutoff oil valve.
 - d. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 - e. Gas Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
 - f. Oil Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
 - g. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - 1) Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
11. Trim for Hot-Water Boilers:
- a. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
 - b. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
 - c. Safety Relief Valve: ASME rated.



- d. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
 - e. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
 - f. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
 - g. Tankless Heater: Carbon-steel **OR** Bronze, **as directed**, header with copper-tube heat exchanger, mounted in a port of upper drum and sealed with fiber gasket.
 - 1) Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - 2) Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
12. Trim for Steam Boilers:
- a. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
 - b. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
 - c. Safety Relief Valve:
 - 1) Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
 - 2) Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - a) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
 - d. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure about 50 percent of full range.
 - e. Water Column: Minimum 12-inch (300-mm) glass gage with shutoff cocks.
 - f. Drain Valves: Minimum NPS 3/4 (DN 20) or nozzle size with hose-end connection.
 - g. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
 - h. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
 - i. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
 - j. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in a port of upper manifold and sealed with fiber gasket.
 - 1) Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - 2) Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
13. Controls:
- a. Refer to Division 23 Section "Instrumentation And Control For Hvac".
OR
Boiler operating controls shall include the following devices and features:
 - 1) Control transformer.
 - 2) Set-Point Adjust: Set points shall be adjustable.
 - 3) Operating Pressure Control for Steam Boilers: Factory wired and mounted to cycle burner.
 - 4) Low-Water Cutoff and Pump Control for Steam Boilers: Cycle feedwater pump(s) for makeup water control.



- 5) Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
OR
Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).
 - 6) Sequence of Operation for Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
 - 7) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
- b. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
- 1) High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature for hot-water boiler or design pressure for steam boiler.
 - 2) Low-Water Cutoff Switch: Electronic (for hot-water boilers) or Float and electronic (for steam boilers) probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
 - 3) Blocked Vent Safety Switch (Atmospheric Boilers): Manual-reset switch factory mounted on draft diverter.
 - 4) Rollout Safety Switch (Atmospheric Boilers): Factory mounted on boiler combustion chamber.
 - 5) Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- c. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
- 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
 - 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
 - 3) A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.
- C. Electrical Power
1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
OR
Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 - a. House in NEMA 250, Type 1 enclosure.
 - b. Wiring shall be numbered and color-coded to match wiring diagram.
 - c. Install factory wiring outside of an enclosure in a metal, **as directed**, raceway.
 - d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - e. Provide branch power circuit to each motor and to controls with disconnect switch or circuit breaker, **as directed**.



- f. Provide each motor with overcurrent protection.

D. Venting Kits

1. Vent Damper (for Finned Water-Tube Boilers): Motorized, UL listed for use on atmospheric burner boiler equipped with draft hood; motor to open and close damper; stainless-steel vent coupling and damper blade; keyed wiring harness connector plug; and dual-position switches to permit burner operation.
2. Kit: Complete system, ASTM A 959, Type 29-4C, **as directed**, stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap, and sealant.
3. Combustion-Air Intake: Stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

E. Source Quality Control

1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
2. Burner and Hydrostatic Test (for Factory-Assembled Boilers): Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
3. Allow the Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

1.3 EXECUTION

A. Boiler Installation

1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install gas-fired boilers according to NFPA 54.
4. Install oil-fired boilers according to NFPA 31.
5. Assemble boiler tubes in sequence and seal each tube joint.
6. Assemble and install boiler trim.
7. Install electrical devices furnished with boiler but not specified to be factory mounted.
8. Install control wiring to field-mounted electrical devices.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
4. Connect oil piping full size to burner inlet with shutoff valve and union.
5. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
6. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
7. Install piping from safety relief valves to nearest floor drain (for hot-water boilers).
8. Install piping from safety valves to drip-pan elbow and to nearest floor drain (for steam boilers).
9. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
10. Boiler Flue Venting (for Finned Water-Tube Boilers):
 - a. Install venting kit and combustion-air intake.



- b. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks".
 11. Connect breeching to full size of boiler outlet. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for venting materials.
 12. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for recirculation duct materials.
 13. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 14. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
 1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. Perform installation and startup checks according to manufacturer's written instructions.
 - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 1) Burner Test (for Field-Assembled Boilers): Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
 - 2) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature **OR** steam pressure, **as directed**.
 - 3) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 3. Remove and replace malfunctioning units and retest as specified above.
 4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
 5. Performance Tests, as directed:
 - a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
 - c. Perform field performance tests to determine the capacity and efficiency of the boilers.
 - 1) For dual-fuel boilers, perform tests for each fuel.
 - 2) Test for full capacity.
 - 3) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40 and 20, **as directed**, percent of full capacity. Determine efficiency at each test point.
 - d. Repeat tests until results comply with requirements indicated.
 - e. Provide analysis equipment required to determine performance.
 - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
 - g. Notify the Owner in advance of test dates.
 - h. Document test results in a report and submit to the Owner.
- D. Demonstration
 1. Train the Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 22 34 36 00



Task	Specification	Specification Description
22 34 36 00	22 12 23 13	Electric, Domestic Water Heaters
22 34 46 00	22 12 23 13a	Fuel-Fired, Domestic Water Heaters



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SECTION 22 35 23 00 - DOMESTIC WATER HEAT EXCHANGERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for heat exchangers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following heat exchangers:
 - a. Heating-fluid-in-coil, instantaneous heat exchangers.
 - b. Domestic-water-in-coil, instantaneous heat exchangers.
 - c. Heating-fluid-in-U-tube-coil, instantaneous heat exchangers.
 - d. Circulating, compact heat exchangers.
 - e. Circulating, storage heat exchangers.
 - f. Noncirculating, compact heat exchangers.
 - g. Noncirculating, storage heat exchangers.
 - h. Brazed-plate heat exchangers.
 - i. Frame-and-plate heat exchangers.
 - j. Heat reclaimers.
 - k. Compression tanks.
 - l. Heat-exchanger accessories.

C. Submittals

1. Product Data: For each type and size of heat exchanger indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.
7. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with water.

E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of heat exchangers that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Structural failures including heat exchanger, storage tank, and supports.
 - 2) Faulty operation of controls.
 - 3) Deterioration of metals, metal finishes, and other materials beyond normal use.
 - b. Warranty Period(s): From date of Final Completion:



- 1) Instantaneous Heat Exchangers:
 - a) Tube Coil and Shell: One year.
 - b) Controls and Other Components: One year.
- 2) Circulating, Storage Heat Exchangers:
 - a) Storage Tank: Five years.
 - b) Tube Coil: Five years.
 - c) Controls and Other Components: Three years.
- 3) Noncirculating, Storage Heat Exchangers:
 - a) Storage Tank: Five years.
 - b) Tube Coil: Five years.
 - c) Controls and Other Components: Three years.
- 4) Plate Heat Exchangers:
 - a) Brazed-Plate Type: One year.
 - b) Plate-and-Frame Type: One year.
- 5) Heat Reclaimers: One year.
- 6) Compression Tanks: One year.

1.2 PRODUCTS

A. Instantaneous Heat Exchangers

1. Heating-Fluid-in-Coil, Instantaneous Heat Exchangers:
 - a. Description: Packaged assembly of tank, heat-exchanger coils, controls, and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in heat-exchanger coils.
 - b. Construction: ASME-code, negligible-capacity, copper-lined, carbon-steel shell with 150-psig (1035-kPa) minimum working-pressure rating.
 - 1) Tappings: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 2) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle except connections and controls.
 - 3) Heat-Exchanger Coils: Copper **OR** Copper nickel **OR** Stainless-steel, **as directed**, helix-wound coils for heating fluid with pressure rating equal to or greater than heating-fluid supply pressure.
 - 4) Temperature Control: Adjustable thermostat that operates control valve and that is capable of maintaining outlet-water temperature within 4 deg F (2 deg C) of setting.
 - 5) Safety Control: Automatic, high-temperature-limit cutoff device or system.
 - 6) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
 - c. Miscellaneous Components for Heating Hot-Water Unit: Control valve, valves, and piping. Include components fitted for pneumatic control.
 - d. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gage, thermometer, and piping. Include components fitted for pneumatic control.
 - 1) Exception: Steam trap is not required if manufacturer's written instructions direct that it not be used.
 - e. Stand: Factory fabricated for floor mounting.



2. Domestic-Water-in-Coil, Instantaneous Heat Exchangers:
 - a. Description: Tankless, packaged assembly of heat-exchanger coils, controls, and specialties for heating domestic water in coils with steam in shell.
 - b. Construction: ASME code, with cast-iron or steel shell for steam.
 - 1) Cast-Iron Shell Pressure Rating: 75 psig (517 kPa).
 - 2) Steel Shell Pressure Rating: 150 psig (1035 kPa).
 - 3) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle except connections and controls.
 - c. Heat-Exchanger Coils: Spiral-wound, copper or copper-alloy **OR** stainless-steel, **as directed**, coils for domestic water.
 - d. Temperature Control: Adjustable thermostat that operates steam-control valve and that is capable of maintaining outlet-water temperature within 3 deg F (2 deg C) of setting.
 - e. Safety Control: Automatic, high-temperature-limit cutoff device or system.
 - f. Miscellaneous Components: Strainers, steam-control valve, steam trap, valves, and piping.
 - g. Stand: Factory fabricated for floor mounting.
3. Heating-Fluid-in-U-Tube-Coil, Instantaneous Heat Exchangers:
 - a. Description: Tankless, packaged assembly of heat-exchanger coil, controls, and specialties for heating domestic water in shell with heating hot water **OR** steam, **as directed**, in coil.
 - b. Construction: ASME-code, negligible-capacity, copper-lined, carbon-steel or copper-alloy shell with 150-psig (1035-kPa) minimum working-pressure rating.
 - 1) Configuration: Horizontal **OR** Vertical, **as directed**.
 - 2) Shell Tappings: Factory fabricated of materials compatible with water heater shell. Attach tappings to shell before testing and labeling.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 3) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle except connections and controls.
 - 4) Heat-Exchanger Coil: Copper, double-wall **OR** single-wall, **as directed**, U tubes for heating fluid.
 - a) Tube Pressure Rating: Equal to or greater than heating-fluid supply pressure.
 - c. Temperature Control: Adjustable thermostat that operates steam-control valve and that is capable of maintaining outlet-water temperature within 5 deg F (3 deg C) of setting.
 - d. Safety Control: Automatic, high-temperature-limit cutoff device or system.
 - e. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into shell.
 - f. Miscellaneous Components for Heating Hot-Water Unit: Control valve, valves, and piping. Include components fitted for pneumatic control.
 - g. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gage, thermometer, and piping. Include components fitted for pneumatic control.
 - h. Stand: Factory fabricated for floor mounting.

B. Circulating, Storage Heat Exchangers

1. Circulating, Compact Heat Exchangers:
 - a. Description: Packaged, small-capacity, hot-water storage tank with heat-exchanger coil; circulator; controls; and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in coil.



- b. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.
 - c. Storage Tank Construction: ASME-code, vertical; copper-silicon or corrosion-resistant metal with 150-psig (1035-kPa) working-pressure rating. Include nozzle and head for heat-exchanger tube coil.
 - 1) Configuration: Vertical.
 - 2) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 3) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.
 - d. Heat-Exchanger Coil: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32), **as directed**, diameter, vented, double-wall, copper or copper-alloy, U tubes with tube sheet and supporting baffles.
 - 1) Heat-Exchanger Pressure Rating: Equal to or greater than heating-fluid supply pressure.
 - e. Temperature Control: Adjustable thermostat.
 - f. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.
 - g. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
 - h. Gages: Factory-mounted thermometer and pressure gage.
 - i. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.
 - 1) Pump Control: Sensor for operating pump and control valve.
 - j. Miscellaneous Components for Heating Hot-Water Units: Control valve, valves, and piping.
 - k. Miscellaneous Components for Steam Units: Strainers, steam-control valve, steam trap, valves, and piping.
 - l. Support: Factory mounted on skids.
 - m. Energy Management System Interface: Normally closed dry contacts for enabling and disabling heat exchanger.
2. Circulating, Storage Heat Exchangers:
- a. Description: Packaged, large-capacity, hot-water storage tank with heat-exchanger coil, circulator, controls, and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in coil.
 - b. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.
 - c. Flow Pattern: Reverse-flow arrangement, with water from storage tank drawn across heat-exchanger coil and returned to bottom of tank. Include hot-water outlet and temperature sensor located in or at coil shell.
 - d. Storage Tank Construction: ASME-code steel with 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working-pressure rating. Include nozzle and head for heat-exchanger tube coil.



- 1) Configuration: Horizontal **OR** Vertical, **as directed**.
 - 2) Manhole: 11 by 15 inches (280 by 380 mm) in end head of horizontal **OR** sidewall of vertical, **as directed**, storage tank shell.
 - 3) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 4) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - 5) Anode Rods: Factory installed, magnesium.
 - 6) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.
 - e. Heat-Exchanger Coil: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32), **as directed**, diameter, vented, double-wall, copper or copper-alloy, U tubes with tube sheet and supporting baffles.
 - 1) Heat-Exchanger Pressure Rating: Equal to or greater than heating-fluid supply pressure.
 - f. Temperature Control: Adjustable temperature aquastat, mounted in storage tank shell head, unless otherwise indicated.
 - g. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.
 - h. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
 - i. Gages: Factory-mounted thermometer and pressure gage.
 - j. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.
 - 1) Pump Control: Sensor for operating pump and control valve.
 - k. Support: Factory mounted on skids.
 - l. Energy Management System Interface: Normally closed dry contacts for enabling and disabling heat exchanger.
- C. Noncirculating, Storage Heat Exchangers
1. Compact Heat Exchangers:
 - a. Description: Hot-water storage tank with integral heat-exchanger coil, controls, and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in coil.
 - b. Storage Tank Shell Construction: Steel or stainless steel with 150-psig (1035-kPa) working-pressure rating.
 - 1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Insulation: Complying with ASHRAE/IESNA 90.1 or ASHRAE 90.2, and suitable for operating temperature. Surround entire tank except connections and controls.
 - 4) Jacket: Steel with enameled finish, unless otherwise indicated.
 - 5) Anode Rods for Steel Tanks: Factory installed, magnesium.



- c. Heat-Exchanger Coil: Copper or stainless-steel coil assembly, permanently installed inside storage tank, for heating fluid. Include working-pressure rating equal to or greater than heating-fluid supply pressure.
 - d. Temperature Control: Adjustable thermostat.
 - e. Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include relief valve with relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select relief valve with sensing element that extends into storage tank.
2. Storage Heat Exchangers:
- a. Description: Assembly of hot-water storage tank with separate heat-exchanger coil; controls; and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in coil.
 - b. Storage Tank Construction: ASME-code steel with 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working-pressure rating. Include nozzle and head for heat-exchanger tube coil.
 - 1) Configuration: Horizontal **OR** Vertical, **as directed**.
 - 2) Manhole: 11 by 15 inches (280 by 380 mm) in end head of horizontal **OR** sidewall of vertical, **as directed**, storage tank shell.
 - 3) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.
 - a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - 4) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - 5) Anode Rods: Factory installed, magnesium.
 - 6) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.
 - c. Heat-Exchanger Coil: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32), **as directed**, diameter, vented, double-wall, copper or copper-alloy, U tubes with tube sheet and supporting baffles.
 - 1) Heat-Exchanger Pressure Rating: Equal to or greater than heating-fluid supply pressure.
 - d. Temperature Control: Adjustable temperature aquastat, mounted in storage tank shell head, unless otherwise indicated.
 - e. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
 - f. Support: Factory mounted on skids.
- D. Plate Heat Exchangers
- 1. Brazed-Plate Heat Exchangers:
 - a. Description: Assembly of heat-exchanger plates, permanently brazed together, for using heating hot water **OR** steam, **as directed**, to heat domestic water.
 - b. Working-Pressure Rating: 150 psig (1035 kPa) **OR** 200 psig (1380 kPa) **OR** 250 psig (1725 kPa) **OR** 400 psig (2760 kPa), **as directed**, minimum.
 - c. Plate Construction: Single **OR** Vented, double, **as directed**, wall.
 - d. Plate Material: ASTM A 666, Type 316 stainless steel.
 - e. Connections: Stainless steel; threaded.



2. Frame-and-Plate Heat Exchangers:
 - a. Description: Assembly of nonfixed-position, heat-exchanger plates, with frame, for using heating hot water **OR** steam, **as directed**, to heat domestic water.
 - b. Working-Pressure Rating: 150 psig (1035 kPa) **OR** 200 psig (1380 kPa) **OR** 250 psig (1725 kPa) **OR** 400 psig (2760 kPa), **as directed**, minimum.
 - c. Frame:
 - 1) Carrying and Guide Bars: Carbon steel **OR** Stainless steel, **as directed**.
 - 2) Fixed, Frame Plate; Pressure Plate; Support Column; and Nuts and Bolts: Carbon steel.
 - d. Channel Plates:
 - 1) Type: Single **OR** Vented, double, **as directed**, wall.
 - 2) Material: ASTM A 666, Type 304 or 316 stainless steel.
 - 3) Gasket Material: Butyl or acrylonitrile-butadiene rubber, suitable for potable water.
 - e. Connections: Stainless steel suitable for potable water.
 - 1) NPS 2 (DN 50) and Smaller: Threaded.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged.
 - f. Protective Shroud: Steel, covering channel plates.
 - g. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire heat exchanger except connections.
- E. Heat Reclaimers
 1. Description: Waste-heat recovery device complying with and listed according to UL 207 for heat reclaimers. Device includes vertical drainage tube with helical, domestic water preheat coil around drainage tube.
 - a. Drainage Tube: ASTM B 306, Type DWV, center, copper drainage tube of size indicated.
 - b. Water Preheat Coil: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube, of size indicated attached to drainage tube.
 - 1) Working-Pressure Rating: 150 psig (1035 kPa) on potable-water supply tubing.
 - c. Capacity and Characteristics:
 - 1) NPS 2 (DN 50) Drainage Tube:
 - a) Domestic Water Preheat Coil: NPS 3/8 (DN 10).
 - b) Unit Height: 20 inches (508 mm) **OR** 24 inches (610 mm) **OR** 30 inches (762 mm), **as directed**.
 - 2) NPS 3 (DN 80) Drainage Tube:
 - a) Domestic Water Preheat Coil: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**.
 - b) Unit Height: 30 inches (762 mm) **OR** 40 inches (1016 mm) **OR** 60 inches (1524 mm), **as directed**.
 - 3) NPS 4 (DN 100) Drainage Tube:
 - a) Domestic-Water Preheat Coil: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**.
 - b) Unit Height: 30 inches (762 mm) **OR** 40 inches (1016 mm) **OR** 60 inches (1524 mm), **as directed**.
- F. Compression Tanks
 1. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
 - a. Construction:
 - 1) Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Air-Charging Valve: Factory installed.
 - b. Capacity and Characteristics:
 - 1) Working-Pressure Rating: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.



- 2) Capacity Acceptable: 2 gal. (7.6 L) **OR** 4 gal. (15.1 L) **OR** 7 gal. (26.5 L) **OR** 10 gal. (37.9 L), **as directed**, minimum.

G. Heat-Exchanger Accessories

1. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select relief valves with sensing element that extends into heat-exchanger storage tank.
2. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than working-pressure rating of heat exchanger.
3. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.
4. Source Quality Control
5. Test and inspect heat-exchanger storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
6. Hydrostatically test commercial heat-exchanger storage tanks before shipment to minimum of one and one-half times pressure rating.
7. Prepare test reports.

1.3 EXECUTION

A. Heat-Exchanger Installation

1. Install heat exchangers on concrete bases.
 - a. Concrete base construction requirements are specified in Division 22 Section "Common Work Results For Plumbing".
2. Install heat exchangers level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
3. Anchor heat exchangers to substrate.
4. Install seismic restraints for heat exchangers. Anchor to substrate.
5. Install temperature and pressure relief valves in top portion of storage tank shells of heat exchangers with domestic water storage. Use relief valves with sensing elements that extend into shells. Extend relief-valve outlet, with drain piping same as water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
6. Install combination temperature and pressure relief valves in water piping for heat exchangers without storage. Extend relief-valve outlet, with drain piping same as water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
7. Install heat-exchanger drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for heat exchangers that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.
8. Install thermometer on each heat-exchanger domestic-water inlet and outlet piping, and install thermometer on each heat-exchanger heating-fluid inlet and outlet piping. Refer to Division 22 Section "Meters And Gages For Plumbing Piping" for thermometers.
9. Install pressure gages on heat-exchanger heating-fluid piping. Refer to Division 22 Section "Meters And Gages For Plumbing Piping" for pressure gages.
10. Fill heat exchangers with water.
11. Charge compression tanks with air.

B. Connections

1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to heat exchangers to allow service and maintenance. Arrange piping for easy removal of heat exchangers.



3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
 2. Perform the following field tests and inspections and prepare test reports:
 - a. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - b. Operational Test: After electrical circuitry has been energized, confirm proper operation.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Remove and replace heat exchangers that do not pass tests and inspections and retest as specified above.
- D. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

END OF SECTION 22 35 23 00



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Task	Specification	Specification Description
22 35 23 00	22 12 23 13	Electric, Domestic Water Heaters
22 40 00 00	22 01 40 81	Plumbing Fixtures
22 41 39 00	22 01 40 81	Plumbing Fixtures
22 41 39 00	22 01 40 81a	Emergency Plumbing Fixtures
22 42 13 13	22 01 40 81	Plumbing Fixtures
22 42 13 13	22 01 40 81a	Emergency Plumbing Fixtures
22 42 13 16	22 01 40 81	Plumbing Fixtures
22 42 13 16	22 01 40 81a	Emergency Plumbing Fixtures
22 42 16 00	22 01 40 81	Plumbing Fixtures
22 42 16 00	22 01 40 81a	Emergency Plumbing Fixtures



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**SECTION 22 42 19 00 - PORCELAIN STEEL BATHTUB LINERS AND SURROUNDS**

DESCRIPTION OF WORK

This specification covers the furnishing and installation of materials for porcelain steel bathtub liners and surrounds. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

GENERAL

System Description

1. Performance Requirements: Comply with following:
 - a. Porcelain Enameled Formed Steel Plumbing Fixtures: FS WWP 542b, Section 12, Porcelain Enameled Fixtures:
 - 1) Specular Gloss: Determined in accordance with ASTM C 346.
 - a) Cover Coat: 45 degree specular gloss.
 - 2) Acid Resistance: Determined in accordance with ASTM C 282.
 - a) Cover Coat: Rating of not less than Class A.
 - 3) Alkali Resistance: Determined in accordance with ASTM C 614.
 - a) Cover Coat: Weight Loss: Not exceed 20 mg/square inch.
 - 4) Abrasion Resistance: Determined in accordance with ASTM C 448.
 - a) Surface Abrasion Index of Cover Coat: 40 or higher.
 - 5) Warpage: Comply with US Dept. of Commerce Commercial Standard (CS) 77, Paragraph 7.1; and US Dept. of Commerce Product Standard (PS) 5, Paragraph 6.2.2.
 - 6) Rigidity: Comply with PS 5, Paragraph 6.6.2.

Submittals

2. Product Data:
 - a. Include porcelain enamel steel samples, backer board material, and joint sealant.
3. Shop Drawings
 - a. Indicate proposed method of panel securing method.
 - b. Templates: Furnish plumber with templates of all openings required in porcelain enamel wall system to accommodate new plumbing trim.
4. Design Drawings: If required, prepare and submit drawings for approval to applicable governmental agencies and obtain necessary permits and certificates for compliance when required.
5. Samples:
 - a. Three samples of steel proposed to be used for bathtub liner and for wall panels.
 - 1) Samples without porcelain enamel coating.
 - 2) Sample: Used to calibrate elcometer to determine amount of porcelain enamel coatings applied.
 - b. Three samples of each type of porcelain enamel finish on steel for acceptance.
 - c. the Owner will retain one set of approved samples.
 - d. Keep one set of approved samples at site throughout construction period.
6. Quality Assurance/Control Submittals:
 - a. Test Reports: Results of testing by accredited independent laboratory demonstrating compliance of porcelain enamel with Performance Requirements.
 - b. Certificates: Manufacturer's written certification that bathtub liners and surrounds meet or exceed specified requirements.



Quality Assurance

7. Materials: Been in general use and satisfactorily performed for minimum of five years. Provide list of locations where such materials have been used.
8. Certifications: Comply with ANSI Z34.2.
9. Regulatory Requirements: Comply with following:
 - a. Install bathtub liners and surrounds in accordance with applicable codes and regulations. Should any specified items or requirements conflict with such codes and regulations, consult with the Owner.
 - b. Accessibility:
 - 1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
 - a) Uniform Federal Accessibility Standards (UFAS).
 - 2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
 - 3) Fair Housing Accessibility Guidelines (24 CF1R Chapter 1).
 - 4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
10. Mock-ups: Install one complete mock-up of each typical bathtub liner and surround installation. Comply with Section _____ for bathroom renovation mock-up requirements.
 - a. Locations: As directed.
 - b. Approved Mock-ups: Standard for rest of work.
 - c. Approved Mock-ups: May remain part of completed project.
11. Pre-Installation Meetings: Hold meeting with associated plumbing items installer. Notify the Owner of time and location of meeting.

Project Conditions

12. Existing Conditions:
 - a. Existing Utilities: Protect any sewer, water, gas, electric or other pipelines or conduits uncovered during work from damage.
13. Field Measurements: Field measure each bathroom before start of fabrication.

Scheduling And Sequencing

14. Scheduling: Schedule bathtub liner and surround work in coordination with associated plumbing work installer.
15. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.

PRODUCTS

Bathtub Liners And Aprons

16. Description: Prefabricated customized inserts to fit existing bathtubs and provide new, substantial units, capable of supporting bather and coordinated and integrated with bathtub/shower surround system.
 - a. Bathtub Liners and Aprons: Completely and uniformly enclose existing bathtubs, obscuring them from view.
 - b. New Tub Liners and Aprons: Integrate with existing bathtubs, wall conditions, floor conditions, and plumbing connections to provide complete installation subject to individual dimensional variations in bathtub.
17. Bathtub Liner and Apron Materials: Sheet steel coated with porcelain enamel.
 - a. Sheet Steel Thickness: No. 16 gage through 20 gage as specified below:

Gage	No. 16	No. 18	No. 20
Standard Thickness, mm (inch)	1.52 (0.0598)	1.21 (0.0478)	1.01 (0.0398)
Minimum Thickness, mm (inch)	1.37 (0.054)	1.09 (0.043)	0.84 (0.0329)



Bathtub/Shower Surrounds

18. Panel System: Prefabricated panels in solid sections and continuous to cover back and side walls of bathtub/shower, coordinated and integrated with bathtub liners and aprons.
 - a. Height of Bathtub/Shower Surround: 1 500 mm (60 inches) above bathtub ledge.
 - b. Contractor's Option: One, two, or three piece back wall system.
 - c. Where window is located over bathtub, install porcelain enamel on steel on full depth of returns at full length of window stool and at jambs; from window stool to top of surround.
 - 1) Sill and Jamb System: Not interfere with easy use of and access to window pulls, handles, screen retainers, etc.
 - d. Access Panels: Provide easily removable panel to provide access to tub and shower valves. Provide panels with shallow formed edge on all four sides to receive bead of joint sealant.
 - e. Method of Securing: Not visible.
19. Panels: Coated with porcelain enamel to provide bright, hard, impervious panels.
 - a. Panels: Retain their surface characteristics and resist wear as result of abrasion or scouring, and staining due to use of ordinary household abrasive cleaners in popular use.
 - b. Material: Special purpose enameling iron or steel or low metalloid for carbon content, especially manufactured and processed for porcelain enamel units for architectural purposes.
 - 1) Thickness: 18 through 22 gage steel.
 - c. Panel Edges: 90 degree flange formed as part of face panel and of same finish.
20. Wall Clips Supporting Panels: Minimum 20 gage, hot-dipped galvanized.
21. Fastening Devices: As required and in accordance with panel manufacturer's instructions and accepted good industry practices and as approved.
 - a. Provide expansion toggle bolts, molly bolts, nylon and other plastic anchors, lead anchors as required for existing wall conditions.

Porcelain Enamel Finish

22. Porcelain Enamel Coating: Hard, impervious arid durable, glass-like coating produced by fusing carefully compounded mixture of mineral substances such as Cryolite, Feldspar, Quartz, Borax, Silica, Tin and Zirconium Oxide Clays at temperatures up to 980 degrees C (1800 degrees F) in accordance with ANSI A112.19.4M.
23. Porcelain Enamel: Apply to all areas of each component, including backs and flanges.
 - a. Initial Enamel Coating: Apply to all surfaces and apply additional separately fired coating of chemically resistant porcelain enamel as face coat.
 - b. Each coat of Porcelain Enamel: 0.10 to 0.15 mm (0.004 to 0.006 inch) when measured in accordance with ASTM D1186.
 - c. Two Coatings of Porcelain Enamel on Exposed Surfaces of Panels: Thickness of 0.20 to 0.05 mm (0.008 to 0.002 inch).
 - d. Final Porcelain Enamel Coat: Chemically resistant, complying with Performance Requirements in this Section.
 - e. Installed Liner and Surround: Uniform color.
 - 1) Color: White.

Accessories

24. Bracing Strips/Filler Material/Backer Board: Fire retardant perlite or molded polystyrene material providing zero capillarity water resistance, and permanent insulation properties.
 - a. Bracing Strips: Fire retardant molded polystyrene material.
 - b. Filler Material: Sound deadening and cushioning material.
 - c. Panel Backer Board: Minimum 12.7 mm (1/2 inch) thick.
25. Joint Sealant: Mildew resistant one-component silicone; FS TT-S-001543A, Class A; ASTM C 920, Type S, Grade NS, Class 25, Uses NT, G, and A.
 - a. Color: Match color of porcelain enamel.
26. Bath Accessories: See Division 10 Section "Bath Accessories."

Fabrication

27. Shop Assembly: Shop assemble panels to greatest extent possible.



- a. Coordinate with bath accessories provided under Division 10 Section "Bath Accessories."

EXECUTION

Examination

28. Site Verification of Conditions:
 - a. Existing Conditions: Examine bathrooms before beginning installation.
 - b. Field Measurements: Verify field measurements are as indicated on Shop Drawings.
 - c. Do not proceed with installation until conditions are satisfactory.

Preparation

29. Protection: Comply with requirements of Detailed Scope of Work.
 - a. Protect or repair utilities damaged by operations under this Section.
 - b. Protect adjacent elements from damage and disfiguration.
 - c. Repair or replace damaged elements in accordance with Detailed Scope of Work.
30. Preparation: Prepare bathtubs and surround walls as required for proper installation in accordance with Detailed Scope of Work.

Installation

31. Interface With Other Work: Coordinate installation of bathtub liner and surround wall panel system with installation of bath accessories under Division 10 Section "Bath Accessories" and plumbing work under Division 15 Section "Plumbing."
32. Bathtub Liners and Aprons:
 - a. Installation: Accomplished without removing existing bathtub fixture.
 - b. Bracing Strips/Filler Material: Partially line clearance between base of existing bathtubs and tub liner with bracing strips.
 - c. Insert new bathtub liner over and into existing bathtub, simultaneously bottoming on and compressing filler material and resting on and being supported by intimate contact with existing bathtub seat and rim on all four sides, to eliminate any movement.
 - d. Apron: Install new apron to extension to new bathtub liner ledge or seat portion; by inserting non-corrosive locating pins and/or fasteners as required between floor and roll rim of new tub liner.
 - e. Customized bathtub liner Insert in accordance with variable field dimensions into variably sized ledges and seat: both in plant fabrication and field installation as required.
 - 1) a. Verify dimensions and conditions by visiting each bathroom for work indicated and specified.
33. Tub Surround Wall Panel System: Integrate wall panels with installation of new tub liners.
 - a. Panel System: Install as extension of bathtub in upward direction bearing configuration and function of bathtub and shower enclosure.
 - b. Install window sill and jamb system where window is located over bathtub in manner not to interfere with easy use of and access to window pulls, handles, screen retainers, etc.
 - c. Existing Walls: Remove obstructions, encountered for installation of porcelain enamel panels.
 - 1) Patch and repair damaged wall board surfaces that are exposed after panel installation in accordance with Detailed Scope of Work.
 - 2) Backer Board: Provide between wall panels and existing masonry walls.
 - d. Method of Securing Panels: Mechanical and not visible.
 - 1) Provide at least two wall clips on both top and bottom flanges of each panel.
 - 2) Exposed bolts, screw heads, grommets, battens, channel moldings. or any other fastening devices not allowed.
 - e. Access Panels: Seal perimeter with joint sealant for waterproof joint.
 - f. Joint Sealing: Permanently seal perimeter edges between new panels and existing walls, joints between panels, joints at window sill and jamb system, and corner joint at juncture of back wall with side walls with joint sealant .



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34. Joint Sealants: Apply in accordance with manufacturers recommendations.
- a. Surfaces to be Sealed: Clean, dry and free of any foreign matter that would degrade adhesion.
 - b. Prime cleaned surfaces in accordance with sealant manufacturer's recommendations.
 - c. Protect surfaces adjacent to joints by masking tape before applying sealant. Remove tape upon finishing sealing work.

Cleaning

35. Cleaning: Comply with requirements of Detailed Scope of Work.
- a. Clean bathtub liners and surrounds after installation is completed with materials compatible with porcelain enamel and having no detrimental effects on porcelain enamel.

END OF SECTION 22 42 19 00



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Task	Specification	Specification Description
22 42 19 00	22 01 40 81	Plumbing Fixtures
22 42 19 00	22 01 40 81a	Emergency Plumbing Fixtures
22 42 23 00	22 01 40 81	Plumbing Fixtures
22 42 23 00	22 01 40 81a	Emergency Plumbing Fixtures
22 42 33 00	22 01 40 81	Plumbing Fixtures
22 42 33 00	22 01 40 81a	Emergency Plumbing Fixtures
22 42 39 00	01 22 16 00	No Specification Required
22 42 39 00	22 01 40 81	Plumbing Fixtures
22 42 39 00	22 01 40 81a	Emergency Plumbing Fixtures
22 42 43 00	22 01 40 81	Plumbing Fixtures
22 42 43 00	22 01 40 81a	Emergency Plumbing Fixtures
22 42 46 00	22 01 40 81	Plumbing Fixtures
22 42 46 00	22 01 40 81a	Emergency Plumbing Fixtures



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**SECTION 22 43 00 00 - MEDICAL PLUMBING FIXTURES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for medical plumbing fixtures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following medical plumbing fixtures and related components:
 - a. Faucets for lavatories, showers, and sinks.
 - b. Laminar-flow, faucet-spout outlets.
 - c. Flushometers.
 - d. Toilet seats.
 - e. Protective shielding guards.
 - f. Fixture supports.
 - g. Bedpan washers.
 - h. Water closets.
 - i. Lavatories.
 - j. Individual showers.
 - k. Patients' combination toilets.
 - l. Clinical sinks.
 - m. Plaster sinks.
 - n. Surgeons' scrub sinks.
 - o. Surgeons' instrument sinks.
 - p. Bathing units.
 - q. Sitz baths.
 - r. Bedpan washing equipment.
 - s. Hydrotherapy whirlpools.
 - t. Outlet boxes.
 - u. Morgue equipment.

C. Definitions

1. Accessible Medical Plumbing Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
2. Fitting: Device that controls the flow of water into or out of the medical plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads, drains and tailpieces, and traps and waste pipes.
3. FRP: Fiberglass-reinforced plastic.
4. PMMA: Polymethyl methacrylate (acrylic) plastic.

D. Submittals

1. Product Data: For each type of medical plumbing fixture indicated.
2. LEED Submittal:
 - a. Product Data for Credit WE 2, 3.1, and 3.2: Documentation indicating flow and water consumption requirements.
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Operation and maintenance data.

E. Quality Assurance



1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act", **as directed**; for plumbing fixtures for people with disabilities.
3. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
4. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
5. Select combinations fixtures and trim, faucets, fittings, and other components that are compatible.
6. Comply with the following applicable standards and other requirements specified for medical plumbing fixtures:
 - a. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
 - b. Plastic Bathtubs: ANSI Z124.1.
 - c. Plastic Shower Enclosures: ANSI Z124.2.
 - d. Slip-Resistant Bathing Surfaces: ASTM F 462.
 - e. Vitreous-China Fixtures: ASME A112.19.2M.
7. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
 - a. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
 - b. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
 - c. Faucets: ASME A112.18.1.
 - d. Hose-Connection Vacuum Breakers: ASSE 1011.
 - e. Hose-Coupling Threads: ASME B1.20.7.
 - f. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 - g. NSF Materials: NSF 61.
 - h. Pipe Threads: ASME B1.20.1.
 - i. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
 - j. Supply Fittings: ASME A112.18.1.
 - k. Brass Waste Fittings: ASME A112.18.2.
8. Comply with the following applicable standards and other requirements specified for bathtub and shower faucets:
 - a. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
 - b. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
 - c. Faucets: ASME A112.18.1.
 - d. Hand-Held Showers: ASSE 1014.
 - e. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
 - f. Hose-Coupling Threads: ASME B1.20.7.
 - g. Manual-Control Antiscald Faucets: ASTM F 444.
 - h. Pipe Threads: ASME B1.20.1.
 - i. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
 - j. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
 - k. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
9. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
 - a. Atmospheric Vacuum Breakers: ASSE 1001.
 - b. Brass and Copper Supplies: ASME A112.18.1.
 - c. Flexible Water Connectors: ASME A112.18.6.
 - d. Manual-Operation Flushometers: ASSE 1037.
 - e. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
 - f. Brass Waste Fittings: ASME A112.18.2.
10. Comply with the following applicable standards and other requirements specified for miscellaneous components:



- a. Grab Bars: ASTM F 446.
- b. Hose-Coupling Threads: ASME B1.20.7.
- c. Off-Floor Fixture Supports: ASME A112.6.1M.
- d. Pipe Threads: ASME B1.20.1.
- e. Plastic Toilet Seats: ANSI Z124.5.
- f. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.2 PRODUCTS

A. Lavatory Faucets

1. Description: Faucet for lavatory-type medical plumbing fixture. Coordinate faucet inlets with supplies, connectors, and fixture holes; coordinate outlet with spout and fixture receptor.
 - a. Maximum Flow Rate: 2.2 gpm (8.3 L/min.).
 - b. Body Material: Solid brass.
 - c. Finish: Polished chrome plate.
 - d. Type: Single-control mixing **OR** Single-valve nonmixing **OR** Two-handle mixing, **as directed**.
 - e. Tempering System: Not required **OR** Thermostatic **OR** Pressure balance, **as directed**.
 - f. Supply Centers: Single hole **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** 12 inches (305 mm) **OR** Adjustable, **as directed**.
 - g. Mounting: Deck, exposed **OR** Deck, concealed **OR** Back/wall, exposed **OR** Back/wall, concealed, **as directed**.
 - h. Handle(s): Single lever **OR** Cross, four arm **OR** Wrist blade, 4 inches (102 mm) **OR** Elbow, 6 inches (152 mm) **OR** Not applicable, **as directed**.
 - i. Temperature Indicators: Color-coded for hot and cold water.
 - j. Inlet(s): NPS 3/8 (DN 10) tubing, plain end **OR** NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor **OR** NPS 1/2 (DN 15) male shank **OR** NPS 1/2 (DN 15) female shank, **as directed**.
 - k. Spout: Rigid **OR** Swing **OR** Rigid gooseneck **OR** Swivel gooseneck, **as directed**, brass.
 - l. Spout Outlet: Aerator **OR** Spray **OR** Laminar flow **OR** Plain end **OR** Spray, 0.5 gpm (1.5 L/min.), **as directed**.
 - m. Operation: Compression, manual **OR** Noncompression, manual **OR** Automatic, hard-wired electric sensor, **as directed**.
 - n. Drain: Pop up **OR** See fixture, **as directed**.

B. Shower Faucets

1. Description: Faucet for shower-type medical plumbing fixtures. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies.
 - a. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
 - b. Body Material: Solid brass.
 - c. Finish: Polished chrome plate.
 - d. Type: Thermostatic **OR** Pressure balance **OR** Thermostatic and pressure balance, **as directed**, with integral or field-installed check stops on hot- and cold-water supplies.
 - e. Mounting: Exposed **OR** Concealed, **as directed**.
 - f. Handle(s): Single lever **OR** Cross, four arm **OR** Not applicable, **as directed**.
 - g. Temperature Indicators: Color-coded for hot and cold water.
 - h. Diverter Valve: Not required **OR** Integral with mixing valve **OR** Not integral with mixing valve, **as directed**.
 - i. Backflow Protection Device for Hand-Held Shower: Required **OR** Not required, **as directed**.
 - j. Operation: Compression, manual **OR** Noncompression, manual **OR** Automatic, hard-wired electric sensor, **as directed**.
 - k. Antiscald Device: Integral with mixing valve **OR** Not required, **as directed**.



- l. Supply Connections: NPS 1/2 (DN 15) **OR** NPS 1/2 (DN 15), union **OR** Sweat, **as directed**.
- m. Shower Head Material: Brass with chrome-plated finish.
- n. Head Type: Ball joint **OR** Without ball joint **OR** Hand held, slide-bar mounted **OR** Hand held, hook mounted, **as directed**.
- o. Spray Pattern: Fixed **OR** Adjustable, **as directed**.
- p. Integral Volume Control: Required **OR** Not required, **as directed**.
- q. Shower-Arm, Flow-Control Fitting: Not required **OR** 1.5 gpm (5.7 L/min.) **OR** 2.0 gpm (7.6 L/min.), **as directed**.

C. Sink Faucets

1. Description: Faucet for sink-type medical plumbing fixtures. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
 - a. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
 - b. Body Material: Solid brass.
 - c. Finish: Polished chrome plate **OR** Rough chrome plate, **as directed**.
 - d. Type: Sink faucet **OR** Clinical-sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook, **as directed**.
 - e. Tempering Device: Thermostatic **OR** Pressure balance **OR** Not required, **as directed**.
 - f. Mixing Valve: Single control **OR** Two-lever handle, **as directed**.
 - g. Backflow Protection Device for Hose Outlet: Required **OR** Not required **OR** Not applicable, **as directed**.
 - h. Supply Centers: Single hole **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** Adjustable, **as directed**.
 - i. Mounting: Deck, exposed **OR** Deck, concealed **OR** Back/wall, exposed **OR** Back/wall, concealed, **as directed**.
 - j. Handle(s): Lever **OR** Knob **OR** Cross, four arm **OR** Wrist blade, 4 inches (102 mm) **OR** Elbow, 6 inches (152 mm) **OR** Not applicable, **as directed**.
 - k. Temperature Indicators: Color-coded for hot water on left and cold water on right.
 - l. Inlet(s): NPS 3/8 (DN 10) plain-end tubing **OR** NPS 3/8 (DN 10) tubing with NPS 1/2 (DN 15) male adapter **OR** NPS 1/2 (DN 15) male shank **OR** NPS 1/2 (DN 15) female shank, **as directed**.
 - m. Spout: Rigid, solid **OR** Swing tubular **OR** Rigid, gooseneck, solid **OR** Swivel, gooseneck, solid, **as directed**, brass with wall brace, **as directed**.
 - n. Spout Outlet: Aerator **OR** Swivel aerator/spray **OR** Spray **OR** Laminar flow **OR** Hose thread **OR** Plain end, **as directed**.
 - o. Vacuum Breaker: Required **OR** Not required, **as directed**.
 - p. Operation: Compression, manual **OR** Noncompression, manual **OR** Automatic, hard-wired electric sensor, **as directed**.

D. Laminar-Flow Faucet-Spout Outlets

1. Description: Chrome-plated-brass faucet-spout outlet that produces non-aerating laminar stream. Include male or female thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

E. Flushometers

1. Description: Flushometer for clinical-sink-type **OR** water-closet-type, **as directed**, medical plumbing fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, **as directed**, control stop with check valve, vacuum breaker, and copper or brass tubing, and polished chrome-plated finish on exposed parts.
 - a. Internal Design: Diaphragm operation.
 - b. Style: Exposed **OR** Concealed, **as directed**.
 - c. Inlet Size: NPS 1 (DN 25).
 - d. Trip Mechanism: Oscillating, lever-handle actuator **OR** Mechanical, push-button actuator with stainless-steel access plate **OR** Hydraulic, push-button actuator **OR** Foot-pedal



actuator **OR** Hard-wired, electric-sensor actuator **OR** Battery-operated sensor actuator, **as directed**.

- e. Consumption: 1.6 gal./flush (6.0 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
- f. Tailpiece Size: NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, and standard length to top of bowl.
- g. Integral Bedpan Washer: Not required **OR** Factory fabricated, attached to tailpiece, and with spray head, **as directed**.

F. Toilet Seats

- 1. Description: Plastic toilet seat for water-closet-type medical plumbing fixture.
 - a. Material: Molded, solid plastic with antimicrobial agent, **as directed**.
 - b. Configuration: Closed **OR** Open, **as directed**, front with **OR** without, **as directed**, cover.
 - c. Size: Elongated, unless otherwise indicated.
 - d. Class: Standard **OR** Heavy-duty, **as directed**, commercial.
 - e. Hinge Type: Stainless-steel CK, check **OR** SC, self-sustaining check, **as directed**.
 - f. Color: White **OR** Black, **as directed**.

G. Protective Shielding Guards

- 1. Protective Shielding Pipe Covers:
 - a. Description: Manufactured plastic wraps for covering medical plumbing fixture hot-water supply **OR** hot- and cold-water supplies, **as directed**, and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
- 2. Protective Shielding Piping Enclosures:
 - a. Description: Manufactured plastic enclosure for covering medical plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

H. Fixture Supports

- 1. Water-Closet Supports:
 - a. Description: Combination carrier designed for accessible **OR** standard, **as directed**, mounting height of wall-mounting, water-closet-type medical plumbing fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
- 2. Lavatory Supports:
 - a. Description: Type I, lavatory carrier with exposed arms and tie rods **OR** Type II, lavatory carrier with concealed arms and tie rod **OR** Type III, lavatory carrier with hanger plate and tie rod, **as directed**, for wall-mounting, lavatory-type medical plumbing fixture. Include steel uprights with feet.
 - b. Accessible-Fixture Support: Include rectangular steel uprights.
- 3. Sink Supports:
 - a. Description: Type I, sink carrier with exposed arms and tie rods **OR** Type II, sink carrier with hanger plate, bearing studs, and tie rod **OR** Type III, sink carrier with hanger plate and exposed arms, **as directed**, for sink-type medical plumbing fixture. Include steel uprights with feet.
- 4. Bedpan Washers
 - a. Description: Wall-mounting, hand-held, hand-control **OR** single-pedal, foot-control **OR** double-pedal, hot- and cold-water control, **as directed**, medical plumbing fixture.
 - 1) Hose: 48-inch- (1220-mm-) long rubber or vinyl hose with spray nozzle, wall bracket, and hook.
 - 2) Self-closing valve.
 - 3) Loose-key supply stop.
 - 4) Vacuum Breaker: Wall mounting, atmospheric.
 - 5) Finish: Polished, chrome-plated finish on metal parts exposed after installation.

I. Water Closets



1. Wall-Mounting Water Closets:
 - a. Description: Accessible, wall-mounting **OR** Wall-mounting, **as directed**, back-outlet, vitreous-china medical plumbing fixture designed for bedpan washing and flushometer valve operation.
 - 1) Style: Flushometer valve.
 - a) Bowl Type: Elongated with siphon-jet design and bedpan lugs or slots.
 - b) Design Consumption: 1.6 gal./flush (6 L/flush).
 - c) Color: White.
2. Floor-Mounting Water Closets:
 - a. Description: Accessible, floor-mounting **OR** Floor-mounting, **as directed**, floor-outlet, vitreous-china medical plumbing fixture designed for bedpan washing and flushometer valve operation.
 - 1) Style: Flushometer valve.
 - a) Bowl Type: Elongated with siphon-jet design and bedpan lugs or slots. Include bolt caps matching fixture.
 - b) Height: Standard **OR** Accessible, **as directed**.
 - c) Design Consumption: 1.6 gal./flush (6 L/flush).
 - d) Color: White.

J. Lavatories

1. Wall-Mounting Lavatories:
 - a. Description: Accessible, wall-mounting **OR** Wall-mounting, **as directed**, vitreous-china medical plumbing fixture.
 - 1) Type: With back **OR** Ledge back **OR** Shelf back **OR** Slab, **as directed**.
 - 2) Size: 18 by 15 inches (457 by 381 mm) **OR** 19 by 16 inches (483 by 406 mm) **OR** 20 by 18 inches (508 by 457 mm) **OR** 24 by 20 inches (610 by 508 mm), **as directed**, rectangular.
 - 3) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.
 - 4) Faucet Hole Location: Top **OR** Front wall **OR** Inclined panel, **as directed**.
 - 5) Color: White.
 - 6) Faucet: Lavatory with pop-up waste **OR** for separate drain, **as directed**.
 - 7) Supplies: NPS 3/8 (DN 10) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
 - 8) Drain: See faucet **OR** Grid **OR** Grid with offset, **as directed**.
 - a) Location: Not applicable.
 - 9) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.
 - 10) Protective Shielding Guard(s): Designation, as directed by the Owner.
 - 11) Fixture Support: Lavatory.
2. Counter-Mounting Lavatories:
 - a. Description: Accessible, **as directed**, Counter-mounting **OR** Undercounter-mounting, **as directed**, vitreous-china, medical plumbing fixture.
 - 1) Type: Flat rim with ledge **OR** Self-rimming, **as directed**.
 - 2) Rectangular Lavatory Size: 18 by 15 inches (457 by 381 mm) **OR** 19 by 16 inches (483 by 406 mm) **OR** 20 by 18 inches (508 by 457 mm) **OR** 24 by 20 inches (610 by 508 mm), **as directed**.
 - 3) Oval Lavatory Size: 19 by 16 inches (483 by 406 mm) **OR** 20 by 17 inches (508 by 432 mm), **as directed**.
 - 4) Round Lavatory Size: 18 inches (457 mm) **OR** 19 inches (483 mm), **as directed**, in diameter.
 - 5) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.



- 6) Faucet Hole Location: Top **OR** Front wall **OR** Inclined panel, **as directed**.
- 7) Color: White.
- 8) Faucet: Lavatory with pop-up waste **OR** for separate drain, **as directed**.
- 9) Supplies: NPS 3/8 (DN 10) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
- 10) Drain: See faucet **OR** Grid **OR** Grid with offset, **as directed**.
 - a) Location: Not applicable.
- 11) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.
- 12) Protective Shielding Guard(s): Designation, as directed by the Owner.

K. Individual Showers:

1. Description: Accessible, **as directed**, FRP **OR** PMMA, **as directed**, shower enclosure medical plumbing fixture with slip-resistant bathing surface complying with ASTM F 462. Comply with ADA requirements for use by people with disabilities.
 - a. Size: 36 by 34 inches (915 by 865 mm) **OR** 42 by 36 inches (1065 by 915 mm) **OR** 43 by 39 inches (1090 by 990 mm) **OR** 48 by 34 inches (1220 by 865 mm) **OR** 52 by 36 inches (1320 by 915 mm) **OR** 60 by 36 inches (1525 by 915 mm) **OR** 72 by 36 inches (1830 by 915 mm), **as directed**.
 - b. Surround: One piece.
 - c. Color: White.
 - d. Faucet: Shower.
 - e. Drain: Grid, NPS 2 (DN 50).
 - 1) Location: Left side **OR** Center **OR** Right side, **as directed**.
 - f. Accessories: If not furnished as integral components of specified fixture. Accessories are specified in Division 10 Section "Toilet, Bath, And Laundry Accessories".
 - 1) Grab bar(s).
 - 2) Normal-duty **OR** Heavy-duty, **as directed**, shower-curtain rod.
 - 3) Vinyl **OR** Duck **OR** Antibacterial, **as directed**, shower curtain.
 - 4) Shower-curtain hooks.
 - 5) Folding seat, **as directed**.

L. Patients' Combination Toilets

1. Swing-Away, Patients' Combination Toilets:
 - a. Description: Factory-fabricated, combination water closet and lavatory medical plumbing fixture.
 - 1) Cabinet: Fixed installation with storage space and toilet paper holder.
 - a) Material: Stainless steel **OR** Stainless steel, plastic laminate, or fiberglass, **as directed**, with laminated-wood or -plastic **OR** solid-plastic **OR** stainless-steel, **as directed**, top surface.
 - b) Color: Not applicable.
 - c) Mounting: Wall bracket.
 - 2) Water Closet: Swivel, floor-mounting, back-outlet **OR** floor-outlet, **as directed**, flushometer valve design.
 - a) Material: Stainless steel.
 - b) Orientation: Left **OR** Right, **as directed**, hand.
 - c) Color: Not applicable.
 - d) Toilet Seat: White, solid plastic.
 - e) Flushometer: Concealed flushometer valve with push-button trip mechanism, check stop, and vacuum breaker on tailpiece.
 - f) Fixture Support: Floor plate.
 - g) Seal: For outlet.
 - 3) Lavatory: Counter mounting.
 - a) Material: Stainless steel.



- b) Color: Not applicable.
 - c) Faucet: Gooseneck type with wrist-blade handles **OR** Swing-spout type with single lever, **as directed**.
 - d) Drain: Grid, NPS 1-1/4 (DN 32).
 - e) Drain Piping: NPS 1-1/4 (DN 32) chrome-plated, cast-brass P-trap; tubular-brass waste to wall; and wall flange.
- 4) Bedpan Washer: On flushometer valve tailpiece or separate attachment affixed to unit.

2. Static, Patients' Combination Toilets:

- a. Description: Factory-fabricated, combination water closet and lavatory fixture.
 - 1) Cabinet: Fixed installation; swing-away cabinet or retractable, water-closet cover design with storage space and toilet paper holder.
 - a) Material: Stainless steel **OR** Stainless steel, plastic laminate, or fiberglass, **as directed**, with laminated-wood or -plastic **OR** solid-plastic **OR** stainless-steel, **as directed**, top surface.
 - b) Color: Not applicable.
 - c) Mounting: Wall bracket.
 - 2) Water Closet: Floor-mounting, floor-outlet, flushometer valve design.
 - a) Material: Stainless steel or vitreous china.
 - b) Orientation: Left **OR** Right, **as directed**, hand.
 - c) Color: Not applicable.
 - d) Toilet Seat: White, solid plastic.
 - e) Flushometer: Concealed flushometer valve with push-button trip mechanism, check stop, and vacuum breaker on tailpiece.
 - f) Seal: For outlet.
 - 3) Lavatory: Counter mounting.
 - a) Material: Stainless steel.
 - b) Color: Not applicable.
 - c) Faucet: Gooseneck type with wrist-blade handles **OR** Swing-spout type with single lever, **as directed**.
 - d) Drain: Grid, NPS 1-1/4 (DN 32).
 - e) Drain Piping: NPS 1-1/4 (DN 32) chrome-plated, cast-brass P-trap; tubular-brass waste to wall; and wall flange.
 - 4) Bedpan Washer: On flushometer valve tailpiece or separate attachment affixed to unit.

M. Clinical Sinks

- 1. Wall-Mounting Clinical Sinks:
 - a. Description: Wall-mounting, back-outlet, vitreous-china, flushing-rim, service-sink-type medical plumbing fixture.
 - 1) Size: Approximately 25 by 20 inches (635 by 510 mm).
 - 2) Color: White.
 - 3) Rim Guard: Stainless steel on front and also on sides if flat rim.
 - 4) Faucet: Sink, polished, chrome-plated, solid-brass, service-sink faucet type, including integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.
- 2. Floor-Mounting Clinical Sinks:
 - a. Description: Floor-mounting, bottom-outlet, vitreous-china, flushing-rim, service-sink-type medical plumbing fixture. Include bolt caps.
 - 1) Size: Approximately 27 by 20 inches (685 by 510 mm).
 - 2) Color: White.
 - 3) Rim Guards: Stainless steel on front and sides.
 - 4) Sink Base: 10-inch (25.4-mm) -high, cast terrazzo if required.



- 5) Faucet: Sink, polished, chrome-plated, solid-brass, service-sink faucet type, including integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.

N. Plaster Sinks:

1. Description: Wall-mounting, vitreous-china medical plumbing fixture.
 - a. Size: 24 by 22 inches (610 by 560 mm) **OR** 30 by 22 inches (760 by 560 mm), **as directed**, with back or ledge faucet holes.
 - b. Color: White.
 - c. Faucet Holes: One **OR** Two, **as directed**, in back or ledge.
 - d. Faucet: Sink.
 - e. Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
 - f. Drain: Grid, NPS 1-1/2 (DN 40) with NPS 1-1/2 (DN 40) to NPS 2 (DN 50) adaptor, **as directed**.
 - g. Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, chrome-plated brass; 0.045-inch- (1.1-mm-) thick waste to interceptor; interceptor to wall; and wall flange.
 - h. Plaster Interceptor:
 - 1) Description: Cast-iron or steel body and removable cover with acid-resistant-enameled interior lining and outside coating; removable, corrosion-resistant metal screens or strainer; and NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, inlet and outlet.
2. Fixture Support: Sink with white-enameled-steel brackets.

O. Surgeons' Scrub Sinks

1. Stainless-Steel Surgeons' Scrub Sinks:
 - a. Description: Wall-mounting, sink-type medical plumbing fixture.
 - 1) Size: Approximately 31 by 20 inches (790 by 510 mm) with back with 1 faucet hole.
 - 2) Faucet: Chrome-plated-brass, gooseneck type matching fixture.
 - 3) Operation: Foot-pedal **OR** Knee **OR** Automatic, hard-wired electric sensor, **as directed**, control.
 - 4) Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
 - 5) Drain: Grid, NPS 1-1/2 (DN 40).
 - 6) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall; and wall flange.
 - 7) Fixture Support: Sink.
2. Vitreous-China Surgeons' Scrub Sinks:
 - a. Description: Wall-mounting, sink-type medical plumbing fixture.
 - 1) Size: 28 by 22 inches (710 by 560 mm) **OR** 30 by 22 inches (760 by 560 mm), **as directed**, with back or ledge with 1 faucet hole.
 - 2) Color: White.
 - 3) Faucet: Chrome-plated-brass, gooseneck-type matching fixture.
 - 4) Operation: Foot-pedal **OR** Knee, **as directed**, control.
 - 5) Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
 - 6) Drain: Grid, NPS 1-1/2 (DN 40).
 - 7) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall; and wall flange.
 - 8) Fixture Support: Sink.

P. Surgeons' Instrument Sinks:

1. Description: Wall-mounting, stainless-steel, sink-type medical plumbing fixture. Include instrument tray on each side.
 - a. Size: 28 by 20 inches (710 by 510 mm) with 1 hole for deck-mounting faucet.



- b. Faucet: Chrome-plated-brass, gooseneck type matching fixture with knee **OR** foot-pedal, **as directed**, control for mixing hot- and cold-water supplies.
- c. Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
- d. Drain: Grid, NPS 1-1/2 (DN 40).
- e. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall; and wall flange.
- f. Fixture Support: Sink.

Q. Bathing Units

1. Institutional Bath Tubs:

- a. Description: Enameled, cast-iron, island medical plumbing fixture with separate wall-mounting faucet.
 - 1) Size: 66 by 30 by 18 inches (1680 by 765 by 455 mm).
 - 2) Base: Enameled, cast iron to raise rim of bathtub to 28 inches (710 mm) above the floor.
 - 3) Faucet: Shower **OR** Sink, **as directed**, modified to include tub filler spout.
 - 4) Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops. Include atmospheric vacuum breaker.
 - 5) Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
 - 6) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall; and wall flange.

2. Bathing Units:

- a. Description: Plastic-tub, institutional side-entry bath **OR** whirlpool-bath, **as directed**, fixture with integral controls.
 - 1) Tub Size: 60 by 30 inches (1525 by 765 mm).
 - 2) Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and hand-held shower head.
 - 3) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves.
 - 4) Drain: NPS 1-1/2 (DN 40) and NPS 2 (DN 50).
 - 5) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, cast-brass P-trap, waste to wall, and wall flange. Include combined drain piping if two drains.

3. Bathing Units:

- a. Description: Plastic-tub, institutional side-entry **OR** transfer-lift-entry **OR** slide-on-entry, **as directed**, adjustable-height **OR** fixed-height, **as directed**, bath fixture with integral controls.
 - 1) Tub Size: 60 by 30 inches (1525 by 765 mm).
 - 2) Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and hand-held shower head.
 - 3) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves.
 - 4) Drain: NPS 1-1/2 (DN 40) and NPS 2 (DN 50).
 - 5) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, cast-brass P-trap, waste to wall, and wall flange. Include combined drain piping if two drains.
 - 6) Lift System: Not required.

4. Bathing Units:

- a. Description: Plastic-tub, institutional front-entry shower fixture with integral controls.
 - 1) Cabinet Size: 35 by 41 inches (889 by 1041 mm).
 - 2) Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and hand-held shower head.
 - 3) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves.
 - 4) Drain: NPS 2 (DN 50).
 - 5) Drain Piping: NPS 2 (DN 50) cast-brass P-trap, waste to wall, and wall flange.



5. Residential Bath Tubs:
- a. Description: Plastic island or against-wall-installation, **as directed**, medical plumbing fixture with side door, seat, and separate wall-mounting faucet.
 - 1) Size 1
 - a) Size: Approximately 60 by 32 by 21 inches (1525 by 815 by 535 mm).
 - b) Seat: Integral.
 - c) Drain Location: Left **OR** Right, **as directed**, end.
 - 2) Size 2
 - a) Size: Approximately 60 by 42 by 24.5 inches (1525 by 1070 by 620 mm).
 - b) Seat: Integral bench **OR** None, **as directed**.
 - c) Drain Location: Right end.
 - 3) Material: PMMA.
 - 4) Skirt: Front only **OR** Full, on three sides, **as directed**.
 - 5) Door: Side opening with rubber sealing gasket.
 - 6) Faucet: Shower **OR** Sink, **as directed**, modified to include tub filler spout.
 - 7) Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops. Include atmospheric vacuum breaker.
 - 8) Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
 - 9) Drain Piping: NPS 1-1/2 (DN 40) cast-brass P-trap and 0.045-inch- (1.1-mm-) thick, tubular-brass waste to wall.

R. Sitz Baths:

1. Description: Pedestal-mounting **OR** Wall-mounting, **as directed**, vitreous-china, perineal bath medical plumbing fixture.
 - a. Color: White.
 - b. Drain: NPS 1-1/2 (DN 40) with removable overflow attachment.
 - c. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; waste to wall; and wall flange.
 - d. Fixture Support: Sink.
 - e. Faucet:
 - 1) Description: Wall-mounting, single-lever-handle, thermostatic-mixing-valve faucet with concealed supplies and wall-mounting thermometer.
 - a) Material: Brass body and escutcheon.
 - b) Flow Rate: Modified to 1.5 gpm (5.7 L/min.) maximum, unless otherwise indicated.
 - c) Finish: Polished chrome plate.
 - d) Temperature Indicators: Color-coded for hot and cold water.
 - f. Exposed Piping: Chrome-plated; brass pipe or copper tube.

S. Bedpan Washing Equipment

1. Bedpan Washers/Sanitizers:
 - a. Description: Recessed-mounting **OR** On-wall-mounting **OR** Pedestal-mounting, **as directed**, medical plumbing fixture for cleaning bedpans and urinals having cast-iron chamber and waste assembly with spray nozzles and enameled-steel **OR** stainless-steel, **as directed**, front panel and cover box.
 - 1) Controls: Electric, 120-V ac, automatic operation with timer, solenoid valves, and circuit breaker.
 - 2) Door Mechanism: Foot-pedal operation.
 - 3) Supplies: NPS 1 (DN 25) cold water and NPS 3/8 (DN 10) hot water **OR** steam, **as directed**.
 - 4) Drain: NPS 3 (DN 80) P-trap and soil pipe.
 - 5) Atmospheric Vent: NPS 2 (DN 50).
 - 6) Mounting Hardware: Matching fixture mounting arrangement.
 - 7) Accessories:
 - a) Bedpan Rack(s): One **OR** Two, **as directed**.



- b) Urinal Rack(s): One **OR** Two, **as directed**.
 - c) Drain Tray(s): One **OR** Two, **as directed**.
 - 2. Bedpan Washers/Disinfectors:
 - a. Description: Freestanding-mounting **OR** On-wall-mounting **OR** Undercounter-mounting, **as directed**, medical plumbing fixture for cleaning bedpans and urinals; with steam generator, pump, and spray nozzle.
 - 1) Controls: Electric, automatic operation.
 - 2) Cabinet: Stainless steel.
 - 3) Wash Chamber: Stainless steel.
 - 4) Supplies: NPS 1/2 (DN 15) cold water and NPS 1/2 (DN 15) hot water.
 - 5) Drain: NPS 4 (DN 100) P-trap and soil pipe.
 - 6) Mounting Hardware: Matching fixture mounting arrangement.
- T. Hydrotherapy Whirlpools
 - 1. Podiatry Whirlpools:
 - a. Description: Stationary, stainless-steel tank for feet and ankles.
 - 1) Water Capacity: 15 gal. (57 L).
 - 2) Drain: Waste connection.
 - 3) Controls.
 - 4) Thermometer: Control panel or tank mounted.
 - 5) One electric turbine ejector.
 - 2. Upper-Extremity Whirlpools:
 - a. Description: Stationary, pedestal-mounted, stainless-steel tank for arms, hands, and elbows.
 - 1) Water Capacity: 25 gal. (95 L).
 - 2) Drain: Waste connection.
 - 3) One arm support.
 - 4) Controls.
 - 5) Thermometer: Control panel or tank mounted.
 - 6) One electric turbine ejector.
 - 3. High-Tank Body Whirlpools:
 - a. Description: Stationary, stainless-steel tank for legs, hip, and back.
 - 1) Water Capacity: 105 gal. (397 L).
 - 2) Drain: Waste connection.
 - 3) Controls.
 - 4) Thermometer: Control panel or tank mounted.
 - 5) One electric turbine ejector.
 - 4. Low-Tank Body Whirlpools:
 - a. Description: Stationary, extended-length stainless-steel tank for legs, hip, and lower back.
 - 1) Water Capacity: 105 gal. (397 L).
 - 2) Drain: Waste connection.
 - 3) Controls.
 - 4) Thermometer: Control panel or tank mounted.
 - 5) Head rest.
 - 6) One electric turbine ejector.
 - 5. Small, Hubbard Immersion Tanks:
 - a. Description: Stationary, butterfly-shaped tank, for full-body massage
 - 1) Tank Dimensions: 93 by 64 by 22 inches (2362 by 1626 by 560 mm).
 - 2) Overall Height: 34 to 38 inches (864 to 965 mm).
 - 3) Water Capacity: 268 gal. (1014 L).
 - 4) Material: Stainless steel.
 - 5) Supports: Legs or base.
 - 6) Controls.
 - 7) Thermometer: Control panel or tank rim mounted.
 - 8) Supply: Over-the-rim fill spout.



- 9) Drains: Two waste connections.
 - 10) Electric Turbine Ejectors: Two; one rail mounted on each side.
 - 11) Thermostatic, mixing-valve assembly.
 - 12) Hose and hand-held shower.
 - 13) Wash-out-hose assembly.
 - 14) Stretcher lift.
 - 15) Overhead electric, **as directed**, hoist.
6. Medium, Hubbard Immersion Tanks:
- a. Description: Stationary, butterfly-shaped tank, for full-body massage.
 - 1) Tank Dimensions: 100 by 73 by 24 inches (2540 by 1854 by 610 mm).
 - 2) Overall Height: 34 to 38 inches (864 to 965 mm).
 - 3) Water Capacity: 377 gal. (1468 L).
 - 4) Material: Stainless steel.
 - 5) Supports: Legs or base.
 - 6) Controls.
 - 7) Thermometer: Control panel or tank rim mounted.
 - 8) Supply: Over-the-rim fill spout.
 - 9) Drain: One waste connection.
 - 10) Electric Turbine Ejector: One, panel mounted.
 - 11) Thermostatic, mixing-valve assembly.
 - 12) Hose and hand-held shower.
 - 13) Wash-out-hose assembly.
 - 14) Stretcher lift.
 - 15) Overhead electric, **as directed**, hoist.
7. Large, Hubbard Immersion Tanks:
- a. Description: Stationary, butterfly-shaped tank, for full-body massage.
 - 1) Tank Dimensions: 106 by 77 by 22 inches (2692 by 1956 by 560 mm).
 - 2) Overall Height: 34 inches (864 mm).
 - 3) Water Capacity: 425 gal. (1609 L).
 - 4) Material: Stainless steel.
 - 5) Supports: Legs or base.
 - 6) Controls.
 - 7) Thermometer: Control panel or tank rim mounted.
 - 8) Supply: Over-the-rim fill spout.
 - 9) Drain(s): One or two waste connections.
 - 10) Electric Turbine Ejectors: Two; one rail mounted on each side.
 - 11) Thermostatic, mixing-valve assembly.
 - 12) Hose and hand-held shower.
 - 13) Wash-out-hose assembly.
 - 14) Stretcher lift.
 - 15) Overhead electric, **as directed**, hoist.
8. Full-Body Immersion Tanks:
- a. Description: Stationary, rectangular tank, for full-body massage
 - 1) Tank Dimensions: 90 by 32 by 19 inches (2286 by 813 by 483 mm) **OR** 95 by 41 by 22 inches (2413 by 1041 by 560 mm), **as directed**.
 - 2) Overall Height: 32 or 34 inches (813 or 860 mm).
 - 3) Water Capacity: 195 gal. (738 L) **OR** 260 gal. (984 L), **as directed**.
 - 4) Material: Stainless steel.
 - 5) Supports: Legs or base.
 - 6) Controls.
 - 7) Thermometer: Control panel or tank rim mounted.
 - 8) Supply: Over-the-rim fill spout.
 - 9) Drain(s): One or two waste connections.
 - 10) Electric Turbine Ejector: One, tank mounted at end **OR** on rail **OR** on side, **as directed**.
 - 11) Thermostatic, mixing-valve assembly.



- 12) Hose and hand-held shower.
- 13) Wash-out-hose assembly.
- 14) Stretcher lift.
- 15) Overhead electric, **as directed**, hoist.

U. Outlet Boxes

1. Dialysis Equipment Outlet Boxes:

- a. Description: Recessed-mounting outlet box with water supply and drain connections.
 - 1) Box and Faceplate: Stainless steel.
 - 2) Supply Fitting(s): 1 **OR** 2, **as directed**, NPS 1/2 (DN 15) PVC ball valve(s) and adapter with male hose-thread outlet.
 - 3) Drain: NPS 2 (DN 50) standpipe, P-trap, and direct waste connection to drainage piping.
- b. Reinforcement: 2-by-4-inch (50-by-100-mm) fire-retardant-treated-wood blocking between studs. Fire-retardant-treated wood blocking is specified in Division 06 Section "Rough Carpentry".

V. Morgue Equipment

1. Autopsy Tables:

- a. Description: Pedestal stainless-steel table with sink; designed for downdraft ventilation.
 - 1) Material: Stainless steel.
 - 2) Overall Size: Approximately 88 by 30 inches (2250 by 760 mm) with deck faucet holes.
 - 3) Faucet: Deck mounted with wrist- or elbow-blade handles.
 - 4) Aspirator: Deck mounted.
 - 5) Removable body supports.
 - 6) Rinse Assembly: Deck-mounted faucet with hose.
 - 7) Disposer: Not required **OR** Required, **as directed**.
 - 8) Fixture Support: Sink.
 - 9) Receptacle: Duplex, hospital grade with ground-fault interruption.
 - 10) Supplies: Chrome-plated copper tubes or flexible connectors, **as directed**, with atmospheric vacuum breakers and stops.
 - 11) Drain: Chrome-plated, cast-brass P-trap and waste to wall.

2. Dissecting Sinks:

- a. Description: Wall-mounting sink with backsplash.
 - 1) Material: Stainless steel.
 - 2) Overall Size: 84 by 28 inches (2134 by 711 mm) with back faucet holes.
 - 3) Sink Size: Approximately 30 inches (763 mm) wide.
 - 4) Equipment drawer.
 - 5) Faucet: Back mounted with wrist- or elbow-blade handles.
 - 6) Aspirator: Back mounted.
 - 7) Rinse Assembly: One back-mounted faucet with hose.
 - 8) Disposer: Not required **OR** Required, **as directed**.
 - 9) Fixture Support: Sink.
 - 10) Supplies: Chrome-plated copper tubes or flexible connectors, **as directed**, with atmospheric vacuum breakers and stops.
 - 11) Drain: Chrome-plated, cast-brass P-trap and waste to wall.
 - 12) Back-mounted, hand-held-type eye wash.

1.3 EXECUTION

A. Installation

1. Assemble medical plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.



2. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 - a. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - b. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - c. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
 3. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
 4. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
 5. Install wall-mounting fixtures with tubular waste piping attached to supports.
 6. Install counter-mounting fixtures in and attached to casework.
 7. Install fixtures level and plumb according to roughing-in drawings.
 8. Install water-supply piping with stop on each supply to each fixture to be connected to domestic water piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - a. Exception: Use ball, gate, or globe valve if stops are not specified with fixture. Valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
 9. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
 10. Install flushometer valves for accessible water closets with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
 11. Install toilet seats on water closets.
 12. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
 13. Install shower flow-control fittings with specified maximum flow rates in shower arms.
 14. Install traps on fixture outlets.
 - a. Exception: Omit trap on fixtures with integral traps.
 15. Install escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results For Plumbing".
 16. Set showers in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results For Plumbing".
 17. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants".
- B. Connections
1. Piping installation requirements are specified in other Division 14.. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Connect water supplies from domestic water piping to medical plumbing fixtures.
 3. Connect drain piping from medical plumbing fixtures to sanitary waste and vent piping.
 4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 5. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Verify that installed medical plumbing fixtures are categories and types specified for locations where installed.
 2. Check that medical plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
 3. Inspect installed medical plumbing fixtures for damage. Replace damaged fixtures and components.
 4. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
 5. Install fresh batteries in sensor-operated mechanisms.



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- D. Adjusting
1. Operate and adjust faucets and controls. Replace damaged and malfunctioning medical plumbing fixtures, fittings, and controls.
 2. Adjust water pressure at faucets, shower valves, and flushometer valves to produce proper flow and stream.
 3. Replace washers and seals of leaking and dripping faucets and stops.
- E. Cleaning
1. Clean medical plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 - a. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
 - b. Remove sediment and debris from drains.
 2. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.
- F. Protection
1. Provide protective covering for installed fixtures and fittings.
 2. Do not allow use of medical plumbing fixtures for temporary facilities unless approved in writing by the Owner.

END OF SECTION 22 43 00 00



Task	Specification	Specification Description
22 43 13 00	22 01 40 81	Plumbing Fixtures
22 43 13 00	22 01 40 81a	Emergency Plumbing Fixtures
22 43 16 00	22 01 40 81	Plumbing Fixtures
22 43 16 00	22 01 40 81a	Emergency Plumbing Fixtures
22 43 39 00	22 01 40 81	Plumbing Fixtures
22 43 39 00	22 43 00 00	Medical Plumbing Fixtures
22 43 39 00	22 01 40 81a	Emergency Plumbing Fixtures
22 43 43 00	22 01 40 81	Plumbing Fixtures
22 45 00 00	22 01 40 81a	Emergency Plumbing Fixtures
22 45 13 00	22 01 40 81	Plumbing Fixtures
22 45 13 00	22 01 40 81a	Emergency Plumbing Fixtures
22 45 16 00	22 01 40 81a	Emergency Plumbing Fixtures
22 45 23 00	22 01 40 81	Plumbing Fixtures
22 45 23 00	22 01 40 81a	Emergency Plumbing Fixtures
22 45 26 00	22 01 40 81	Plumbing Fixtures
22 45 26 00	22 01 40 81a	Emergency Plumbing Fixtures
22 45 29 00	22 01 40 81a	Emergency Plumbing Fixtures
22 45 33 00	22 01 40 81	Plumbing Fixtures
22 45 33 00	22 01 40 81a	Emergency Plumbing Fixtures
22 45 36 00	22 01 40 81a	Emergency Plumbing Fixtures
22 45 39 00	22 01 40 81a	Emergency Plumbing Fixtures



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SECTION 22 46 13 00 - SECURITY PLUMBING FIXTURES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for security plumbing fixtures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following security plumbing fixtures and related components:
 - a. Combination units.
 - b. Drinking fountains.
 - c. Lavatories.
 - d. Service sinks.
 - e. Shampoo bowls.
 - f. Showers.
 - g. Urinals.
 - h. Water closets.
 - i. Flushometer valves for vitreous-china water closets.
 - j. Fixture supports for front-mounting, stainless-steel fixtures and vitreous-china, wall-mounting fixtures.

C. Definitions

1. Accessible Fixture: Security plumbing fixture that can be approached and used by people with disabilities.
2. Back-Mounting-Type Fixture: Security plumbing fixture designed to mount on wall sleeve built into wall so installation and removal of fixture and piping and other components are only accessible from service space behind wall.
3. Front-Mounting-Type Fixture: Security plumbing fixture designed to mount on fixture support with installation and removal from fixture side of wall, and piping and other components are accessible from access panels in fixture or wall.

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit WE 2, 3.1, and 3.2: Documentation indicating flow and water consumption requirements.
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Field quality-control test reports.
5. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act", **as directed**; about security plumbing fixtures for people with disabilities. Comply with requirements in "Energy Policy Act" about water flow and consumption rates for plumbing fixtures.
3. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.



4. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

1.2 PRODUCTS

A. Combination Units

1. Security Combination Units:

- a. Description: Back-mounting, cabinet, security plumbing fixture with integral water closet and lavatory; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Water Closet: Comply with IAPMO PS 61 for water-closet component.
 - a) Bowl: Elongated, with back inlet, integral trap, blowout design with back **OR** siphon-jet design with back **OR** siphon-jet design with floor, **as directed**, outlet and contoured seat.
 - i. Seat Surface: SSINA No. 7 polished finish.
 - ii. Punching: Provide two holes for installation of separate toilet seat.
 - iii. Drain: NPS 4 (DN 100) **OR** NPS 3 (DN 80), **as directed**, horizontal with cleanout and slip joint **OR** vertical, **as directed**.
 - b) Toilet Seat: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
 - c) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 2) Lavatory: In top of cabinet.
 - a) Receptor: Oval **OR** Rectangular, **as directed**, bowl with integral soap depression.
 - b) Hot- and Cold-Water and Bubbler, **as directed**, Supply Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with push-button actuation and individual check stop.
 - c) Filler Spout: Backsplash **OR** Deck, **as directed**, mounted.
 - d) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2 **OR** concealed waste piping to spill into water-closet bowl, **as directed**.
 - e) Toothbrush Holders: One on each **OR** left **OR** right, **as directed**, side of backsplash.
 - f) Towel Hooks: One **OR** Two, **as directed**, on each **OR** left **OR** right, **as directed**, side of fixture.
 - g) Bubbler Location: On backsplash **OR** deck, **as directed**.
 - 3) Cabinet Configuration: Rectangular apron **OR** Five-sided apron with two angled sides **OR** Four-sided apron with angled left side **OR** Four-sided apron with angled right side, **as directed**, made for above-floor **OR** on-floor, **as directed**, installation and with backsplash.
 - a) Water-Closet Bowl Location: Centered on front **OR** Left of center on front **OR** Right of center on front **OR** On angled left side **OR** On angled right side, **as directed**, of apron.
 - b) Toilet Paper Holder: Recessed, 0.063-inch (1.6-mm) minimum thickness, stainless steel complying with ASTM A 666, Type 304 and located above water closet and centered in front **OR** in front **OR** right of center in front **OR** left of center in front **OR** in angled right side **OR** in angled left side **OR** in right side **OR** in left side, **as directed**, of apron.



- 4) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support entire fixture. Include steel bars or other design that will prevent escape if fixture is removed.

B. Drinking Fountains

1. Security Drinking Fountains, Back-Mounting:
 - a. Description: Back-mounting, accessible, **as directed**, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Receptor: Bowl or depression in top and with backsplash.
 - 2) Bubbler Location: On backsplash **OR** deck, **as directed**.
 - 3) Bubbler Water-Supply Valve: Pneumatic type with push-button actuation.
 - 4) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - 5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.
2. Security Drinking Fountains, Front-Mounting:
 - a. Description: Front-mounting, accessible, **as directed**, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Receptor: Bowl or depression in top and with backsplash.
 - 2) Bubbler Location: On backsplash **OR** deck, **as directed**.
 - 3) Bubbler Water-Supply Valve: Pneumatic type with push-button actuation.
 - 4) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum tailpiece, trap, and waste, and complying with ASME A112.18.2.
 - 5) Access to Internal Components: Vandal-resistant access panels.
 - 6) Mounting Device: Wall bracket.
 - 7) Support: Chair carrier. Refer to "Fixture Supports" Article.

C. Lavatories

1. Security Lavatories, Back-Mounting:
 - a. Description: Back-mounting, accessible, **as directed**, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Receptor: Oval **OR** Rectangular, **as directed**, bowl with integral soap depression and backsplash.
 - 2) Hot- and Cold-Water and Bubbler, **as directed**, Supply Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with push-button actuation and individual check stop.
 - 3) Filler Spout: Backsplash **OR** Deck, **as directed**, mounted.
 - 4) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - 5) Toothbrush Holders: One on each **OR** left **OR** right, **as directed**, side of backsplash.
 - 6) Towel Hooks: One **OR** Two, **as directed**, on each **OR** left **OR** right, **as directed**, side of fixture.
 - 7) Bubbler Location: On backsplash **OR** deck, **as directed**.
 - 8) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.
2. Security Lavatories, Front-Mounting:
 - a. Description: Front-mounting, accessible, **as directed**, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness,



ASTM A 666, Type 304, stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.

- 1) Receptor: Oval **OR** Rectangular, **as directed**, bowl with integral soap depression and backsplash.
 - 2) Hot- and Cold-Water and Bubbler, **as directed**, Supply Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with push-button actuation and individual check stop.
 - 3) Filler Spout: Backsplash **OR** Deck, **as directed**, mounted.
 - 4) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum tailpiece, trap, and waste complying with ASME A112.18.2.
 - 5) Toothbrush Holders: One on each **OR** left **OR** right, **as directed**, side of backsplash.
 - 6) Towel Hooks: One **OR** Two, **as directed**, on each **OR** left **OR** right, **as directed**, side of fixture.
 - 7) Bubbler Location: On backsplash **OR** deck, **as directed**.
 - 8) Access to Internal Components: Vandal-resistant access panels.
 - 9) Mounting Device: Wall bracket.
 - 10) Support: Chair carrier. Refer to "Fixture Supports" Article.
3. Security Lavatories, Vitreous-China:
- a. Description: ASME A112.19.2M, vitreous-china security plumbing fixture made for institutional applications, with integral soap depression and NPS 1-1/4 (DN 32) waste outlet and with factory-installed, push-button, self-closing, chrome-plated brass faucets complying with ASME A112.18.1.
 - 1) Waste: NPS 1-1/4 (DN 32) minimum piping and trap complying with ASME A112.18.2.
 - 2) Mounting Device: Wall bracket.
 - 3) Support: Chair carrier. Refer to "Fixture Supports" Article.

D. Service Sinks

1. Security Service Sinks:
 - a. Description: Back-mounting security plumbing fixture made for above-floor **OR** on-floor, **as directed**, installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Receptor: Rectangular bowl with high backsplash.
 - 2) Hot- and Cold-Water-Supply Valves: Pneumatic type with push-button actuation and individual check stop.
 - 3) Filler Spout: Backsplash mounted.
 - 4) Drain: Grid with NPS 2 (DN 50) waste and trap complying with ASME A112.18.2.
 - 5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

E. Shampoo Bowls

1. Security Shampoo Bowls:
 - a. Description: Front-mounting security plumbing fixture made for above-floor **OR** counter-mounting, **as directed**, installation; fabricated from 0.078-inch (2.0-mm) thickness, ASTM A 666, Type 304 stainless steel and corrosion-resistant metal internal piping and bracing.
 - 1) Receptor: Bowl with contoured neck rest.
 - 2) Finish: White **OR** Black, **as directed**, enamel.
 - 3) Exposed Surfaces without Enamel Finish: SSINA No. 4 polished finish.
 - 4) Faucet: Dial single-lever control with vacuum breaker, hose, and spray.
 - 5) Drain: Basket strainer with NPS 1-1/2 (DN 40) tailpiece, trap, and waste to wall complying with ASME A112.18.2.



- 6) Access to Internal Components: Vandal-resistant access panels.
- 7) Mounting Device: Wall bracket.
- 8) Support: Chair carrier. Refer to "Fixture Supports" Article.

F. Showers

1. Security Showers, Back-Mounting, Recessed:
 - a. Description: Back-mounting, accessible, **as directed**, recessed security plumbing fixture made with wall plate for flush installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Wall type with shower head and soap dish.
 - 2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stop.
 - 3) Shower: Hose with vandal-resistant, hand-held **OR** Vandal-resistant, fixed-type **OR** Vandal-resistant, swivel-type, **as directed**, head.
 - 4) Soap Dish: Recessed, stainless steel.
 - 5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.
2. Security Showers, Front-Mounting, Recessed:
 - a. Description: Front-mounting, accessible, **as directed**, recessed security plumbing fixture made with wall plate for flush installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Wall type with shower head and soap dish.
 - 2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stop.
 - 3) Shower: Hose with vandal-resistant, hand-held **OR** Vandal-resistant, fixed-type **OR** Vandal-resistant, swivel-type, **as directed**, head.
 - 4) Soap Dish: Recessed, stainless steel.
 - 5) Access to Internal Components: Vandal-resistant access panels.
 - 6) Mounting Device: Wall-mounting frame.
3. Security Showers, Front-Mounting, Surface Installation:
 - a. Description: Front-mounting, accessible, **as directed**, security plumbing fixture made for surface installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Wall type with shower head and soap dish.
 - 2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stops.
 - 3) Soap Dish: Recessed, stainless steel.
 - 4) Access to Internal Components: Vandal-resistant access panels.
 - 5) Mounting Device: Wall-mounting frame.
4. Security Showers, Back-Mounting, Accessible:
 - a. Description: Back-mounting, accessible, cabinet, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Cabinet 42 or 44 by 36 inches (1065 or 1120 by 915 mm) **OR** 48 by 36 inches (1220 by 915 mm), **as directed**, with floor and top, **as directed**, with stainless-steel soap dish, towel hook, drain, seat, and grab bar.



- 2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stops.
- 3) Shower: Hose with vandal-resistant, hand-held head.
- 4) Drain: NPS 2 (DN 50) strainer, waste to wall, and trap complying with ASME A112.18.2.
- 5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

5. Security Showers, Back-Mounting:

- a. Description: Back-mounting, cabinet, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Cabinet 30 by 30 inches (760 by 760 mm) **OR** 32 by 32 inches (815 by 815 mm) **OR** 36 by 36 inches (915 by 915 mm), **as directed**, with floor and top, **as directed**, and with stainless-steel soap dish, towel hook, and drain.
 - 2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stops.
 - 3) Shower: Vandal-resistant, fixed **OR** Fixed **OR** Swivel, **as directed**,-type head.
 - 4) Drain: NPS 2 (DN 50) strainer, waste to wall, and trap complying with ASME A112.18.2.
 - 5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

G. Urinals

1. Security Urinals, Back-Mounting:

- a. Description: Back-mounting security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Type and Configuration: Blowout **OR** Washout, **as directed**, type with back inlet and extended shields.
OR
Type and Configuration: Washout, trough type, and 36 inches (915 mm) **OR** 48 inches (1220 mm), **as directed**, wide.
 - 2) Drain: Strainer with NPS 2 (DN 50) tailpiece, trap under fixture, and drain piping.
 - 3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.5-gal./flush (5.7-L/flush) **OR** 1.0-gal./flush (3.78-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 4) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

2. Security Urinals, Front-Mounting:

- a. Description: Front-mounting security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Type and Configuration: Blowout **OR** Washout, **as directed**, type with back **OR** top, **as directed**, inlet and extended shields.
OR
Type and Configuration: Washout, trough type, and 36 inches (915 mm) **OR** 48 inches (1220 mm), **as directed**, wide.
 - 2) Drain: Strainer with NPS 2 (DN 50) tailpiece, trap under fixture, and drain piping complying with ASME A112.18.2.



- 3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.5-gal./flush (5.7-L/flush) **OR** 1.0-gal./flush (3.78-L/flush), **as directed** consumption. Refer to "Flushometer Valves" Article.
 - 4) Support: Chair carrier. Refer to "Fixture Supports" Article.
 3. Security Urinals, Back-Mounting, Wall-And-Floor Installation:
 - a. Description: Back-mounting security plumbing fixture made for wall-and-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Type and Configuration: Washout, stall type with back inlet.
 - 2) Drain: Strainer with NPS 2 (DN 50) outlet.
 - 3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 1.5-gal./flush (5.7-L/flush) **OR** 1.0-gal./flush (3.78-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 4. Security Urinals, Front-Mounting, Wall-And-Floor Installation:
 - a. Description: Front-mounting security plumbing fixture made for wall-and-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Type and Configuration: Washout, stall type with back **OR** top, **as directed**, inlet.
 - 2) Drain: Strainer with NPS 2 (DN 50) outlet.
 - 3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 1.5-gal./flush (5.7-L/flush) **OR** 1.0-gal./flush (3.78-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 4) Support: Chair carrier. Refer to "Fixture Supports" Article.
- H. Water Closets
1. Security Water Closets, Back-Mounting, Above Floor Installation:
 - a. Description: IAPMO PS 61, back-mounting, accessible, **as directed**, security plumbing fixture made for above-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Compact design, with bowl on wall flange.
 - 2) Bowl: Elongated, with back inlet, integral trap, blowout design with back outlet and contoured seat.
 - a) Seat Surface: SSINA No. 7 polished finish.
 - b) Punching: Provide two holes for installation of separate toilet seat.
 - c) Drain: NPS 4 (DN 100) **OR** NPS 3 (DN 80), **as directed**, horizontal with cleanout and slip joint.
 - 3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 4) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
 - 5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture. Include steel bars or other design that will prevent escape if fixture is removed.
 2. Security Water Closets, Back-Mounting, Off Floor Installation:
 - a. Description: IAPMO PS 61, back-mounting, accessible, **as directed**, security plumbing fixture made for off-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR**



- 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
- 1) Configuration: Standard design.
 - 2) Bowl: Elongated, with back **OR** top, **as directed**, inlet, integral trap, blowout **OR** siphon-jet, **as directed**, design with back outlet and contoured seat.
 - a) Seat Surface: SSINA No. 7 polished finish.
 - b) Punching: Provide two holes for installation of separate toilet seat.
 - c) Drain: NPS 4 (DN 100) **OR** NPS 3 (DN 80), **as directed**, horizontal with cleanout and slip joint.
 - 3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 4) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
 - 5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture. Include steel bars or other design that will prevent escape if fixture is removed.
3. Security Water Closets, Front-Mounting, Off-Floor Installation:
- a. Description: IAPMO PS 61, front-mounting, accessible, **as directed**, security plumbing fixture made for off-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Standard design.
 - 2) Bowl: Elongated, with back **OR** top, **as directed**, inlet, integral trap, blowout **OR** siphon-jet, **as directed**, design with back outlet and contoured seat.
 - a) Seat Surface: SSINA No. 7 polished finish.
 - b) Punching: Provide two holes for installation of separate toilet seat.
 - 3) Access to Internal Components: Vandal-resistant access panels.
 - 4) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 5) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
 - 6) Support: Combination support and waste fitting assembly. Refer to "Fixture Supports" Article.
4. Security Water Closets, Back-Mounting, On-Floor Installation:
- a. Description: IAPMO PS 61, back-mounting security plumbing fixture made for on-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4, polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Standard design.
 - 2) Bowl: Elongated, with back **OR** top, **as directed**, inlet, integral trap, blowout **OR** siphon-jet, **as directed**, design with back outlet and contoured seat.
 - a) Seat Surface: SSINA No. 7 polished finish.
 - b) Punching: Provide two holes for installation of separate toilet seat.
 - c) Drain: NPS 4 (DN 100) **OR** NPS 3 (DN 80), **as directed**, horizontal with cleanout and slip joint.



- 3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 4) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
5. Security Water Closets, Front-Mounting, On-Floor Installation:
- a. Description: IAPMO PS 61, front-mounting security plumbing fixture made for on-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
 - 1) Configuration: Standard design.
 - 2) Bowl: Elongated, with back **OR** top, **as directed**, inlet, integral trap, siphon-jet design with back **OR** floor, **as directed**, outlet and contoured seat.
 - a) Seat Surface: SSINA No. 7 polished finish.
 - b) Punching: Provide two holes for installation of separate toilet seat.
 - 3) Access to Internal Components: Vandal-resistant access panels.
 - 4) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 5) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
 - 6) Support: Combination support and waste fitting assembly. Refer to "Fixture Supports" Article.
6. Security Water Closets, Vitreous-China, Wall-Mounting, On-Floor Installation
- a. Description: ASME A112.19.2M, vitreous-china, wall-mounting and on-floor installation, back-inlet, blowout **OR** siphon-jet, **as directed**, fixture with integral contoured seat and made for institutional applications.
 - 1) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
 - 2) Support: Combination support and waste fitting assembly. Refer to "Fixture Supports" Article.
7. Security Water Closets, Vitreous-China, Wall-Mounting:
- a. Description: ASME A112.19.2M, vitreous-china, accessible, **as directed**, wall-mounting, back-inlet, blowout fixture with integral contoured seat and made for institutional applications.
 - 1) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 3.5-gal./flush (13.3-L/flush) consumption. Refer to "Flushometer Valves" Article.
 - 2) Support: Combination support and waste fitting assembly. Refer to "Fixture Supports" Article.
- I. Flushometer Valves
1. Flushing Devices for Vitreous-China Water Closets:
 - a. Description: Flushometer valves, trim, and components complying with ASSE 1037. Include brass body, check-stop inlet, diaphragm operation, vacuum breaker, tailpiece, chrome-plated finish on exposed components, and non-hold-open feature on oscillating lever-handle trip mechanism. See fixture type for consumption.
- J. Fixture Supports
1. Back-mounting fixtures are installed on wall sleeves. Front-mounting and wall-mounting fixtures are installed on supports specified herein.



2. Off-Floor, Plumbing Fixture Supports:
 - a. Description: ASME A112.6.1M carriers with dimensions and trim matching fixture.
 - 1) Stainless-Steel, Front-Mounting Fixtures: With modifications.
 - a) Drinking Fountains: Type I drinking fountain carrier.
 - b) Lavatories: Type III lavatory carrier.
 - c) Shampoo Bowls: Type II sink carrier.
 - d) Urinals: Type I urinal carrier with inlet seal unless Type II is required.
 - e) Water Closets: Combination support and waste fitting assembly.
 - 2) Vitreous-China, Wall-Mounting Fixtures:
 - a) Lavatories: Type III lavatory carrier.
 - b) Water Closets: Combination support and waste fitting assembly.
 - 3) Carriers: With vertical steel uprights with feet. Include tie rods, bearing plates, and mounting studs matching fixture to be supported.
 - 4) Combination Support and Waste Fitting Assemblies: With feet and inlet seal.
 - 5) Carriers for Accessible Fixtures: Include rectangular, vertical steel uprights instead of steel pipe uprights.

1.3 EXECUTION

A. Security Plumbing Fixture Installation

1. Install back-mounting-type, stainless-steel security plumbing fixtures as follows:
 - a. Install wall sleeve in wall.
 - b. Install fixture on wall sleeve; mount components on or attached to wall sleeve with access from accessible service space.
 - c. Extend supply piping from service space to fixture.
 - d. Install soil and waste piping from fixture and extend into service space.
 - e. Install fixture trap in service space instead of below fixture drain.
2. Install front-mounting-type, stainless-steel security plumbing fixtures as follows:
 - a. Install fixture support or mounting bracket.
 - b. Install fixture on support; mount components inside of or attached to fixture.
 - c. Extend supply piping from pipe space to fixture.
 - d. Install trap below fixture and extend soil and waste piping into pipe space.
3. Install vitreous-china security plumbing fixtures onto accessible service space as follows:
 - a. Install fixture support in service space.
 - 1) Use combination support and waste fitting assembly for water closet.
 - 2) Use chair carriers for lavatory.
 - b. Install fixture on support.
 - c. Install components in service space.
4. Install vitreous-china security plumbing fixtures onto accessible pipe space as follows:
 - a. Install fixture support in pipe space.
 - 1) Use combination support and waste fitting assembly for water closet.
 - 2) Use carrier support for lavatory.
 - b. Install fixture on support.
 - c. Install components in pipe space with access panels. See Division 08 Section "Access Doors And Frames" for access panels not in this Section.
5. Install security plumbing fixture outlets with gasket seals.
6. Install fixtures designated "accessible" according to ICC A117.1 for heights, dimensions, and clearances.
7. Install fixtures level and plumb.
8. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".



9. Install dielectric fittings in water-supply piping to fixtures if piping and fixture connections are made of different metals. See Division 22 Section "Common Work Results For Plumbing" for dielectric fittings.
 10. Install toilet seats on water closets and combination units if seats are indicated.
- B. Connections
1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Connect hot- and cold-water supply piping to security plumbing fixtures. Include supply stops, if specified, or ball valve on each supply. Ball valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
 3. Connect soil and waste piping to security plumbing fixtures.
 4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 5. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
 - a. Testing: After installing security plumbing fixtures and after electrical circuitry has been energized, test for compliance with requirements.
 - b. Remove and replace malfunctioning security plumbing fixtures. Retest as specified above after repairs or replacements are made.
- D. Adjusting
1. Operate and adjust water-supply flushometers and flow-control valves on security plumbing fixtures.
- E. Cleaning
1. Clean security plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 - a. Remove faucet spouts and strainers, remove sediment and debris, and reinstall spouts and strainers.
 - b. Remove sediment and debris from drains.
 2. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.
- F. Protection
1. Provide protective covering for installed security plumbing fixtures and fittings.
 2. Do not allow use of security plumbing fixtures for temporary facilities unless approved in writing by the Owner.

END OF SECTION 22 46 13 00



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Task	Specification	Specification Description
22 46 16 00	22 46 13 00	Security Plumbing Fixtures
22 46 19 00	22 46 13 00	Security Plumbing Fixtures
22 46 56 00	22 46 13 00	Security Plumbing Fixtures



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**SECTION 22 47 13 00 - DRINKING FOUNTAINS AND WATER COOLERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for drinking fountains and water coolers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Style F, freestanding drinking fountains.
 - b. Style W, wall-mounting drinking fountains.
 - c. Type PB, pressure with bubbler, Style F, freestanding water coolers.
 - d. Type PB, pressure with bubbler, Style W, wall-mounting water coolers.
 - e. Fixture supports.

C. Definitions

1. Accessible Drinking Fountain or Water Cooler: Fixture that can be approached and used by people with disabilities.
2. Cast Polymer: Dense, cast-filled-polymer plastic.
3. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.
4. Fitting: Device that controls flow of water into or out of fixture.
5. Fixture: Drinking fountain or water cooler unless one is specifically indicated.
6. Remote Water Cooler: Electrically powered equipment for generating cooled drinking water.
7. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.
3. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
4. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.
5. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.
6. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants" for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.



1.2 PRODUCTS

A. Drinking Fountains

1. Description: Accessible, Style F, freestanding drinking fountain.
 - a. Pedestal:
 - 1) Material: Concrete **OR** Painted cast iron or steel, **as directed**.
 - 2) Shape: Rectangular **OR** Round, **as directed**, with offset to receptor **OR** with side receptor(s), **as directed**.
 - b. Receptor(s):
 - 1) Number: One **OR** Two **OR** Three, **as directed**.
 - 2) Material: Bronze **OR** Chrome-plated brass or stainless steel, **as directed**.
 - 3) Shape: Rectangular **OR** Round **OR** Rounded front, **as directed**.
 - 4) Bubbler: One for each receptor, with adjustable stream regulator, located on deck.
 - c. Controls: Foot pedal **OR** Push bar **OR** Push button, **as directed**, with adjustable stream regulator.
 - d. Access to Internal Components: Panel in pedestal.
 - e. Supply: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, with ball, gate, or globe valve.
 - f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2 **OR** waste to drainage system, **as directed**.
2. Description: Accessible, Style F, antifreeze, freestanding drinking fountain designed to operate without draining into ground.
 - a. Pedestal: Rectangular, painted cast iron or steel.
 - b. Receptor: Rectangular, chrome-plated brass or stainless steel with bubbler.
 - c. Control: Foot pedal with control valve assembly.
 - d. Supply: NPS 1/2 (DN 15) with underground shutoff and flow-control valve assembly.
 - e. Drain: Grid with NPS 1 (DN 25) **OR** NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, minimum waste to drainage system.
 - f. Bury Depth, Grade to Valve Components: 36 inches (915 mm) **OR** 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**.
3. Description: Accessible, Style W, wall-mounting drinking fountain.
 - a. Material: Bronze **OR** Metal **OR** Cast polymer **OR** Stainless steel **OR** Vitreous china complying with ASME 112.19.2M for drinking fountains with backsplash, **as directed**.
 - b. Receptor Shape: Rectangular **OR** Round **OR** Rounded front, **as directed**.
 - c. Back Panel: Stainless-steel wall plate behind drinking fountain.
 - d. Bubblers: One **OR** Two **OR** Three, **as directed**, with adjustable stream regulator, located on deck.
 - e. Control: Push button **OR** Push bar, **as directed**.
 - f. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - g. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - h. Support: Type I, water cooler carrier. Refer to "Fixture Supports" Article.
4. Description: Accessible, Style WS, wall-mounting, semirecessed drinking fountain.
 - a. Material: Stainless steel **OR** Bronze **OR** Vitreous china complying with ASME A112.19.2M for semirecessed drinking fountains, **as directed**.
 - b. Receptor Shape: Concave with projecting bowl.
 - c. Bubbler: One, with adjustable stream regulator, located on deck.
 - d. Control: Push button **OR** Push bar, **as directed**.
 - e. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - f. Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - g. Support: Mounting frame or brackets for attaching to substrate.
5. Description: Style RE, stainless-steel, recessed drinking fountain.
 - a. Receptor Shape: Concave with flush wall flange.
 - b. Bubbler: One, with adjustable stream regulator, located on deck.



- c. Control: Push button **OR** bar, **as directed**.
 - d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - e. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - f. Support: Mounting frame or brackets for attaching to substrate.
- B. Water Coolers
- 1. Description: ARI 1010, Type PB, pressure with bubbler, Style F, freestanding or Style FW, flush-to-wall water cooler.
 - a. Cabinet: All stainless steel **OR** Steel with powder-coat-finish **OR** Vinyl-covered steel with stainless-steel top, **as directed**.
 - b. Bubbler: One, with adjustable stream regulator, located on deck.
 - c. Control: Push button **OR** Foot pedal, **as directed**.
 - d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - g. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - 1) Capacity: 5 gph (0.0053 L/s) **OR** 8 gph (0.0084 L/s) **OR** 10 gph (0.0105 L/s) **OR** 14 gph (0.0147 L/s), **as directed**, of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
 - 2) Electrical Characteristics: 1/6 **OR** 1/5 **OR** 1/4, **as directed**, hp; 120-V ac; single phase; 60 Hz.
 - 2. Description: ARI 1010, Type PBC, pressure with bubbler and compartment, Style F, freestanding water cooler.
 - a. Cabinet: All stainless steel **OR** Vinyl-covered steel with stainless-steel top, **as directed**, with refrigerated compartment in front panel.
 - b. Bubbler: One, with adjustable stream regulator, located on deck.
 - c. Control: Push button.
 - d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - g. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - 1) Capacity: 3 gph (0.0032 L/s) of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
 - 2) Electrical Characteristics: 1/8 hp; 120-V ac; single phase; 60 Hz.
 - 3. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style W, wall-mounting water cooler for adult **OR** child, **as directed**, -mounting height.
 - a. Cabinet: Single **OR** Bilevel with two attached cabinets **OR** Bilevel with two attached cabinets and with bilevel skirt kit, **as directed**, all stainless steel **OR** vinyl-covered steel with stainless-steel top, **as directed**.
 - b. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
 - c. Control: Push button **OR** Push bar, **as directed**.
 - d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - f. Drain(s): Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.1.



- g. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - 1) Capacity: 5 gph (0.0053 L/s) **OR** 8 gph (0.0084 L/s), **as directed**, of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
 - 2) Electrical Characteristics: 1/6 **OR** 1/5 **OR** 1/4 **OR** 1/3, **as directed**, hp; 120-V ac; single phase; 60 Hz.
 - h. Support: Type I **OR** II, **as directed**, water cooler carrier. Refer to "Fixture Supports" Article.
4. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style WS, semirecessed water cooler.
- a. Cabinet: All stainless steel **OR** Vinyl-covered steel with stainless-steel top, **as directed**.
 - b. Bubbler: One, with adjustable stream regulator, located on deck.
 - c. Control: Push button **OR** Push bar, **as directed**.
 - d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - g. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - 1) Capacity: 8 gph (0.0084 L/s) **OR** 12 gph (0.0126 L/s), **as directed**, of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
 - 2) Electrical Characteristics: 1/6 **OR** 1/5, **as directed**, hp; 120-V ac; single phase; 60 Hz.
 - h. Support: Mounting frame or brackets for attaching to substrate.
5. Description: ARI 1010, Type PB, pressure with bubbler, Style RE, recessed water cooler.
- a. Cabinet: All stainless steel.
 - b. Bubbler: One, with adjustable stream regulator, located on deck.
 - c. Control: Push button **OR** bar, **as directed**.
 - d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
 - g. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - 1) Capacity: 8 gph (0.0084 L/s) **OR** 12 gph (0.0126 L/s), **as directed**, of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
 - 2) Electrical Characteristics: 1/6 **OR** 1/5, **as directed**, hp; 120-V ac; single phase; 60 Hz.
 - h. Ventilation Grille: Stainless steel, located above **OR** below, **as directed**, fountain.
 - i. Support: Mounting frame for attaching to substrate.

C. Water Station Water Coolers

- 1. Description: Water-station configuration, freestanding, cabinet water cooler with top-mounting glass fillers.
 - a. Cabinet: All stainless steel **OR** Enameled-steel panels with stainless-steel top, **as directed**, 0.05 inch (1.3 mm) thick; and 32 inches (813 mm) **OR** 36 inches (915 mm), **as directed**, high.



- b. Receptors: Two **OR** Four, **as directed**, stainless-steel bowls, with grid drain and bottom outlet in top; with two facing front and two facing back.
 - c. Glass Fillers: Two **OR** Four, **as directed**, push-back type **OR** pedestal type, **as directed**, on top, over receptors.
 - d. Tray Slides: One on front and one on back, stainless steel.
 - e. Supply: NPS 1/2 (DN 15) with ball, gate, or globe valve, and connected to filter, chiller, and each glass filler.
 - f. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - g. Drain: Waste piping from each receptor connected to NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, trap and waste to wall **OR** indirect waste to floor receptor, **as directed**, complying with ASME A112.18.2.
 - h. Cooling System: Electric, complying with ARI 1010, for Type R remote water coolers.
 - 1) Chassis: Galvanized or corrosion-resistant-coated steel.
 - 2) Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
 - 3) Storage Tank: 2 gal. (7.6 L) **OR** 4 gal. (15.1 L) **OR** 6 gal. (22.7 L) **OR** 14 gal. (53 L) **OR** 25 gal. (95 L), **as directed**, stainless steel.
 - 4) Controls: Adjustable thermostat.
 - 5) One-Hour Peak Capacity Rate: 8 gph (0.0084 L/s) **OR** 12 gph (0.0126 L/s) **OR** 18 gph (0.0189 L/s) **OR** 29 gph (0.0305 L/s) **OR** 50 gph (0.0526 L/s), **as directed**, of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
 - 6) Electrical Characteristics: 1/5 **OR** 1/4 **OR** 1/3 **OR** 1/2 **OR** 3/4, **as directed**, hp; 120 **OR** 240 **OR** 277 **OR** 480, **as directed**,-V ac; single phase; 60 Hz.
2. Description: Water-station configuration, freestanding, cabinet water cooler with front-mounting glass fillers.
- a. Cabinet: All stainless steel **OR** Enameled-steel panels with stainless-steel top, **as directed**, 0.05 inch (1.3 mm) thick; and 42 inches (1067 mm) **OR** 48 inches (1219 mm), **as directed**, high.
 - b. Receptors: One **OR** Two, **as directed**, stainless-steel tray(s), with antisplash design, drain, and bottom outlet, in vertical panel(s), with one facing front and one facing back.
 - c. Glass Fillers: Two **OR** Four, **as directed**, push-back type, on vertical panel(s), over receptor(s).
 - d. Shelves: One **OR** Two, **as directed**, stainless steel, on each side panel.
 - e. Supply: NPS 1/2 (DN 15) with ball, gate, or globe valve, and connected to filter, chiller, and each glass filler.
 - f. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - g. Drain: NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, trap and waste to wall **OR** indirect waste to floor receptor, **as directed**, complying with ASME A112.18.2.
 - h. Cooling System: Electric, complying with ARI 1010, for Type R remote water coolers.
 - 1) Chassis: Galvanized or corrosion-resistant-coated steel.
 - 2) Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
 - 3) Storage Tank: 6 gal. (22.7 L) **OR** 14 gal. (53 L) **OR** 25 gal. (95 L) **OR** 30 gal. (113.6 L) **OR** 40 gal. (151.4 L), **as directed**, stainless steel.
 - 4) Controls: Adjustable thermostat.
 - 5) One-Hour Peak Capacity Rate: 18 gph (0.0189 L/s) **OR** 29 gph (0.0305 L/s) **OR** 50 gph (0.0526 L/s) **OR** 65 gph (0.0684 L/s) **OR** 85 gph (0.0894 L/s), **as directed**, of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
 - 6) Electrical Characteristics: 1/3 **OR** 1/2 **OR** 3/4 **OR** 1 **OR** 1-1/2, **as directed**, hp; 120 **OR** 240 **OR** 277 **OR** 480, **as directed**,-V ac; single phase; 60 Hz.

D. Remote Water Coolers



1. Description: ARI 1010, Style R, remote chiller equipment for installation separate from drinking fountains. Include filter, reverse-osmosis system and ultra-violet-disinfection equipment, **as directed**.
 - a. Cooling System: Electric.
 - 1) Chassis: Galvanized or corrosion-resistant-coated steel.
 - 2) Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
 - 3) Storage Tank: 0.5 gal. (1.9 L) **OR** 4 gal. (15.1 L), **as directed**, stainless steel.
 - 4) Controls: Adjustable thermostat.
 - 5) Capacity: 5 gph (0.0053 L/s) **OR** 8 gph (0.0084 L/s) **OR** 14 gph (0.0147 L/s), **as directed**, of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
 - 6) Electrical Characteristics: 1/5 **OR** 1/4 **OR** 1/3, **as directed**, hp; 120 **OR** 240 **OR** 277 **OR** 480, **as directed**,-V ac; single phase; 60 Hz.
 - b. Ventilation Grille: Stainless steel.
 - c. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
- E. Fixture Supports
1. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
 - a. Type I: Hanger-type carrier with two vertical uprights.
 - b. Type II: Bilevel, hanger-type carrier with three vertical uprights.
 - c. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

1.3 EXECUTION

A. Applications

1. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.
2. Use mounting frames for recessed water coolers, unless otherwise indicated.
3. Set freestanding and pedestal drinking fountains on floor.
4. Set remote water coolers on floor, unless otherwise indicated.
5. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

B. Installation

1. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.
2. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.
3. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.
4. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-duty Valves For Plumbing Piping".
5. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
6. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Common Work Results For Plumbing".



7. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants".
- C. Connections
1. Connect fixtures with water supplies, traps, and risers, and with soil, waste, and vent piping. Use size fittings required to match fixtures.
 2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- D. Field Quality Control
1. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
 - a. Remove and replace malfunctioning units and retest as specified above.
 - b. Report test results in writing.
- E. Adjusting
1. Adjust fixture flow regulators for proper flow and stream height.
 2. Adjust water cooler temperature settings.

END OF SECTION 22 47 13 00



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Task	Specification	Specification Description
22 47 16 00	01 22 16 00	No Specification Required
22 47 16 00	22 01 40 81	Plumbing Fixtures
22 47 16 00	22 01 40 81a	Emergency Plumbing Fixtures
22 47 16 00	22 47 13 00	Drinking Fountains And Water Coolers
22 47 23 00	22 47 13 00	Drinking Fountains And Water Coolers
22 47 26 00	22 01 40 81	Plumbing Fixtures
22 51 13 00	01 22 16 00	No Specification Required
22 51 19 00	01 22 16 00	No Specification Required
22 66 53 00	07 63 00 00	Common Work Results for Fire Suppression
22 66 53 00	07 63 00 00a	Common Work Results for Plumbing
22 66 53 00	07 63 00 00b	Common Work Results for HVAC
22 66 53 00	22 11 16 00a	Sanitary Waste And Vent Piping
22 66 53 00	22 11 16 00f	General-Service Compressed-Air Piping



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**SECTION 22 66 83 16 - CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for chemical-waste systems for laboratory and healthcare facilities. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

C. Summary

1. Section Includes:
 - a. Single-wall piping.
 - b. Double-containment piping.
 - c. Field-fabrication containment piping.
 - d. Piping specialties.
 - e. Neutralization tanks.
 - f. Neutralization systems.
 - g. Manholes.
 - h. Leak-detection systems.

D. Definitions

1. CR: Chlorosulfonated polyethylene synthetic rubber.
2. FPM: Vinylidene fluoride-hexafluoro propylene copolymer rubber.

E. Performance Requirements

1. Single-Wall Piping Pressure Rating: 10 feet head of water (30 kPa).
2. Double-Containment Piping Pressure Rating:
 - a. Carrier Piping: 5-psig (34.5-kPa) air test pressure.
 - b. Containment Piping: 5-psig (34.5-kPa) air test pressure.
3. Field-Fabrication Containment-Piping Pressure Rating: 5-psig (34.5-kPa) air test pressure.
4. Delegated Design: Design seismic restraints for aboveground piping, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings: For neutralization system and leak-detection system. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail neutralization-system assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Detail leak-detection-system assemblies and indicate required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For seismic restraints of aboveground piping, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Profile Drawings for Outdoor Underground Piping: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not



less than 1 inch equals 5 feet (1:50). Indicate underground structures and pipes. Show types, sizes, materials, and elevations of other utilities crossing system piping.

6. Field quality-control test reports.
7. Operation and Maintenance Data: For chemical-waste specialties and neutralization tanks, neutralization systems, and leak-detection systems to include in emergency, operation, and maintenance manuals.

G. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 70, "National Electrical Code."

H. Delivery, Storage, And Handling

1. Deliver and store piping and specialties with sealing plugs in ends or with end protection.
2. Do not store plastic pipe or fittings in direct sunlight.
3. Protect pipe, fittings, and seals from dirt and damage.

I. Project Conditions

1. Interruption of Existing Chemical-Waste Service: Do not interrupt chemical-waste service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary chemical-waste service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of chemical-waste service.
 - b. Do not proceed with interruption of chemical-waste service without the Owner's written permission.

1.2 PRODUCTS

A. Single-Wall Pipe And Fittings

1. PE Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin.
 - a. Pipe: ASTM F 1412, Schedule 40.
 - b. Fittings: ASTM F 1412, Schedule 40, socket-fusion, drainage pattern complying with ASTM D 3311.
2. PP Drainage Pipe and Fittings: ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM D 4101; with fusion **OR** fusion- and mechanical **OR** mechanical, **as directed**,-joint ends.
 - a. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
3. PVC Drainage Pipe and Fittings: ASTM D 2665, pipe and drainage-pattern fittings.
4. PVDF Drainage Pipe and Fittings: ASTM F 1673, Schedule 40, pipe and drainage-pattern fittings. Include fittings with fusion **OR** fusion- and mechanical **OR** mechanical, **as directed**,-joint ends.
5. Fiberglass Pipe and Fittings, Centrifugally Cast: ASTM D 2997, Type II, Grade 1 **OR** Grade 2, **as directed**, Class A **OR** Class B **OR** Class C, **as directed**, RTRP pipe; with ASTM D 5685, Type 4, RTRF fittings matching pipe; and adhesive-bonding **OR** butt-and-wrap-joint, **as directed**, materials. Include wall thickness that will provide 160-psig (1105-kPa) minimum, sustained water test pressure rating.
6. Fiberglass Pipe and Fittings, Filament Wound: ASTM D 2996, Type I, Grade 1 **OR** Grade 2, **as directed**, Class A **OR** Class B **OR** Class C **OR** Class E **OR** Class F, **as directed**, RTRP pipe; ASTM D 5685, Type 1, RTRF fittings matching pipe; and adhesive-bonding **OR** butt-and-wrap-joint, **as directed**, materials. Include wall thickness that will provide 160-psig (1105-kPa) minimum, sustained water test pressure rating.



7. High-Silicon-Iron, Hub-and-Plain-End Pipe and Fittings: ASTM A 861, pipe and drainage-pattern fittings; acid-resistant packing; and lead caulking materials.
 8. High-Silicon-Iron, Mechanical-Joint Pipe and Fittings: ASTM A 861, pipe and drainage-pattern fittings; and stainless-steel clamps with TFE inner sleeve and CR outer sleeve.
 9. Stainless-Steel Drainage Pipe and Fittings: ASME A112.3.1, ASTM A 666, Type 316L, stainless-steel pipe and drainage-pattern fittings; with socket and spigot ends for gasket joints; and having piping manufacturer's FPM lip-seal rubber gaskets shaped to fit socket groove, with plastic backup ring.
 10. Borosilicate Glass Pipe and Fittings: ASTM C 1053, pipe and drainage-pattern fittings; with manufacturer's standard couplings.
 - a. Covering: Factory-applied polystyrene for pipe installed underground.
 11. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.
- B. Double-Containment Pipe And Fittings
1. Description: Factory-fabricated, double-wall pipe and fittings. Sizes indicate carrier-pipe size; with carrier (inner) pipe and fittings; annular-space, carrier-pipe supports; containment (outer) pipe and fittings; and joining materials and fasteners. Include manufacturer's standard piping materials according to the following:
 - a. PE, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin.
 - 1) Carrier and Containment Pipes: ASTM F 1412, Schedule 40.
 - 2) Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311.
 - b. PP, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 4101, PP resin.
 - 1) Carrier and Containment Pipes: ASTM F 1412, Schedule 40.
 - 2) Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311.
 - c. PP/PVC, Double-Containment Drainage Pipe and Fittings:
 - 1) PP Carrier Pipe: ASTM F 1412, Schedule 40; made of ASTM D 4101, PP resin.
 - 2) PP Carrier-Pipe Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311; made of ASTM D 4101, PP resin.
 - 3) PVC Containment Pipe: ASTM D 2665, PVC pipe.
 - 4) PVC Containment Pipe Fittings: ASTM D 2665, PVC drainage pattern.
 - d. PVDF, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 3222, PVDF resin.
 - 1) Carrier and Containment Pipes: ASTM F 1673, Schedule 40.
 - 2) Fittings: ASTM F 1673, Schedule 40 drainage pattern complying with ASTM D 3311.
 - e. PVDF/PVC, Double-Containment Drainage Pipe and Fittings:
 - 1) PVDF Carrier Pipe: ASTM F 1673, Schedule 40; made of ASTM D 3222, PVDF resin.
 - 2) PVDF Carrier-Pipe Fittings: ASTM F 1673, Schedule 40 drainage pattern complying with ASTM D 3311; made of ASTM D 3222, PVDF resin.
 - 3) PVC Containment Pipe: ASTM D 2665, PVC pipe.
 - 4) PVC Containment Pipe Fittings: ASTM D 2665, PVC drainage pattern.
 2. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.
- C. Field-Fabrication Containment Piping
1. Description: Containment split pipe and split fittings with carrier-pipe centralizers. Include manufacturer's fastening devices and materials.
 - a. Material: HDPE **OR** PP **OR** Yellow PVC **OR** Clear PVC, **as directed**, pipe and fittings.
 - b. Fastening System: FPM gaskets, clamps, and pins.



- c. Material: Clear PVC pipe and fittings with adhesive channels, for use with drainage-pattern carrier piping.
- d. Fastening System: Adhesive.

D. Joining Materials

1. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.
2. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.
3. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.
4. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Fiberglass-Pipe Adhesive: As furnished or recommended by pipe manufacturer.
 - a. Use fiberglass adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Piping Specialties

1. Plastic Dilution Traps:
 - a. Material: Corrosion-resistant PP, with removable base.
 - b. End Connections: Mechanical joint.
 - c. Dilution Tanks: 1-gal. (3.8-L) capacity, with clear base unless colored base is indicated; with two NPS 1-1/2 (DN 40) top inlets and one NPS 1-1/2 (DN 40) side outlet.
 - d. Small Dilution Jars: 1-pint (0.5-L) capacity, with clear base unless colored base is indicated; with NPS 1-1/2 (DN 40) top inlet and NPS 1-1/2 (DN 40) side outlet.
 - e. Large Dilution Jars: 1-quart (1-L) capacity; with NPS 1-1/2 (DN 40) top inlet and NPS 1-1/2 (DN 40) side outlet.
2. High-Silicon-Iron Dilution Traps:
 - a. Standard: ASTM A 861.
 - b. Size: NPS 1-1/2 or NPS 2 (DN 40 or DN 50) as required for fixture and waste.
 - c. End Connections: Mechanical.
3. Glass, Drain-Line, Interceptor Traps:
 - a. Standard: ASTM C 1053.
 - b. Type: Drum trap.
 - c. Size: NPS 1-1/2 (DN 40), NPS 2 by NPS 1-1/2 (DN 50 by DN 40), or NPS 2 (DN 50), as required to match connecting piping.
4. Corrosion-Resistant Traps:
 - a. Type: P-trap or drum trap.
 - b. Size: NPS 1-1/2 or NPS 2 (DN 40 or DN 50), as required to match connected piping.
 - c. High-Silicon Iron: ASTM A 861, with horizontal outlet and hub-and-plain or plain ends to match connecting piping.
 - d. PP: ASTM D 4101, with mechanical-joint pipe connections.
 - e. PVDF: ASTM D 3222, with mechanical-joint pipe connections.
 - f. Glass: ASTM C 1053, with coupling pipe connections.
5. High-Silicon-Iron Floor Drains:
 - a. Standard: ASTM A 861.
 - b. Body: With integral flashing flange and weep holes; and with flashing ring and stainless-steel strip, sediment basin and funnel attachment, **as directed**.



- c. Top: 8-3/4-inch (222-mm) diameter with grate.
 - d. Size: NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150) outlet as indicated.
 6. Stainless-Steel Floor Drains:
 - a. Standard: ASME A112.3.1, ASTM A 666, Type 316L.
 - b. Body: With 8.5-by-8.5-inch (215-by-215-mm) **OR** 12.4-by-12.4-inch (315-by-315-mm), **as directed**, top with grate.
 - c. Outlet: Bottom, of size indicated.
 7. PP Floor Drains:
 - a. Body: With 7- to 9-inch (178- to 230-mm) top diameter, with flashing flange and weep holes; and with flashing clamp, basket strainer, funnel attachment, and trap-primer connection, **as directed**.
 - b. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150) outlet as indicated.
 8. High-Silicon-Iron Cleanouts:
 - a. Standard: ASTM A 861, fitting with PTFE gasket and closure plug, of design appropriate for piping application.
 9. Stainless-Steel Cleanouts:
 - a. Standard: ASME A112.3.1, ASTM A 666, Type 316L, stainless steel.
 - b. Aboveground Piping: Cleanout tee of size matching piping.
 - c. Underground and Underslab Piping: Floor access cleanout of size matching piping.
 10. High-Silicon-Iron Backwater Valves:
 - a. Standard: ASTM A 861.
 - b. Body: Hub-and-plain end with swing-check valve; and with high-silicon-iron pipe extension of length to reach floor surface, and high-silicon-iron closure plug, **as directed**.
 11. Plastic Backwater Valves:
 - a. Description: Full-port NPS 3 (DN 80) check valve, PP or PVDF, matching or compatible with system piping and compatible with system liquid, with EPDM seals and flanged ends.
 - 1) Exception: PVC material for use with PVC piping systems.
 12. High-Silicon-Iron Sink Outlets:
 - a. Standard: ASTM A 861, high-silicon iron, NPS 1-1/2 (DN 40), with clamping device and 4-, 6-, or 8-inch- (100-, 150-, or 200-mm-) high overflow fitting, as indicated.
 13. PP Sink Outlets:
 - a. Description: NPS 1-1/2 (DN 40), with clamping device, stopper, and 7-inch- (178-mm-) high overflow fitting.
 14. Glass Sink Outlets:
 - a. Standard: ASTM C 1053, components for field assembly, NPS 1-1/2 (DN 40); with sink assembly of outlet, strainer, gasket, and locknut; overflow fitting of length indicated; and tailpiece assembly of borosilicate glass and locknut.
- F. Neutralization Tanks
1. Plastic Neutralization Tanks:
 - a. Description: Corrosion-resistant plastic materials; with removable, gastight cover; interior, sidewall, dip-tube inlet; outlet; vent; and threaded or flanged, sidewall pipe connections.
 - 1) Material: HDPE **OR** ASTM D 4101, PP, **as directed**.
 - 2) Tank Capacity: as directed by the Owner.
 - 3) Dip Tube: On outlet pipe instead of inlet pipe.
 - 4) Extension: HDPE, PE, or PP.
 - 5) Traffic Cover: Light-duty **OR** Heavy-duty pedestrian or light-duty vehicular, steel plate over, **as directed**, plastic, bolted.
 - 6) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
OR



Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

2. Ceramic Neutralization Tanks:
 - a. Description: Corrosion-resistant, cast-ceramic shell; with removable, reinforced-plastic, gastight cover; inlet; interior, sidewall, dip-tube outlet; vent; and bell, sidewall pipe connections.
 - 1) Extension: Ceramic, of size and length indicated, and with cast-iron manhole frame and cover.
OR
Extension: Steel with protective coating, 28-inch (710-mm) diameter, and cast-iron manhole frame and cover.
 - 2) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
OR
Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
3. Collection Tanks: Corrosion-resistant, cast-ceramic shell. Include removable, reinforced-plastic, gastight cover; inlet; vent; and bell, sidewall pipe connections.
 - a. Extension: Ceramic **OR** Steel with protective coating, **as directed**, 28-inch (710-mm) minimum diameter, and cast-iron manhole frame and cover.

G. Neutralization Systems

1. Plastic-Tank Neutralization Systems:
 - a. Description: Automatic system for neutralizing chemical waste.
 - 1) Controls: Factory-wired and -tested, 120-V ac, to operate probes, control valves, and metering pumps and to monitor pH of effluent; with wiring and electrical-power terminals.
 - 2) Panel: NEMA 250, Type 4X enclosure, unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, but not less than the following:
 - a) Power light and on/off switch.
 - b) pH analyzer with meter and high- and low-pH indicators.
 - c) Low caustic- and acid-solution level indicators.
 - d) Alarm horn with silencer and reset switch.
 - e) Agitator running light with on/off switch.
 - f) Running lights with on/off switches for caustic- and acid-solution pumps.
 - 3) Strip chart recorder with capacity for 30-day record.
 - 4) Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.
 - 5) Interceptor Tank: Same material as mixing tank; with removable, gastight cover; and sidewall inlet and outlet piping connections.
 - 6) Neutralization Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and vent connection in sidewall or top.
 - a) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
OR
Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
 - 7) Mixing Tank: With removable, gastight cover; sidewall inlet and outlet piping connections; vent connection in sidewall or top; neutralizing-solution piping connections; and openings in top for probe and agitator.



- a) Material: HDPE **OR** ASTM D 4101, PP, **as directed**.
 - b) pH Probe: Type and length suitable for mixing-tank size.
 - c) Agitator: Electric, with stainless-steel shaft and propeller.
 - 8) Caustic-Solution Storage Tank: PP.
 - a) Caustic Chemical: Sodium hydroxide solution.
 - 9) Acid Storage Tank: PP.
 - a) Acid Chemical: Sulfuric acid solution.
 - 10) Metering Pumps: Types suitable for neutralizing solutions.
 - 11) Sampling Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and opening in top for probe.
 - a) pH probe: Type and length suitable for sampling-tank size.
2. Ceramic-Tank Neutralization Systems:
- a. Description: Automatic system for neutralizing chemical waste.
 - 1) Controls: Factory-wired and -tested, 120-V ac, to operate probes, control valves, and metering pumps and to monitor pH of effluent; with wiring and electrical-power terminals.
 - 2) Panel: NEMA 250, Type 4X enclosure, unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, including the following:
 - a) Power light and on/off switch.
 - b) pH analyzer with meter and high- and low-pH indicators.
 - c) Low caustic- and acid-solution level indicators.
 - d) Alarm horn with silencer and reset switch.
 - e) Agitator running light with on/off switch.
 - f) Running lights with on/off switches for caustic- and acid-solution pumps.
 - 3) Strip chart recorder with capacity for 30-day record.
 - 4) Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.
 - 5) Interceptor Tank: Same material as mixing tank; with removable, gastight cover; and sidewall inlet and outlet piping connections.
 - 6) Neutralization Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and vent connection in sidewall or top.
 - a) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
OR
Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
 - 7) Mixing Tank: With removable, gastight cover; sidewall inlet and outlet piping connections; vent connection in sidewall or top; neutralizing-solution piping connections; and openings in top for probe and agitator.
 - a) Material: Clay, vitrified into ceramic unit.
 - b) pH Probe: Type and length suitable for mixing tank size.
 - c) Agitator: Electric, with stainless-steel shaft and propeller.
 - 8) Caustic-Solution Storage Tank: PP.
 - a) Caustic Chemical: Sodium hydroxide solution.
 - 9) Acid Storage Tank: PP.
 - a) Acid Chemical: Sulfuric acid solution.
 - 10) Metering Pumps: Types suitable for neutralizing solutions.
 - 11) Sampling Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and opening in top for probe.
 - a) pH probe: Type and length suitable for sampling-tank size.

H. Manholes



1. Description: ASTM F 1759, fabricated from PE components. Include bottom, sidewalls, and top sections; corrosion-resistant, manhole frame and cover; fusion or other watertight joints; and design to prohibit flotation.
 - a. Construction: Single wall **OR** Double wall with interstitial space, **as directed**.
 - b. Bottom: Channeled.
 - c. Connections: Inlets and outlet matching or suitable for piping.
 - d. Steps: Manufacturer's standard, fusion welded to sidewall. Omit steps for manholes less than 60 inches (1500 mm) deep.
 - e. Top: Include 24-inch- (610-mm-) nominal-diameter frame and cover.

- I. Leak-Detection Systems
 1. Leak-Detection Systems:
 - a. Description: Cable leak-detection system capable of detecting and annunciating fluid leaks; with controls, panel, wiring, cable sensors, probes if required, and piping.
 - 1) Annunciator Panel: Enclosure with visual and audible alarms and leak location indicator.
 - 2) Sensors: Electric cable, suitable for insertion into double-containment piping annular space, with capability of detecting fluid leaks and signaling locations of leaks.

- J. Sleeves
 1. Cast-Iron Wall Pipes: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
 2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
 3. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
 4. Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, plain ends.
 5. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.

- K. Sleeve Seals
 1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

- L. Escutcheons
 1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
 3. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 4. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 5. One-Piece, Floor-Plate Escutcheons: Cast iron.
 6. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

- M. Grout
 1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.



- a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
- b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Earthwork

1. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Concrete Bases

1. Anchor neutralization tanks and neutralization system tanks to concrete bases.
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 19-inch (480-mm) centers around full perimeter of base.
 - b. For installed equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - e. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - f. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
 - g. Comply with requirements in Division 31 for cast-in-place concrete materials and placement.

C. Piping Installation

1. Chemical-Waste Sewerage Outside the Building:
 - a. Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground chemical-waste sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
 - b. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
 - c. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
 - d. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
 - e. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.
 - f. Install drainage piping pitched down in direction of flow, at minimum slope of 1 **OR** 2, **as directed**, percent, unless otherwise indicated.
 - g. Install drainage piping with 36-inch (915-mm) **OR** 48-inch (1220-mm) **OR** 60-inch (1524-mm) **OR** 72-inch (1830-mm), **as directed**, minimum cover.
 - h. Install PE drainage piping according to ASTM D 2321 and ASTM F 1668.
 - i. Install PVC drainage piping according to ASTM D 2321 and ASTM F 1668.
 - j. Install PVDF drainage piping according to ASTM D 2321 and ASTM F 1668.
 - k. Install fiberglass piping according to ASTM D 3839 and ASTM F 1668.
 - l. Install field-fabrication containment piping over new and existing carrier piping. Use containment piping manufacturer's fastening system.

Chemical-Waste Systems for Laboratory and Healthcare



- m. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.
- 2. Chemical-Waste Piping Inside the Building:
 - a. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
 - b. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
 - c. Flanges may be used on aboveground piping unless otherwise indicated.
 - d. Install underground fiberglass piping according to ASTM D 3839.
 - e. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
 - f. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
 - g. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 - h. Install piping at indicated slopes.
 - i. Install piping free of sags and bends.
 - j. Install fittings for changes in direction and branch connections.
 - k. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1) New Piping:
 - a) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b) Insulated Piping: One-piece, stamped-steel type with spring clips.
 - c) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - d) Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge **OR** One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
 - e) Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
 - f) Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
 - g) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
 - 2) Existing Piping:
 - a) Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
 - b) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
 - c) Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
 - d) Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
 - e) Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
 - f) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
 - l. Sleeves are not required for core-drilled holes.
 - m. Permanent sleeves are not required for holes formed by removable PE sleeves.
 - n. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

**OR**

Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

- 1) Cut sleeves to length for mounting flush with both surfaces.
 - a) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
- 2) Install sleeves in new walls and slabs as new walls and slabs are constructed.
- 3) Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
 - c) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
 - d) Seal space outside of sleeve fittings with grout.
- 4) Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- o. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1) Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - 2) Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
 - 3) Sleeve-Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- p. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1) Sleeve-Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- r. Verify final equipment locations for roughing-in.

D. Piping Specialty Installation

1. Embed floor drains in 4-inch (100-mm) minimum depth of concrete around bottom and sides. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for concrete.
2. Fasten grates to drains if indicated.
3. Set floor drains with tops flush with pavement surface.
4. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.



- a. Set cleanout bodies in earth in cast-in-place concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding grade. Set cleanout plugs in concrete pavement with tops flush with pavement surface. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for formwork, reinforcement, and concrete requirements.
5. Install backwater valves in horizontal position. Include riser to cleanout at grade.

E. Joint Construction

1. Chemical-Waste Sewerage Outside the Building:
 - a. Plastic-Piping, Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
 - b. Make fiberglass-piping bonded joints according to ASTM D 3839.
 - c. Make fiberglass butt-and-wrap joints according to ASTM D 3839.
 - d. Join dissimilar pipe materials with adapters compatible with pipe materials being joined.
 - e. Join high-silicon-iron, hub-and-plain-end piping with calked joints using acid-resistant packing and lead.
 - f. Join high-silicon-iron, mechanical-joint piping with coupled joints using clamps and sleeves.
 - g. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
2. Chemical-Waste Piping Inside the Building:
 - a. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
 - b. Fiberglass-Piping Joints: Make joints with piping manufacturer's bonded adhesive.
 - c. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.
 - d. Join high-silicon-iron, hub-and-plain-end piping with calked joints using acid-resistant packing and lead.
 - e. Join high-silicon-iron, mechanical-joint piping with coupled joints using clamps and sleeves.
 - f. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

F. Hanger And Support Installation

1. Pipe sizes in this article refer to aboveground, single-wall piping and carrier piping of containment piping, **as directed**.
2. Comply with requirements in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
3. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices. Install the following:
 - a. Vertical Piping: MSS Type 8 or MSS Type 42, riser clamps.
 - b. Individual, Straight, Horizontal Piping Runs:
 - 1) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - 2) Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - 3) Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.
 - c. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - d. Base of Vertical Piping: MSS Type 52, spring hangers.
4. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for installation of supports.
5. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting and coupling.
6. Support vertical piping and tubing at base and at each floor.
7. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of 3/8 inch (10 mm).
8. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 2 (DN 50): 33 inches (840 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.



- c. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
- d. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
- e. NPS 8 (DN 200): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.
9. Install supports for vertical PP piping every 72 inches (1830 mm).
10. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/4 (DN 32): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 42 inches (1067 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.
 - d. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
 - e. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
 - f. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.
11. Install supports for vertical PVC piping every 48 inches (1220 mm).
12. Install vinyl-coated hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. All Sizes: Install continuous support for piping with liquid waste at temperatures above 140 deg F (60 deg C).
 - b. NPS 1/2 (DN 15) and Smaller: 30 inches (760 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
 - d. NPS 2 (DN 50): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
 - e. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.
 - f. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
 - g. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
13. Install supports for vertical PVDF piping NPS 1-1/2 (DN 40) every 48 inches (1220 mm) and NPS 2 (DN 50) and larger every 72 inches (1830 mm).
14. Install vinyl-coated hangers for fiberglass piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 2 (DN 50) and Smaller: 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - b. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 10 feet (3 m) with 1/2-inch (13-mm) rod.
 - c. NPS 4 and NPS 5 (DN 100 and DN 125): 10 feet (3 m) with 5/8-inch (16-mm) rod.
 - d. NPS 6 (DN 150): 10 feet (3 m) with 3/4-inch (19-mm) rod.
 - e. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.6 m) with 7/8-inch (22-mm) rod.
15. Install supports for vertical fiberglass piping every 12 feet (3.6 m).
16. Install hangers for stainless-steel drainage piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - b. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
 - c. NPS 3 (DN 80): 12 feet (3.6 m) with 1/2-inch (13-mm) rod.
 - d. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.6 m) with 5/8-inch (16-mm) rod.
 - e. NPS 6 (DN 150): 12 feet (3.6 m) with 3/4-inch (19-mm) rod.
17. Install supports for vertical stainless-steel drainage piping every 15 feet (4.5 m).
18. Install hangers for high-silicon-iron piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1520 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 3 (DN 80): 60 inches (1520 mm) with 1/2-inch (13-mm) rod.
 - c. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1520 mm) with 5/8-inch (16-mm) rod.
 - d. NPS 6 (DN 150): 60 inches (1520 mm) with 3/4-inch (19-mm) rod.
 - e. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1520 mm) with 7/8-inch (22-mm) rod.
 - f. NPS 15 (DN 375): 60 inches (1520 mm) with 1-inch (25-mm) rod.
 - g. Spacing for horizontal pipe in 84-inch (2134-mm) lengths may be increased to 84 inches (2134 mm). Spacing for fittings is limited to 60 inches (1520 mm).



19. Install supports for vertical high-silicon-iron piping every 15 feet (4.5 m).
20. Install vinyl-coated hangers for glass piping with the following maximum horizontal spacing and minimum rod diameters:
 - a. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1830 mm) with 3/8-inch (10-mm) rod.
 - b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2440 mm) with 3/8-inch (10-mm) rod.
 - c. NPS 3 (DN 80): 96 inches (2440 mm) with 1/2-inch (13-mm) rod.
 - d. NPS 4 and NPS 6 (DN 100 and DN 150): 96 inches (2440 mm) with 5/8-inch (16-mm) rod.
21. Install supports for vertical glass piping every 96 inches (2440 mm).
22. Support piping and tubing not listed above according to MSS SP-69.

G. Neutralization Tank Installation

1. Install exterior collection **OR** neutralization, **as directed**, tanks, complete with appurtenances indicated.
 - a. Set tops of tank covers flush with finished surface where covers occur in pavements. Set covers 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.
 - b. Include initial fill of limestone for neutralization tanks.
2. Install interior neutralization tanks on smooth and level concrete base **OR** floor surface, **as directed**. Include full initial charge of limestone.

H. Neutralization System Installation

1. Install neutralization systems on smooth and level concrete base **OR** floor surface, **as directed**. Include neutralizing solutions and full initial charge of limestone.

I. Manhole Installation

1. General: Install manholes, complete with appurtenances and accessories indicated. Comply with requirements in Division 22 Section "Facility Sanitary Sewers".
2. Set tops of manhole frames and covers flush with finished surface where manholes occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.

J. Leak-Detection System Installation

1. Single-Pipe, Chemical-Waste Sewerage Piping: Install leak-detection system below piping.
2. Double-Containment Piping: Install leak-detection system in piping annular space.
3. Manholes: Install leak-detection system around bottom of exterior.
4. Install panel in location indicated.

K. Concrete Placement

1. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for concrete supports.
2. Place cast-in-place concrete according to ACI 318/318R.

L. Connections

1. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Make connections to existing piping so finished Work complies as nearly as practical with requirements specified for new Work.
3. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
4. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.
5. Install piping adjacent to equipment to allow service and maintenance.



- M. Labeling And Identification
1. Comply with requirements in Division 22 Section "Identification For Plumbing Piping And Equipment" for labeling of equipment and piping.
 - a. Use warning tape **OR** detectable warning tape, **as directed**, over ferrous piping.
 - b. Use detectable warning tape over nonferrous piping and over edges of underground structures.
- N. Field Quality Control
1. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place and again at completion of Project.
 - a. Defects requiring correction include the following:
 - 1) Alignment: Less than full diameter of inside of pipe is visible between inspection points.
 - 2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - 3) Crushed, broken, cracked, or otherwise damaged piping.
 - 4) Hydrostatic Tests for Drainage Piping:
 - a) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile (4.6 L/mm of nominal pipe size per kilometer) of pipe, during 24-hour period.
 - b) Close openings in system and fill with water.
 - c) Purge air and refill with water.
 - d) Disconnect water supply.
 - e) Test and inspect joints for leaks.
 - 5) Air Tests for Drainage Piping: Comply with UNI-B-6.
 - b. Leaks and loss in test pressure constitute defects that must be repaired.
 - c. Submit separate reports for each test.
 2. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.
 3. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 4. Tests and Inspections:
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled neutralization systems and leak-detection systems and their installation, including piping and electrical connections, and to assist in testing.
 - b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 5. Chemical-waste piping will be considered defective if it does not pass tests and inspections.
 6. Prepare test and inspection reports.
- O. Startup Service
1. Perform startup service for neutralization systems and leak-detection systems.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Neutralization Systems:
 - 1) Verify that neutralization system is installed and connected according to the Contract Documents.
 - 2) Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 22.
 - 3) Install neutralizing solutions and limestone.
 - 4) Energize circuits.
 - 5) Start and run systems through complete sequence of operations.



- 6) Adjust operating controls.
- c. Leak-Detection Systems:
 - 1) Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 22.
 - 2) Energize circuits.
 - 3) Adjust operating controls.
- P. Adjusting
 1. Adjust neutralization-system set points.
 2. Adjust leak-detection-system control and device settings.
- Q. Cleaning
 1. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
 - a. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - b. Clean piping by flushing with potable water.
- R. Demonstration
 1. Train the Owner's maintenance personnel to adjust, operate, and maintain neutralization systems and leak-detection systems.
- S. Piping Schedule
 1. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.
 2. Single-Wall, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:
 - a. NPS 2 to NPS 4 (DN 50 to DN 100): High-silicon-iron, hub-and-plain-end pipe and fittings and calked **OR** High-silicon-iron, mechanical-joint pipe and fittings and coupled, **as directed**, joints.
 - b. NPS 2 to NPS 4 (DN 50 to DN 100): Stainless-steel drainage pipe and fittings and gasketed joints.
 - c. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PE drainage pipe and fittings and heat-fusion joints.
 - d. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PP drainage pipe and fittings and electrofusion joints.
 - e. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PVC drainage pipe and fittings and solvent-cemented joints.
 - f. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PVDF drainage pipe and fittings and electrofusion joints.
 - g. NPS 2 to NPS 4 (DN 50 to DN 100): Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
 - h. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): Glass pipe and fittings and coupled joints.
 - i. NPS 6 (DN 150): High-silicon-iron, hub-and-plain-end pipe and fittings and calked **OR** High-silicon-iron, mechanical-joint pipe and fittings and coupled, **as directed**, joints.
 - j. NPS 6 (DN 150): Stainless-steel drainage pipe and fittings and gasketed joints.
 - k. NPS 6 (DN 150): PE drainage pipe and fittings and heat-fusion joints.
 - l. NPS 6 (DN 150): PP drainage pipe and fittings and electrofusion joints.
 - m. NPS 6 (DN 150): PVC drainage pipe and fittings and solvent-cemented joints.
 - n. NPS 6 (DN 150): PVDF drainage pipe and fittings and electrofusion joints.
 - o. NPS 6 (DN 150): Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
 - p. NPS 6 (DN 150): Glass pipe and fittings and coupled joints.



- q. NPS 8 to NPS 12 (DN 200 to DN 300): High-silicon-iron, hub-and-plain-end pipe and fittings and calked joints.
 - r. NPS 8 to NPS 12 (DN 200 to DN 300): PP drainage pipe and fittings and electrofusion joints.
 - s. NPS 8 to NPS 12 (DN 200 to DN 300): PVC drainage pipe and fittings and solvent-cemented joints.
 - t. NPS 8 to NPS 12 (DN 200 to DN 300): PVDF drainage pipe and fittings and electrofusion joints.
 - u. NPS 8 to NPS 12 (DN 200 to DN 300): Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
 - v. NPS 15 (DN 375): High-silicon-iron, hub-and-plain-end pipe and fittings and calked joints.
 - w. NPS 15 (DN 375): NPS 16 (DN 400) centrifugally cast **OR** NPS 14 (DN 350) filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
3. Underground, Double-Containment, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:
- a. NPS 2 to NPS 12 (DN 50 to DN 300): PE double-containment drainage pipe and fittings.
 - b. NPS 2 to NPS 12 (DN 50 to DN 300): PP double-containment drainage pipe and fittings.
 - c. NPS 2 to NPS 12 (DN 50 to DN 300): PP/PVC double-containment drainage pipe and fittings.
 - d. NPS 2 to NPS 12 (DN 50 to DN 300): PVDF double-containment drainage pipe and fittings.
 - e. NPS 2 to NPS 12 (DN 50 to DN 300): PVDF/PVC double-containment drainage pipe and fittings.
4. Aboveground Chemical-Waste Piping: Use any of the following piping materials for each size range:
- a. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PP drainage piping and electrofusion **OR** mechanical, **as directed**, joints.
 - b. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVC drainage piping and solvent-cemented joints.
 - c. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVDF drainage piping and electrofusion **OR** mechanical, **as directed**, joints.
 - d. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 6 (DN 50 to DN 150) high-silicon-iron piping with hub-and-plain ends and calked joints.
 - e. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): High-silicon-iron piping with mechanical-joint ends, mechanical couplings, and coupled joints.
 - f. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100) stainless-steel drainage piping with socket-and-spigot ends and gasketed joints.
 - g. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): Borosilicate glass pipe and fittings, couplings, and coupled joints.
 - h. NPS 8 to NPS 12 (DN 200 to DN 300): PVC drainage pipe and fittings and solvent-cemented joints.
 - i. NPS 8 to NPS 12 (DN 200 to DN 300): High-silicon-iron piping with hub-and-plain ends and calked joints.
5. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use any of the following piping materials for each size range:
- a. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PP drainage piping and electrofusion joints.
 - b. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVC drainage piping and solvent-cemented joints.
 - c. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVDF drainage piping and electrofusion joints.
 - d. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100) high-silicon-iron piping with hub-and-plain ends and calked joints.
 - e. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100) stainless-steel drainage piping with socket-and-spigot ends and gasketed joints.



- f. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): Borosilicate glass piping with covering, couplings, and coupled joints.
- g. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PE **OR** PP **OR** PP/PVC **OR** PVDF **OR** PVDF/PVC, **as directed**, double-containment drainage piping and manufacturer's standard joints.
- h. NPS 8 (DN 200): PVC drainage piping and solvent-cemented joints.
- i. NPS 8 (DN 200): High-silicon-iron piping with hub-and-plain ends and calked joints.
- j. NPS 8 (DN 200): PE **OR** PP **OR** PP/PVC **OR** PVDF **OR** PVDF/PVC, **as directed**, double-containment drainage piping and manufacturer's standard joints.
- k. NPS 10 and NPS 12 (DN 250 and DN 300): PVC drainage piping and solvent-cemented joints.
- l. NPS 10 to NPS 15 (DN 250 to DN 375): High-silicon-iron piping with hub-and-plain ends and calked joints.

END OF SECTION 22 66 83 16

**SECTION 23 01 10 91 - SEQUENCE OF OPERATION**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for sequence of operation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes control sequences for HVAC systems, subsystems, and equipment.

C. Definitions

1. DDC: Direct digital control.
2. VAV: Variable air volume.

D. Heating Control Sequences

1. Heating-Water Supply Temperature Control:
 - a. Input Device: Thermostat **OR** Thermistor temperature sensor **OR** Resistance temperature sensor, **as directed**.
 - b. Output Device: Control valve.
 - c. Action: Modulate control valve to maintain heating-water supply temperature.
 - d. Display:
 - 1) Heating-water supply temperature.
 - 2) Heating-water supply temperature set point.
 - 3) Control-valve position.
2. Heating-Water Supply Temperature Reset:
 - a. Input Device: Electric, outdoor-air-reset controller **OR** Outdoor-air sensor, **as directed**.
 - b. Output Device: Unitary controller **OR** DDC system software, **as directed**.
 - c. Action: Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:
 - 1) 195 deg F (90 deg C) heating water when outdoor-air temperature is minus 30 deg F (minus 35 deg C).
 - 2) 130 deg F (54 deg C) heating water when outdoor-air temperature is 75 deg F (24 deg C).
 - 3) 150 deg F (65 deg C) minimum, heating-water temperature.
 - d. Display:
 - 1) Outdoor-air temperature.
 - 2) Heating-water supply temperature.
 - 3) Heating-water supply temperature set point.
3. Control Primary Circulating Pump(s):
 - a. Input Device: Thermostat **OR** DDC system, **as directed**.
 - b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
 - c. Action: Energize pump(s) at outdoor-air temperatures below 65 deg F (18 deg C).
 - d. Display:
 - 1) Outdoor-air temperature.
 - 2) Operating status of primary circulating pump(s).

E. Central Refrigeration Equipment Sequences

1. Start and Stop Condenser-Water Pump(s):
 - a. Enable: Allow pump to start when water is in cooling tower:
 - 1) Input Device: Water pressure transducer.



- 2) Output Device: Hard wired through motor starter; DDC system binary output, **as directed**.
- 3) Action: Confirm water in cooling-tower sump.
- b. Enable: When outdoor-air temperature conditions are met:
 - 1) Input Device: Space thermostat **OR** DDC system outdoor-air temperature, **as directed**.
 - 2) Output Device: Hard wired through motor starter; DDC system binary output, **as directed**.
 - 3) Action: Confirm outdoor-air temperature is above 50 deg F (10 deg C).
- c. Enable: When demand conditions are met:
 - 1) Input Device: DDC system software demand.
 - 2) Action: Confirm cooling demand from ventilation system(s).
- d. Initiate:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Energize pump(s).
- e. Display:
 - 1) Low-level cooling-tower sump alarm.
 - 2) Outdoor-air temperature.
 - 3) Cooling (software) demand indication.
 - 4) Time and time schedule.
 - 5) Condenser-water pump(s) on-off status.
 - 6) Condenser-water pump(s) on-off indication.
2. Start and Stop Chilled-Water Pump(s):
 - a. Input Device: Flow switch in condenser-water circuit.
 - b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
 - c. Action: Energize pump(s).
 - d. Display:
 - 1) Chilled-water flow indication.
 - 2) Chilled-water pump(s) on-off status.
 - 3) Chilled-water pump(s) on-off indication.
3. Start and Stop Cooling-Tower Fans(s):
 - a. Input Device: Flow switch in condenser-water circuit.
 - b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
 - c. Action: Energize fan(s).
 - d. Display:
 - 1) Condenser-water flow indication.
 - 2) Cooling-tower fan(s) on-off indication.
4. Start and Stop Refrigeration Machine(s):
 - a. Input Device: Flow switch in condenser-water circuit. Flow switch in chilled-water circuit, **as directed**.
 - b. Output Device: Refrigeration **OR** DDC system command to refrigeration, **as directed**, machine terminal strip.
 - c. Action: Energize refrigeration machine(s) internal control circuit.
 - d. Display:
 - e. Condenser-water flow indication.
 - f. Chilled-water flow indication.
 - g. Refrigeration machine on-off indication.
 - h. Chilled-water supply and return temperature.
 - i. Chilled-water temperature control-point adjustment.
5. Start and Stop Chiller(s):
 - a. Input Device: Flow switches in condenser-water and chilled-water circuit.
 - b. Output Device: Chiller **OR** DDC system command to chiller, **as directed**, terminal strip.
 - c. Action: Energize chiller internal control circuit.



- d. Display:
 - 1) Condenser-water flow indication.
 - 2) Chilled-water flow indication.
 - 3) Chiller(s) on-off status.
 - 4) Chiller(s) on-off indication.
 - 5) Chilled-water supply and return temperature.
 - 6) Chilled-water temperature control-point adjustment.
- 6. Alternate Chiller(s):
 - a. Input Device: Electric alternator **OR** DDC system software, **as directed**.
 - b. Output Device: Chiller **OR** DDC system command to chiller, **as directed**, terminal strip.
 - c. Action: Operate chiller(s) on lead-lag, alternating each startup.
OR
Action: Adding and dropping chiller(s) as follows: **<Insert sequence and parameters.>**
 - d. Display: Chiller(s) on-off indication.
- 7. Alarm Chiller(s) Start Failure:
 - a. Input Device: Chiller control panel terminal strip contact **OR** software signal, **as directed**.
 - b. Output Device: Analog control panel **OR** DDC system alarm, **as directed**.
 - c. Action: Signal alarm.
 - d. Display: Chiller "failure-to-start" indication.
- 8. Chilled-Water Level:
 - a. Input Device: Expansion tank level switch **OR** liquid sensor, **as directed**.
 - b. Output Device: Electric relay signal to alarm panel **OR** DDC system alarm, **as directed**.
 - c. Action: Signal alarm.
 - d. Display: Expansion tank low-level alarm.
- 9. Chilled-Water Supply Temperature:
 - a. Input Device: Temperature sensor **OR** transmitter, **as directed**, in common chilled-water supply piping.
 - b. Output Device: Integral chiller controls **OR** DDC system signal to chiller control panel, **as directed**.
 - c. Action: Maintain constant leaving chilled-water temperature reset according to highest cooling demand, **as directed**.
 - 1) Display: Chilled-water supply temperature.
- 10. Condenser-Water Temperature:
 - a. Input Device: Temperature sensor **OR** transmitter, **as directed**, in cooling-tower sump.
 - b. Output Device: Bypass control valve **OR** Cooling-tower fan starter relay **OR** DDC system command to cooling-tower fan starter relay, **as directed**.
 - c. Action: Modulate control valve open to cooling tower and closed to bypass and cycle tower fan(s) on and off **OR** and to low speed and then to high speed, **as directed**, to maintain 65 deg F (18 deg C) **OR** 70 deg F (21 deg C), **as directed**, sump temperature. Close valve when unoccupied, **as directed**.
 - d. Display:
 - 1) Condenser-water sump (return) control-point temperature.
 - 2) Condenser-water sump (return) temperature.
 - 3) Control-valve position.
 - 4) Cooling-tower fan(s) on-off indication.
 - 5) Condenser-water supply temperature.
- 11. Cooling-Tower Sump Heater:
 - a. Input Device: Sump temperature sensor **OR** transmitter, **as directed**.
 - b. Output Device: Electric relay **OR** DDC system command to electric relay, as directed, and solenoid valve, **as directed**.
 - c. Action: Energize sump heater; drain sump on low temperature, **as directed**.
 - d. Display:
 - 1) Cooling-tower sump temperature.
 - 2) Cooling-tower sump heater on-off indication.
 - 3) Cooling-tower dump indication.
- 12. Operator Station Display: Indicate the following on operator workstation display terminal:



- a. DDC system graphic.
- b. DDC system status, on-off.
- c. Low-level cooling-tower sump alarm.
- d. Outdoor-air temperature.
- e. Cooling (software) demand indication.
- f. Time and time schedule.
- g. Condenser-water pump(s) on-off status.
- h. Condenser-water pump(s) on-off indication.
- i. Condenser-water flow indication.
- j. Chilled-water pump(s) on-off status.
- k. Chilled-water pump(s) on-off indication.
- l. Cooling-tower fan(s) on-off indication.
- m. Chilled-water flow indication.
- n. Refrigeration machine on-off indication.
- o. Chilled-water supply temperature.
- p. Chilled-water return temperature.
- q. Chilled-water temperature control-point adjustment.
- r. Chiller(s) on-off status.
- s. Chiller(s) on-off indication.
- t. Chiller "failure-to-start" indication.
- u. Expansion tank low-level alarm.
- v. Condenser-water sump (return) control-point temperature.
- w. Condenser-water sump (return) temperature.
- x. Condenser-water control-valve position.
- y. Cooling-tower fan(s) on-off indication.
- z. Condenser-water supply temperature.
- aa. Cooling-tower sump temperature.
- bb. Cooling-tower sump heater on-off indication.
- cc. Cooling-tower dump indication.
- dd. Chilled-water pressure drop through chiller.
- ee. Entering condenser-water temperature.
- ff. Leaving condenser-water temperature.
- gg. Condenser-water pressure drop through chiller.
- hh. Chiller condenser-water supply and return temperature.
- ii. Chiller chilled-water supply and return temperature.
- jj. System capacity in tons.

F. Air-Handling-Unit Control Sequences

1. Start and Stop Supply Fan(s):
 - a. Enable: Freeze Protection:
 - 1) Input Device: Duct-mounted averaging element thermostat, located before supply fan.
 - 2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
 - 3) Action: Allow start if duct temperature is above 37 deg F (3 deg C); signal alarm if fan fails to start as commanded.
 - b. Enable: High-Temperature Protection:
 - 1) Input Device: Duct-mounted thermostat, located in return air.
 - 2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
 - 3) Action: Allow start if duct temperature is below 300 deg F (150 deg C).
 - c. Enable: Smoke Control:
 - 1) Input Device: Duct-mounted smoke detector, located in return **OR** supply, **as directed**, air.



- 2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
 - 3) Action: Allow start if duct is free of products of combustion.
 - d. Initiate: Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
 - 3) Action: Energize fan(s).
 - e. Initiate: Unoccupied Time Schedule:
 - 1) Input Device: Room thermostat **OR** DDC system demand, **as directed**.
 - 2) Output Device: Room thermostat **OR** Binary output, **as directed**, to motor starter.
 - 3) Action: Energize fan(s).
 - f. Unoccupied Ventilation:
 - 1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
 - 2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**, to motor starter.
 - 3) Action: Cycle fan(s) during unoccupied periods.
 - g. Display: Supply-fan on-off indication.
2. Supply Fan(s) Variable-Volume Control:
- a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Enable control.
 - b. Volume Control (for fans equipped with variable inlet vanes):
 - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing supply-duct static pressure referenced to conditioned-space static pressure.
 - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
 - 3) Action: Maintain constant supply-duct static pressure.
 - c. Volume Control (for fans equipped with variable-speed drives):
 - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing supply-duct static pressure referenced to conditioned-space static pressure.
 - 2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
 - 3) Action: Maintain constant supply-duct static pressure.
 - d. High Pressure:
 - 1) Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
 - 2) Output Device: Receiver controller **OR** DDC system binary output, **as directed**, to alarm panel **OR** motor starter, **as directed**.
 - 3) Action: Stop fan and signal alarm when static pressure rises above excessive-static-pressure set point.
 - e. Display:
 - 1) Supply-fan-discharge static-pressure indication.
 - 2) Supply-fan-discharge static-pressure set point.
 - 3) Supply-fan airflow rate.
 - 4) Supply-fan inlet vane position **OR** speed, **as directed**.

3. Start and Stop Return Fan(s):

- a. Initiate: Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.



- 3) Action: Energize fans when supply fans are energized.
- b. Initiate: Unoccupied Time Schedule:
 - 1) Input Device: Room thermostat **OR** DDC system demand, **as directed**.
 - 2) Output Device: Room thermostat **OR** Binary output, **as directed**, to motor starter.
 - 3) Action: Energize fans when supply fans are energized.
- c. Unoccupied Ventilation:
 - 1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
 - 2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**, to motor starter.
 - 3) Action: Cycle fan(s) during unoccupied periods.
- d. Display: Return-fan on-off indication.
4. Return Fan(s) Variable-Volume Control:
 - a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Enable control.
 - b. Volume Control (for fans equipped with variable inlet vanes):
 - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
 - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
 - 3) Action: Maintain constant building static pressure.
 - c. Volume Control (for fans equipped with variable-speed drives):
 - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
 - 2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
 - 3) Action: Maintain constant building static pressure.
 - d. Display:
 - 1) Return-air static-pressure indication.
 - 2) Return-air static-pressure set point.
 - 3) Return-fan airflow rate.
 - 4) Return-fan inlet vane position **OR** speed, **as directed**.
 - 5) Building static-pressure indication.
 - 6) Building static-pressure set point.
5. Return Fan(s) Variable-Volume Control:
 - a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Enable control.
 - b. Volume Control (for fans equipped with variable inlet vanes):
 - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
 - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
 - 3) Action: Maintain constant building static pressure.
 - c. Volume Control (for fans equipped with variable-speed drives):
 - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.



- 2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
- 3) Action: Maintain constant building static pressure.
- d. Display:
 - 1) Return-fan-discharge static-pressure indication.
 - 2) Return-fan-discharge static-pressure set point.
 - 3) Return-fan airflow rate.
 - 4) Return-fan inlet vane position **OR** speed, **as directed**.
6. Preheat Coil:
 - a. Freeze Protection:
 - 1) Input Device: Duct-mounted averaging element thermostat, located after preheat coil.
 - 2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
 - 3) Action: Allow start if duct temperature is above 33 deg F (1 deg C).
 - b. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
 - 3) Action: Energize coil circulating pump(s).
 - c. Supply **OR** Discharge, **as directed**, -Air Temperature:
 - 1) Input Device: Time clock and duct-mounted thermostat **OR** DDC system time schedule and electronic temperature sensor, **as directed**.
 - 2) Output Device: Modulating control valve.
 - 3) Action: Maintain air temperature set point of 55 deg F (13 deg C).
 - d. Unoccupied Time Schedule:
 - 1) Input Device: Time clock and duct-mounted thermostat mounted in outdoor air **OR** DDC system time schedule and outdoor-air temperature, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
 - 3) Action: Energize coil circulating pump(s) when outdoor-air temperature falls below 35 deg F (2 deg C).
 - e. Display:
 - 1) Preheat-coil air-temperature indication.
 - 2) Preheat-coil air-temperature set point.
 - 3) Preheat-coil pump operation indication.
 - 4) Preheat-coil control-valve position.
7. Mixed-Air Control:
 - a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Pneumatic relay **OR** DDC system output, **as directed**.
 - 3) Action: Enable control.
 - b. Minimum Position:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
 - 3) Action: Open minimum outdoor-air dampers **OR** outdoor-air dampers to minimum position, **as directed**.
 - c. Heating Reset:
 - 1) Input Device: Room thermostat **OR** DDC system software, **as directed**.
 - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
 - 3) Action: Close minimum outdoor-air dampers **OR** Set outdoor-air dampers to minimum position, **as directed**.
 - d. Supply **OR** Mixed, **as directed**, -Air Temperature:



- 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
- 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
- 3) Action: Modulate outdoor-, return-, and relief-air dampers to maintain air temperature set point of 55 deg F (13 deg C).
- e. Cooling Reset:
 - 1) Input Device: Outdoor- and return-air, duct-mounted thermostats **OR** electronic temperature sensors, **as directed**.
 - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to damper actuator(s).
 - 3) Action: Set outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature **OR** enthalpy exceeds return-air enthalpy, **as directed**.
- f. Unoccupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
 - 3) Action: Position outdoor- and relief-air dampers closed and return-air dampers open.
- g. Display:
 - 1) Mixed-air-temperature indication.
 - 2) Mixed-air-temperature set point.
 - 3) Mixed-air damper position.
8. Humidifier:
 - a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**, and airflow switch
 - 2) Output Device: Pneumatic relay **OR** DDC system output, **as directed**.
 - 3) Action: Enable control.
 - b. Humidity:
 - 1) Input Device: Room humidistat **OR** Return-air, duct-mounted humidistat **OR** DDC system, **as directed**.
 - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, enables humidifier **OR** modulates control valve to maintain humidity **OR** cycles pump to maintain humidity **OR** cycles pump and modulates control valve to maintain humidity, **as directed**, in straight-line relationship for the following conditions:
 - a) 20 percent when outdoor-air temperature is minus 30 deg F (minus 35 deg C).
 - b) 40 percent when outdoor-air temperature is 75 deg F (24 deg C).
 - 3) Action: Modulate outdoor-, return-, and relief-air dampers to maintain air temperature set point of 55 deg F (13 deg C).
 - c. Display:
 - 1) Relative humidity indication.
 - 2) Relative humidity set point.
 - 3) Relative humidity control-valve position.
9. Filters: During occupied periods, when fan is running, differential air-pressure transmitters exist.
 - a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Electric relay **OR** DDC system output, **as directed**.
 - 3) Action: Enable control.
 - b. Differential Pressure:



- 1) Input Device: Differential-pressure switches **OR** Pressure transmitter, **as directed**.
 - 2) Output Device: Analog alarm panel **OR** DDC system alarm, **as directed**.
 - 3) Action: Signal alarm on low- and high-pressure conditions.
 - c. Display:
 - 1) Filter air-pressure-drop indication.
 - 2) Filter low-air-pressure set point.
 - 3) Filter high-air-pressure set point.
10. Hydronic **OR** Steam, **as directed**, Heating Coil:
- a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Enable control.
 - b. Supply **OR** Discharge, **as directed**, -Air Temperature:
 - 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Normally open **OR** closed, **as directed**, modulating control valve.
 - 3) Action: Maintain supply-air temperature set point of 55 deg F (13 deg C).
 - c. Temperature Reset (for constant-temperature supply-air systems):
 - 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**, in return air.
 - 2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**, in straight-line relationship for the following conditions:
 - a) 65 deg F (18 deg C) when return-air temperature is 70 deg F (21 deg C).
 - b) 55 deg F (13 deg C) when return-air temperature is 75 deg F (24 deg C).
 - 3) Action: Reset supply-air temperature set point of 55 deg F (13 deg C).
 - d. Temperature Reset (for multizone or dual-duct supply-air systems):
 - 1) Input Device: Load analyzer **OR** DDC system, **as directed**, with input from room thermostats **OR** temperature sensors, **as directed**.
 - 2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**.
 - 3) Action: Reset supply-air temperature in response to greatest heating demand.
 - e. Unoccupied Time Schedule:
 - 1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
 - 2) Output Device: Room thermostat (cycling fan) **OR** DDC system binary output, **as directed**.
 - 3) Action: Enable normal control **OR** Return valve to normal position, **as directed**, when fan is cycled on.
 - f. Display:
 - 1) Fan-discharge air-temperature indication.
 - 2) Fan-discharge air-temperature set point.
 - 3) Heating-coil air-temperature indication.
 - 4) Heating-coil air-temperature set point.
 - 5) Heating-coil pump operation indication.
 - 6) Heating-coil control-valve position.
 - 7) Hot-deck air-temperature indication.
 - 8) Hot-deck air-temperature set point.
11. Hydronic Cooling Coil:
- a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Enable control.
 - b. Supply **OR** Discharge, **as directed**, -Air Temperature:
 - 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Normally open **OR** closed, **as directed**, modulating control valve.
 - 3) Action: Maintain supply-air temperature set point of 55 deg F (13 deg C).



- c. Temperature Reset (for constant-temperature systems):
 - 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**, in return air.
 - 2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**, in straight-line relationship for the following conditions:
 - a) 65 deg F (18 deg C) when return-air temperature is 70 deg F (21 deg C).
 - b) 55 deg F (13 deg C) when return-air temperature is 75 deg F (24 deg C).
 - 3) Action: Reset supply-air temperature set point of 55 deg F (13 deg C).
 - d. Temperature Reset (for multizone or dual-duct supply-air systems):
 - 1) Input Device: Load analyzer **OR** DDC system, **as directed**, with input from room thermostats **OR** temperature sensors, **as directed**.
 - 2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**.
 - 3) Action: Reset supply-air temperature in response to greatest heating demand.
 - e. Unoccupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Disable control.
 - f. Display:
 - 1) Fan-discharge air-temperature indication.
 - 2) Fan-discharge air-temperature set point.
 - 3) Cooling-coil air-temperature indication.
 - 4) Cooling-coil air-temperature set point.
 - 5) Cooling-coil control-valve position.
 - 6) Cold-deck air-temperature indication.
 - 7) Cold-deck air-temperature set point.
12. Multizone Damper Control:
- a. Occupied Time Schedule:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Enable control.
 - b. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Damper actuator.
 - 3) Action: Maintain room temperature.
 - c. Display:
 - 1) Room temperature indication.
 - 2) Room temperature set point.
 - 3) Multizone damper position.
13. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.
14. Operator Station Display: Indicate the following on operator workstation display terminal:
- a. DDC system graphic.
 - b. DDC system on-off indication.
 - c. DDC system occupied/unoccupied mode.
 - d. Outdoor-air-temperature indication.
 - e. Supply-fan on-off indication.
 - f. Supply-fan-discharge static-pressure indication.
 - g. Supply-fan-discharge static-pressure set point.
 - h. Supply-fan airflow rate.
 - i. Supply-fan inlet vane position **OR** speed, **as directed**.
 - j. Return-fan on-off indication.
 - k. Return-air static-pressure indication.
 - l. Return-air static-pressure set point.
 - m. Return-fan airflow rate.
 - n. Return-fan inlet vane position **OR** speed, **as directed**.



- o. Building static-pressure indication.
- p. Building static-pressure set point.
- q. Preheat-coil air-temperature indication.
- r. Preheat-coil air-temperature set point.
- s. Preheat-coil pump operation indication.
- t. Preheat-coil control-valve position.
- u. Mixed-air-temperature indication.
- v. Mixed-air-temperature set point.
- w. Mixed-air damper position.
- x. Relative humidity indication.
- y. Relative humidity set point.
- z. Relative humidity control-valve position.
- aa. Filter air-pressure-drop indication.
- bb. Filter low-air-pressure set point.
- cc. Filter high-air-pressure set point.
- dd. Fan-discharge air-temperature indication.
- ee. Fan-discharge air-temperature set point.
- ff. Heating-coil air-temperature indication.
- gg. Heating-coil air-temperature set point.
- hh. Heating-coil pump operation indication.
- ii. Heating-coil control-valve position.
- jj. Hot-deck air-temperature indication.
- kk. Hot-deck air-temperature set point.
- ll. Cooling-coil air-temperature indication.
- mm. Cooling-coil air-temperature set point.
- nn. Cooling-coil control-valve position.
- oo. Cold-deck air-temperature indication.
- pp. Cold-deck air-temperature set point.
- qq. Room temperature indication.
- rr. Room temperature set point.
- ss. Multizone damper position.

G. Terminal Unit Operating Sequence

1. Cabinet Unit Heater, Hydronic **OR** Steam, **as directed**:
 - a. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**.
 - 3) Action: Cycle fan to maintain temperature.
 - b. Low-Temperature Safety:
 - 1) Input Device: Line-voltage, on-off thermostat, pipe mounted.
 - 2) Output Device: Hard wired.
 - 3) Action: Stop fan when return heating-water **OR** condensate, **as directed**, temperature falls below 35 deg F (2 deg C).
 - c. Display:
 - 1) Room temperature indication.
 - 2) Room temperature set point.
2. Cabinet Unit Heater, Electric: Room thermostat cycles fan and sequences stages of heating.
3. Unit Heater, Hydronic **OR** Steam, **as directed**:
 - a. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**.
 - 3) Action: Cycle fan to maintain temperature.
 - b. Low-Temperature Safety:
 - 1) Input Device: Line-voltage, on-off thermostat, pipe mounted.
 - 2) Output Device: Hard wired.



- 3) Action: Stop fan when return heating-water **OR** condensate, **as directed**, temperature falls below 35 deg F (2 deg C).
- c. Display:
 - 1) Room temperature indication.
 - 2) Room temperature set point.
4. Unit Heater, Electric: Room thermostat cycles fan and sequences stages of heating.
5. Combustion-Air Unit Heaters:
 - a. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
 - 3) Action: Modulate valve to maintain temperature.
 - b. Display:
 - 1) Room temperature indication.
 - 2) Room temperature set point.
 - 3) Control-valve position.
6. Radiant Heating Cable, Electric: Room thermostat cycles power.
7. Radiant Heating Panel, Electric: Room thermostat cycles power.
8. Radiant Heating Panel, Hydronic:
 - a. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
 - 3) Action: Modulate valve to maintain temperature.
 - b. Display:
 - 1) Room temperature indication.
 - 2) Room temperature set point.
 - 3) Control-valve position.
9. Two-Pipe, Single-Coil, Fan-Coil Unit:
 - a. Occupied Time Schedule:
 - 1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Start and stop fan and enable control.
 - b. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**, in room **OR** return air, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
 - 3) Action: Modulate valve to maintain temperature.
 - c. DDC System Changeover:
 - 1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in supply-water **OR** on supply-water piping **OR** DDC system, **as directed**.
 - 2) Output Device: Hard-wired relay **OR** DDC system software, **as directed**.
 - 3) Action: Reverse control-valve action to switch from heating to cooling.
 - d. Display:
 - 1) DDC system graphic.
 - 2) DDC system on-off indication.
 - 3) DDC system occupied/unoccupied mode.
 - 4) Room temperature indication.
 - 5) Room temperature set point.
 - 6) Control-valve position.
 - 7) Supply-water temperature indication.
10. Four-Pipe, Hydronic Fan-Coil Unit:
 - a. Occupied Time Schedule:
 - 1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.



- 3) Action: Start and stop fan, and enable control.
 - b. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators.
 - 3) Action: Modulate multiport control valves to maintain temperature.
 - c. Display:
 - 1) DDC system graphic.
 - 2) DDC system on-off indication.
 - 3) DDC system occupied/unoccupied mode.
 - 4) Room temperature indication.
 - 5) Room temperature set point.
 - 6) Control-valve position.
11. Unit Ventilator: Room thermostat modulates heating-and-cooling control valves; airstream thermostats modulate outdoor- and return-air dampers as follows:
 - a. Occupied Time Schedule:
 - 1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Time clock **OR** Binary output, **as directed**.
 - 3) Action: Start and stop fan, move outdoor- and return-air dampers to minimum **OR** maximum, **as directed**, outdoor-air position, and enable control.
 - b. Room Temperature - Valves:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators.
 - 3) Action: Modulate heating-water supply control valve and chilled-water supply control valve in sequence to maintain temperature.
 - c. Room Temperature - Dampers:
 - 1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in mixed air.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control damper actuators.
 - 3) Action: Modulate outdoor- and return-air dampers to maintain temperature.
 - d. Supply-Air Temperature Limit:
 - 1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in discharge air.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators and control damper actuators.
 - 3) Action: Override room thermostat to control valves and dampers to prevent discharge air from dropping below a minimum set point.
 - e. Warm-up Cycle:
 - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
 - 2) Output Device: Hard-wired relay **OR** DDC system binary output, **as directed**.
 - 3) Action: Open heating-water supply control valve, close outdoor-air damper, and open return-air damper.
 - f. Display:
 - 1) DDC system graphic.
 - 2) DDC system on-off indication.
 - 3) DDC system occupied/unoccupied mode.
 - 4) Room temperature indication.
 - 5) Room temperature set point.
 - 6) Control-valve position.
 - 7) Damper position.
12. Heating Coils, Hydronic **OR** Steam, **as directed**:
 - a. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
 - 3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.



- b. Display:
 - 1) Room temperature indication.
 - 2) Room temperature set point.
 - 3) Control-valve position.
- 13. Heating Coils, Electric: Room thermostat cycles coils **OR** sequences stages of heating, **as directed**.
- 14. Radiators and Convectors, Hydronic **OR** Steam, **as directed**:
 - a. Occupancy:
 - 1) Input Device: Occupancy sensor.
 - 2) Output Device: DDC system binary output.
 - 3) Action: Report occupancy and enable occupied temperature set point.
 - b. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
 - 3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.
 - a) Occupied Temperature: 75 deg F (24 deg C).
 - b) Unoccupied Temperature: 65 deg F (18 deg C).
 - c. Display:
 - 1) Room/area served.
 - 2) Room temperature indication.
 - 3) Room temperature set point.
 - 4) Room temperature set point, occupied.
 - 5) Room temperature set point, occupied standby.
 - 6) Room temperature set point, unoccupied.
 - 7) Control-valve position as percent open.
- 15. Radiators and Convectors, Electric: Room thermostat cycles coils **OR** sequences stages of heating, **as directed**.
- 16. Constant-Volume, Terminal Air Units, Hydronic **OR** Steam, **as directed**:
 - a. Occupancy:
 - 1) Input Device: Occupancy sensor.
 - 2) Output Device: DDC system binary output.
 - 3) Action: Report occupancy and enable occupied temperature set point.
 - a) Occupied Temperature: 75 deg F (24 deg C).
 - b) Unoccupied Temperature: 65 deg F (18 deg C).
 - b. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
 - 3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.
 - c. Display:
 - 1) Room/area served.
 - 2) Room occupied/unoccupied.
 - 3) Room temperature indication.
 - 4) Room temperature set point.
 - 5) Room temperature set point, occupied.
 - 6) Room temperature set point, unoccupied.
 - 7) Control-valve position as percent open.
- 17. VAV, Terminal Air Units with Hydronic **OR** Steam, **as directed**, Coils:
 - a. Occupancy:
 - 1) Input Device: Occupancy sensor.
 - 2) Output Device: DDC system binary output.
 - 3) Action: Report occupancy and enable occupied temperature set point.
 - a) Occupied Temperature: 75 deg F (24 deg C).
 - b) Unoccupied Temperature: 65 deg F (18 deg C).



- b. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, damper actuators and control-valve operators.
 - 3) Action: Modulate damper and valve to maintain temperature.
 - a) Sequence damper from full open to minimum position, then valve from closed to fully open.
 - c. Display:
 - 1) Room/area served.
 - 2) Room occupied/unoccupied.
 - 3) Room temperature indication.
 - 4) Room temperature set point.
 - 5) Room temperature set point, occupied.
 - 6) Room temperature set point, unoccupied.
 - 7) Air-damper position as percent open.
 - 8) Control-valve position as percent open.
18. Dual-Duct, VAV, Terminal Air Units:
- a. Occupancy:
 - 1) Input Device: Occupancy sensor.
 - 2) Output Device: DDC system binary output.
 - 3) Action: Report occupancy and enable occupied temperature set point.
 - a) Occupied Temperature: 75 deg F (24 deg C).
 - b) Unoccupied Temperature: 65 deg F (18 deg C).
 - b. Room Temperature:
 - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
 - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, damper actuators.
 - 3) Action: Modulate dampers to maintain temperature.
 - a) Sequence when space temperature is below set point: Close VAV damper to minimum position, open hot-deck dampers and close cold-deck dampers, then open VAV damper.
 - b) Sequence when space temperature is above set point: Close VAV damper to minimum position, close hot-deck dampers and open cold-deck dampers, then open VAV damper.
 - c. Display:
 - 1) Room/area served.
 - 2) Room occupied/unoccupied.
 - 3) Room temperature indication.
 - 4) Room temperature set point.
 - 5) Room temperature set point, occupied.
 - 6) Room temperature set point, unoccupied.
 - 7) VAV damper position as percent open.
 - 8) Hot-deck damper position as percent open.
 - 9) Cold-deck damper position as percent open.

H. Ventilation Sequences

- 1. Combustion-Air, Makeup Unit Control, Electric: Start fan when served appliance burner starts; room thermostat sequences stages of heating.
- 2. Combustion-Air, Makeup Unit Control, Hydronic **OR** Steam, **as directed**: Start fan when served appliance burner starts; room thermostat cycles **OR** modulates, **as directed**, control valve.
- 3. Gravity Roof Ventilator: Occupancy sensor **OR** Room thermostat, **as directed**, opens dampers.
- 4. Exhaust Fan: Occupancy sensor **OR** Interlock with light switch **OR** Room thermostat, **as directed**, cycles fan.
- 5. Kitchen Exhaust Fan: Occupancy sensor starts fan and energizes makeup air unit.

23 - Heating, Ventilating, And Air-Conditioning (HVAC)



1.2 PRODUCTS (Not Applicable)

1.3 EXECUTION (Not Applicable)

END OF SECTION 23 01 10 91



SECTION 23 01 10 91a - TESTING, ADJUSTING, AND BALANCING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for testing, adjusting and balancing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Balancing Air Systems:
 - 1) Constant-volume air systems.
 - 2) Dual-duct systems.
 - 3) Variable-air-volume systems.
 - 4) Multizone systems.
 - 5) Induction-unit systems.
 - b. Balancing Hydronic Piping Systems:
 - 1) Constant-flow hydronic systems.
 - 2) Variable-flow hydronic systems.
 - 3) Primary-secondary hydronic systems.

C. Definitions

1. AABC: Associated Air Balance Council.
2. NEBB: National Environmental Balancing Bureau.
3. TAB: Testing, adjusting, and balancing.
4. TABB: Testing, Adjusting, and Balancing Bureau.
5. TAB Specialist: An entity engaged to perform TAB Work.

D. Submittals

1. LEED Submittal:
 - a. Air-Balance Report for LEED Prerequisite EQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2, "Air Balancing."
2. Strategies and Procedures Plan: Within 30 **OR** 60 **OR** 90, **as directed**, days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
3. Certified TAB reports.

E. Quality Assurance

1. TAB Contractor Qualifications: Engage a TAB entity certified by AABC **OR** NEBB **OR** TABB, **as directed**.
 - a. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC **OR** NEBB **OR** TABB, **as directed**.
 - b. TAB Technician: Employee of the TAB contractor and who is certified by AABC **OR** NEBB **OR** TABB, **as directed**, as a TAB technician.
2. Certify TAB field data reports and perform the following:
 - a. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - b. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
3. TAB Report Forms: Use standard TAB contractor's forms approved by the Owner **OR** Commissioning Authority, **as directed**.
4. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."



F. Project Conditions

1. Full the Owner Occupancy: the Owner will occupy the site and existing building during entire TAB period. Cooperate with the Owner during TAB operations to minimize conflicts with the Owner's operations.

OR

Partial the Owner Occupancy: the Owner may occupy completed areas of building before Final Completion. Cooperate with the Owner during TAB operations to minimize conflicts with the Owner's operations.

1.2 PRODUCTS (Not Applicable)

1.3 EXECUTION

A. Examination

1. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
2. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
3. Examine the approved submittals for HVAC systems and equipment.
4. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
5. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section(s) "Metal Ducts" OR "Nonmetal Ducts", **as directed**, and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
6. Examine equipment performance data including fan and pump curves.
 - a. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - b. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
7. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
8. Examine test reports specified in individual system and equipment Sections.
9. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
10. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
11. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
12. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
13. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
14. Examine system pumps to ensure absence of entrained air in the suction piping.
15. Examine operating safety interlocks and controls on HVAC equipment.
16. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.



B. Preparation

1. Prepare a TAB plan that includes strategies and step-by-step procedures.
2. Complete system-readiness checks and prepare reports. Verify the following:
 - a. Permanent electrical-power wiring is complete.
 - b. Hydronic systems are filled, clean, and free of air.
 - c. Automatic temperature-control systems are operational.
 - d. Equipment and duct access doors are securely closed.
 - e. Balance, smoke, and fire dampers are open.
 - f. Isolating and balancing valves are open and control valves are operational.
 - g. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - h. Windows and doors can be closed so indicated conditions for system operations can be met.

C. General Procedures For Testing And Balancing

1. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" **OR** ASHRAE 111 **OR** NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" **OR** SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing", **as directed**, and in this Section.
 - a. Comply with requirements in ASHRAE 62.1, Section 7.2.2, "Air Balancing."
2. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - a. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
OR
After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories".
 - b. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "Hvac Insulation".
3. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
4. Take and report testing and balancing measurements in inch-pound (IP) **OR** metric (SI) **OR** inch-pound (IP) and metric (SI), **as directed**, units.

D. General Procedures For Balancing Air Systems

1. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
2. Prepare schematic diagrams of systems' "as-built" duct layouts.
3. For variable-air-volume systems, develop a plan to simulate diversity.
4. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
5. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
6. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
7. Verify that motor starters are equipped with properly sized thermal protection.
8. Check dampers for proper position to achieve desired airflow path.
9. Check for airflow blockages.
10. Check condensate drains for proper connections and functioning.
11. Check for proper sealing of air-handling-unit components.
12. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts".

E. Procedures For Constant-Volume Air Systems

1. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.



- a. Measure total airflow.
 - 1) Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
 - b. Measure fan static pressures as follows to determine actual static pressure:
 - 1) Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - 2) Measure static pressure directly at the fan outlet or through the flexible connection.
 - 3) Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - 4) Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 - c. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - 1) Report the cleanliness status of filters and the time static pressures are measured.
 - d. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
 - e. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - f. Obtain approval from the Owner **OR** Commissioning Authority, **as directed**, for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 21 for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - g. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
2. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 - a. Measure airflow of submain and branch ducts.
 - 1) Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 - b. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
 - c. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
 3. Measure air outlets and inlets without making adjustments.
 - a. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
 4. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
 - a. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 - b. Adjust patterns of adjustable outlets for proper distribution without drafts.
- F. Procedures For Dual-Duct Systems
1. Verify that the cooling coil is capable of full-system airflow, and set mixing boxes at full-cold airflow position for fan volume.



2. Measure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.
 - a. If insufficient static pressure exists, increase airflow at the fan.
3. Test and adjust the constant-volume mixing boxes as follows:
 - a. Verify both hot and cold operations by adjusting the thermostat and observing changes in air temperature and volume.
 - b. Verify sufficient inlet static pressure before making volume adjustments.
 - c. Adjust mixing boxes to indicated airflows within specified tolerances. Measure airflow by Pitot-tube traverse readings or by measuring static pressure at mixing-box taps if provided by mixing-box manufacturer.
4. Do not overpressurize ducts.
5. Remeasure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.
6. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume, dual-duct systems; adjust maximum- and minimum-airflow setting of each mixing box.

G. Procedures For Variable-Air-Volume Systems

1. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - a. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
 - b. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 - c. Measure total system airflow. Adjust to within indicated airflow.
 - d. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 - e. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - 1) If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 - f. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - 1) Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - g. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 - h. Record final fan-performance data.
3. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - a. Balance variable-air-volume systems the same as described for constant-volume air systems.
 - b. Set terminal units and supply fan at full-airflow condition.



- c. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 - d. Readjust fan airflow for final maximum readings.
 - e. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
 - f. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
 - g. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - 1) If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 - h. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - 1) Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
4. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
- a. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
 - b. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 - c. Set terminal units at full-airflow condition.
 - d. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 - e. Adjust terminal units for minimum airflow.
 - f. Measure static pressure at the sensor.
 - g. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
- H. Procedures For Multizone Systems
1. Set unit at maximum airflow through the cooling coil.
 2. Adjust each zone's balancing damper to achieve indicated airflow within the zone.
- I. Procedures For Induction-Unit Systems
1. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.
 2. Adjust each induction unit.
- J. General Procedures For Hydronic Systems
1. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
 2. Prepare schematic diagrams of systems' "as-built" piping layouts.
 3. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 - a. Open all manual valves for maximum flow.
 - b. Check liquid level in expansion tank.
 - c. Check makeup water-station pressure gage for adequate pressure for highest vent.



- d. Check flow-control valves for specified sequence of operation, and set at indicated flow.
- e. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
- f. Set system controls so automatic valves are wide open to heat exchangers.
- g. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
- h. Check air vents for a forceful liquid flow exiting from vents when manually operated.

K. Procedures For Constant-Flow Hydronic Systems

1. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
 - a. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 1) If impeller sizes must be adjusted to achieve pump performance, obtain approval from the Owner **OR** Commissioning Authority, **as directed**, and comply with requirements in Division 23 Section "Hydronic Pumps".
 - b. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 - 1) Monitor motor performance during procedures and do not operate motors in overload conditions.
 - c. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 - d. Report flow rates that are not within plus or minus 10 percent of design.
2. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
3. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
4. Set calibrated balancing valves, if installed, at calculated presettings.
5. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 - a. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
6. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
7. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 - a. Determine the balancing station with the highest percentage over indicated flow.
 - b. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 - c. Record settings and mark balancing devices.
8. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
9. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.
10. Check settings and operation of each safety valve. Record settings.

L. Procedures For Variable-Flow Hydronic Systems

1. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

M. Procedures For Primary-Secondary Hydronic Systems

1. Balance the primary circuit flow first and then balance the secondary circuits.

**N. Procedures For Steam Systems**

1. Measure and record upstream and downstream pressure of each piece of equipment.
2. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
3. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
4. Check settings and operation of each safety valve. Record settings.
5. Verify the operation of each steam trap.

O. Procedures For Heat Exchangers

1. Measure water flow through all circuits.
2. Adjust water flow to within specified tolerances.
3. Measure inlet and outlet water temperatures.
4. Measure inlet steam pressure.
5. Check settings and operation of safety and relief valves. Record settings.

P. Procedures For Motors

1. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - a. Manufacturer's name, model number, and serial number.
 - b. Motor horsepower rating.
 - c. Motor rpm.
 - d. Efficiency rating.
 - e. Nameplate and measured voltage, each phase.
 - f. Nameplate and measured amperage, each phase.
 - g. Starter thermal-protection-element rating.
2. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

Q. Procedures For Chillers

1. Balance water flow through each evaporator and condenser, **as directed**, to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - a. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - b. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
 - c. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
 - d. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
 - e. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
 - f. Capacity: Calculate in tons of cooling.
 - g. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

R. Procedures For Cooling Towers

1. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:
 - a. Measure condenser-water flow to each cell of the cooling tower.
 - b. Measure entering- and leaving-water temperatures.
 - c. Measure wet- and dry-bulb temperatures of entering air.
 - d. Measure wet- and dry-bulb temperatures of leaving air.
 - e. Measure condenser-water flow rate recirculating through the cooling tower.



- f. Measure cooling-tower spray pump discharge pressure.
 - g. Adjust water level and feed rate of makeup water system.
 - h. Measure flow through bypass.
- S. Procedures For Condensing Units
- 1. Verify proper rotation of fans.
 - 2. Measure entering- and leaving-air temperatures.
 - 3. Record compressor data.
- T. Procedures For Boilers
- 1. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.
 - 2. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.
- U. Procedures For Heat-Transfer Coils
- 1. Measure, adjust, and record the following data for each water coil:
 - a. Entering- and leaving-water temperature.
 - b. Water flow rate.
 - c. Water pressure drop.
 - d. Dry-bulb temperature of entering and leaving air.
 - e. Wet-bulb temperature of entering and leaving air for cooling coils.
 - f. Airflow.
 - g. Air pressure drop.
 - 2. Measure, adjust, and record the following data for each electric heating coil:
 - a. Nameplate data.
 - b. Airflow.
 - c. Entering- and leaving-air temperature at full load.
 - d. Voltage and amperage input of each phase at full load and at each incremental stage.
 - e. Calculated kilowatt at full load.
 - f. Fuse or circuit-breaker rating for overload protection.
 - 3. Measure, adjust, and record the following data for each steam coil:
 - a. Dry-bulb temperature of entering and leaving air.
 - b. Airflow.
 - c. Air pressure drop.
 - d. Inlet steam pressure.
 - 4. Measure, adjust, and record the following data for each refrigerant coil:
 - a. Dry-bulb temperature of entering and leaving air.
 - b. Wet-bulb temperature of entering and leaving air.
 - c. Airflow.
 - d. Air pressure drop.
 - e. Refrigerant suction pressure and temperature.
- V. Procedures For Testing, Adjusting, And Balancing Existing Systems
- 1. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
 - a. Measure and record the operating speed, airflow, and static pressure of each fan.
 - b. Measure motor voltage and amperage. Compare the values to motor nameplate information.
 - c. Check the refrigerant charge.
 - d. Check the condition of filters.
 - e. Check the condition of coils.
 - f. Check the operation of the drain pan and condensate-drain trap.
 - g. Check bearings and other lubricated parts for proper lubrication.
 - h. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.



2. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
 - a. New filters are installed.
 - b. Coils are clean and fins combed.
 - c. Drain pans are clean.
 - d. Fans are clean.
 - e. Bearings and other parts are properly lubricated.
 - f. Deficiencies noted in the preconstruction report are corrected.
3. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
 - a. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
 - b. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
 - c. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
 - d. Balance each air outlet.

W. Tolerances

- X. Set HVAC system's air flow rates and water flow rates within the following tolerances:
- a. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 - b. Air Outlets and Inlets: Plus or minus 10 percent.
 - c. Heating-Water Flow Rate: Plus or minus 10 percent.
 - d. Cooling-Water Flow Rate: Plus or minus 10 percent.

Y. Reporting

1. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
2. Status Reports: Prepare weekly **OR** biweekly **OR** monthly, **as directed**, progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

Z. Final Report

1. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - a. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - b. Include a list of instruments used for procedures, along with proof of calibration.
2. Final Report Contents: In addition to certified field-report data, include the following:
 - a. Pump curves.
 - b. Fan curves.
 - c. Manufacturers' test data.
 - d. Field test reports prepared by system and equipment installers.
 - e. Other information relative to equipment performance; do not include Shop Drawings and product data.
3. General Report Data: In addition to form titles and entries, include the following data:
 - a. Title page.
 - b. Name and address of the TAB contractor.



- c. Project name.
- d. Project location.
- e. Architect's name and address.
- f. Engineer's name and address.
- g. Contractor's name and address.
- h. Report date.
- i. Signature of TAB supervisor who certifies the report.
- j. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
- k. Summary of contents including the following:
 - 1) Indicated versus final performance.
 - 2) Notable characteristics of systems.
 - 3) Description of system operation sequence if it varies from the Contract Documents.
- l. Nomenclature sheets for each item of equipment.
- m. Data for terminal units, including manufacturer's name, type, size, and fittings.
- n. Notes to explain why certain final data in the body of reports vary from indicated values.
- o. Test conditions for fans and pump performance forms including the following:
 - 1) Settings for outdoor-, return-, and exhaust-air dampers.
 - 2) Conditions of filters.
 - 3) Cooling coil, wet- and dry-bulb conditions.
 - 4) Face and bypass damper settings at coils.
 - 5) Fan drive settings including settings and percentage of maximum pitch diameter.
 - 6) Inlet vane settings for variable-air-volume systems.
 - 7) Settings for supply-air, static-pressure controller.
 - 8) Other system operating conditions that affect performance.
- 4. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 - a. Quantities of outdoor, supply, return, and exhaust airflows.
 - b. Water and steam flow rates.
 - c. Duct, outlet, and inlet sizes.
 - d. Pipe and valve sizes and locations.
 - e. Terminal units.
 - f. Balancing stations.
 - g. Position of balancing devices.
- 5. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
 - a. Unit Data:
 - 1) Unit identification.
 - 2) Location.
 - 3) Make and type.
 - 4) Model number and unit size.
 - 5) Manufacturer's serial number.
 - 6) Unit arrangement and class.
 - 7) Discharge arrangement.
 - 8) Sheave make, size in inches (mm), and bore.
 - 9) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - 10) Number, make, and size of belts.
 - 11) Number, type, and size of filters.
 - b. Motor Data:
 - 1) Motor make, and frame type and size.
 - 2) Horsepower and rpm.
 - 3) Volts, phase, and hertz.
 - 4) Full-load amperage and service factor.
 - 5) Sheave make, size in inches (mm), and bore.
 - 6) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - c. Test Data (Indicated and Actual Values):
 - 1) Total air flow rate in cfm (L/s).



- 2) Total system static pressure in inches wg (Pa).
 - 3) Fan rpm.
 - 4) Discharge static pressure in inches wg (Pa).
 - 5) Filter static-pressure differential in inches wg (Pa).
 - 6) Preheat-coil static-pressure differential in inches wg (Pa).
 - 7) Cooling-coil static-pressure differential in inches wg (Pa).
 - 8) Heating-coil static-pressure differential in inches wg (Pa).
 - 9) Outdoor airflow in cfm (L/s).
 - 10) Return airflow in cfm (L/s).
 - 11) Outdoor-air damper position.
 - 12) Return-air damper position.
 - 13) Vortex damper position.
6. Apparatus-Coil Test Reports:
- a. Coil Data:
 - 1) System identification.
 - 2) Location.
 - 3) Coil type.
 - 4) Number of rows.
 - 5) Fin spacing in fins per inch (mm) o.c.
 - 6) Make and model number.
 - 7) Face area in sq. ft. (sq. m).
 - 8) Tube size in NPS (DN).
 - 9) Tube and fin materials.
 - 10) Circuiting arrangement.
 - b. Test Data (Indicated and Actual Values):
 - 1) Air flow rate in cfm (L/s).
 - 2) Average face velocity in fpm (m/s).
 - 3) Air pressure drop in inches wg (Pa).
 - 4) Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
 - 5) Return-air, wet- and dry-bulb temperatures in deg F (deg C).
 - 6) Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
 - 7) Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
 - 8) Water flow rate in gpm (L/s).
 - 9) Water pressure differential in feet of head or psig (kPa).
 - 10) Entering-water temperature in deg F (deg C).
 - 11) Leaving-water temperature in deg F (deg C).
 - 12) Refrigerant expansion valve and refrigerant types.
 - 13) Refrigerant suction pressure in psig (kPa).
 - 14) Refrigerant suction temperature in deg F (deg C).
 - 15) Inlet steam pressure in psig (kPa).
7. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
- a. Unit Data:
 - 1) System identification.
 - 2) Location.
 - 3) Make and type.
 - 4) Model number and unit size.
 - 5) Manufacturer's serial number.
 - 6) Fuel type in input data.
 - 7) Output capacity in Btu/h (kW).
 - 8) Ignition type.
 - 9) Burner-control types.
 - 10) Motor horsepower and rpm.
 - 11) Motor volts, phase, and hertz.
 - 12) Motor full-load amperage and service factor.



- 13) Sheave make, size in inches (mm), and bore.
- 14) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
- b. Test Data (Indicated and Actual Values):
 - 1) Total air flow rate in cfm (L/s).
 - 2) Entering-air temperature in deg F (deg C).
 - 3) Leaving-air temperature in deg F (deg C).
 - 4) Air temperature differential in deg F (deg C).
 - 5) Entering-air static pressure in inches wg (Pa).
 - 6) Leaving-air static pressure in inches wg (Pa).
 - 7) Air static-pressure differential in inches wg (Pa).
 - 8) Low-fire fuel input in Btu/h (kW).
 - 9) High-fire fuel input in Btu/h (kW).
 - 10) Manifold pressure in psig (kPa).
 - 11) High-temperature-limit setting in deg F (deg C).
 - 12) Operating set point in Btu/h (kW).
 - 13) Motor voltage at each connection.
 - 14) Motor amperage for each phase.
 - 15) Heating value of fuel in Btu/h (kW).
8. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
 - a. Unit Data:
 - 1) System identification.
 - 2) Location.
 - 3) Coil identification.
 - 4) Capacity in Btu/h (kW).
 - 5) Number of stages.
 - 6) Connected volts, phase, and hertz.
 - 7) Rated amperage.
 - 8) Air flow rate in cfm (L/s).
 - 9) Face area in sq. ft. (sq. m).
 - 10) Minimum face velocity in fpm (m/s).
 - b. Test Data (Indicated and Actual Values):
 - 1) Heat output in Btu/h (kW).
 - 2) Air flow rate in cfm (L/s).
 - 3) Air velocity in fpm (m/s).
 - 4) Entering-air temperature in deg F (deg C).
 - 5) Leaving-air temperature in deg F (deg C).
 - 6) Voltage at each connection.
 - 7) Amperage for each phase.
9. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - a. Fan Data:
 - 1) System identification.
 - 2) Location.
 - 3) Make and type.
 - 4) Model number and size.
 - 5) Manufacturer's serial number.
 - 6) Arrangement and class.
 - 7) Sheave make, size in inches (mm), and bore.
 - 8) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - b. Motor Data:
 - 1) Motor make, and frame type and size.
 - 2) Horsepower and rpm.
 - 3) Volts, phase, and hertz.
 - 4) Full-load amperage and service factor.
 - 5) Sheave make, size in inches (mm), and bore.
 - 6) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).



- 7) Number, make, and size of belts.
- c. Test Data (Indicated and Actual Values):
 - 1) Total airflow rate in cfm (L/s).
 - 2) Total system static pressure in inches wg (Pa).
 - 3) Fan rpm.
 - 4) Discharge static pressure in inches wg (Pa).
 - 5) Suction static pressure in inches wg (Pa).
10. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - a. Report Data:
 - 1) System and air-handling-unit number.
 - 2) Location and zone.
 - 3) Traverse air temperature in deg F (deg C).
 - 4) Duct static pressure in inches wg (Pa).
 - 5) Duct size in inches (mm).
 - 6) Duct area in sq. ft. (sq. m).
 - 7) Indicated air flow rate in cfm (L/s).
 - 8) Indicated velocity in fpm (m/s).
 - 9) Actual air flow rate in cfm (L/s).
 - 10) Actual average velocity in fpm (m/s).
 - 11) Barometric pressure in psig (Pa).
11. Air-Terminal-Device Reports:
 - a. Unit Data:
 - 1) System and air-handling unit identification.
 - 2) Location and zone.
 - 3) Apparatus used for test.
 - 4) Area served.
 - 5) Make.
 - 6) Number from system diagram.
 - 7) Type and model number.
 - 8) Size.
 - 9) Effective area in sq. ft. (sq. m).
 - b. Test Data (Indicated and Actual Values):
 - 1) Air flow rate in cfm (L/s).
 - 2) Air velocity in fpm (m/s).
 - 3) Preliminary air flow rate as needed in cfm (L/s).
 - 4) Preliminary velocity as needed in fpm (m/s).
 - 5) Final air flow rate in cfm (L/s).
 - 6) Final velocity in fpm (m/s).
 - 7) Space temperature in deg F (deg C).
12. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - a. Unit Data:
 - 1) System and air-handling-unit identification.
 - 2) Location and zone.
 - 3) Room or riser served.
 - 4) Coil make and size.
 - 5) Flowmeter type.
 - b. Test Data (Indicated and Actual Values):
 - 1) Air flow rate in cfm (L/s).
 - 2) Entering-water temperature in deg F (deg C).
 - 3) Leaving-water temperature in deg F (deg C).
 - 4) Water pressure drop in feet of head or psig (kPa).
 - 5) Entering-air temperature in deg F (deg C).
 - 6) Leaving-air temperature in deg F (deg C).



13. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
 - a. Unit Data:
 - 1) Unit identification.
 - 2) Location.
 - 3) Service.
 - 4) Make and size.
 - 5) Model number and serial number.
 - 6) Water flow rate in gpm (L/s).
 - 7) Water pressure differential in feet of head or psig (kPa).
 - 8) Required net positive suction head in feet of head or psig (kPa).
 - 9) Pump rpm.
 - 10) Impeller diameter in inches (mm).
 - 11) Motor make and frame size.
 - 12) Motor horsepower and rpm.
 - 13) Voltage at each connection.
 - 14) Amperage for each phase.
 - 15) Full-load amperage and service factor.
 - 16) Seal type.
 - b. Test Data (Indicated and Actual Values):
 - 1) Static head in feet of head or psig (kPa).
 - 2) Pump shutoff pressure in feet of head or psig (kPa).
 - 3) Actual impeller size in inches (mm).
 - 4) Full-open flow rate in gpm (L/s).
 - 5) Full-open pressure in feet of head or psig (kPa).
 - 6) Final discharge pressure in feet of head or psig (kPa).
 - 7) Final suction pressure in feet of head or psig (kPa).
 - 8) Final total pressure in feet of head or psig (kPa).
 - 9) Final water flow rate in gpm (L/s).
 - 10) Voltage at each connection.
 - 11) Amperage for each phase.
14. Instrument Calibration Reports:
 - a. Report Data:
 - 1) Instrument type and make.
 - 2) Serial number.
 - 3) Application.
 - 4) Dates of use.
 - 5) Dates of calibration.

AA. Inspections

1. Initial Inspection:
 - a. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
 - b. Check the following for each system:
 - 1) Measure airflow of at least 10 percent of air outlets.
 - 2) Measure water flow of at least 5 percent of terminals.
 - 3) Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - 4) Verify that balancing devices are marked with final balance position.
 - 5) Note deviations from the Contract Documents in the final report.
2. Final Inspection:
 - a. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by the Owner **OR** Commissioning Authority, **as directed**.



- b. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of the Owner **OR** Commissioning Authority, **as directed**.
 - c. the Owner **OR** Commissioning Authority, **as directed**, shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 - d. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
 - e. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
3. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
 - a. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 - b. If the second final inspection also fails, the Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
 4. Prepare test and inspection reports.

BB. Additional Tests

1. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
2. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 01 10 91a



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 01 20 91	23 01 10 91	Sequence Of Operation
23 01 20 91	23 01 10 91a	Testing, Adjusting, And Balancing



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SECTION 23 01 30 51 - AIR DUCT CLEANING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC air-distribution system cleaning. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes cleaning HVAC air-distribution equipment, ducts, plenums, and system components.

C. Definitions

1. ASCS: Air systems cleaning specialist.
2. NADCA: National Air Duct Cleaners Association.

D. Submittals

1. Qualification Data: For an ASCS.
2. Strategies and procedures plan.
3. Cleanliness verification report.

E. Quality Assurance

1. ASCS Qualifications: A certified member of NADCA.
 - a. Certification: Employ an ASCS certified by NADCA on a full-time basis.
 - b. Supervisor Qualifications: Certified as an ASCS by NADCA.
2. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.
3. Cleaning Conference: Conduct conference at Project site.

1.2 PRODUCTS (Not Used)

1.3 EXECUTION

A. Examination

1. Examine HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.
2. Perform "Project Evaluation and Recommendation" according to NADCA ACR 2006.
3. Prepare written report listing conditions detrimental to performance of the Work.
4. Proceed with work only after unsatisfactory conditions have been corrected.

B. Preparation

1. Prepare a written plan that includes strategies and step-by-step procedures. At a minimum, include the following:
 - a. Supervisor contact information.
 - b. Work schedule including location, times, and impact on occupied areas.
 - c. Methods and materials planned for each HVAC component type.
 - d. Required support from other trades.
 - e. Equipment and material storage requirements.
 - f. Exhaust equipment setup locations.
2. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.



3. Comply with NADCA ACR 2006, "Guidelines for Constructing Service Openings in HVAC Systems" Section.

C. Cleaning

1. Comply with NADCA ACR 2006.
2. Remove visible surface contaminants and deposits from within the HVAC system.
3. Systems and Components to Be Cleaned:
 - a. Air devices for supply and return air.
 - b. Air-terminal units.
 - c. Ductwork:
 - 1) Supply-air ducts, including turning vanes and reheat coils, to the air-handling unit.
 - 2) Return-air ducts to the air-handling unit.
 - 3) Exhaust-air ducts.
 - d. Air-Handling Units:
 - 1) Interior surfaces of the unit casing.
 - 2) Coil surfaces compartment.
 - 3) Condensate drain pans.
 - 4) Fans, fan blades, and fan housings.
 - e. Filters and filter housings.
4. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.
5. Particulate Collection:
 - a. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
 - b. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,
6. Control odors and mist vapors during the cleaning and restoration process.
7. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.
8. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.
9. Clean all air-distribution devices, registers, grilles, and diffusers.
10. Clean visible surface contamination deposits according to NADCA ACR 2006 and the following:
 - a. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
 - b. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
 - c. Clean evaporator coils, reheat coils, and other airstream components.
11. Duct Systems:
 - a. Create service openings in the HVAC system as necessary to accommodate cleaning.
 - b. Mechanically clean duct systems specified to remove all visible contaminants so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
12. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.
13. Mechanical Cleaning Methodology:
 - a. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.



- 1) Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
 - 2) Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.
 - b. Cleaning Mineral-Fiber Insulation Components:
 - 1) Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.
 - 2) Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
 - 3) Fibrous materials that become wet shall be discarded and replaced.
14. Coil Cleaning:
- a. Measure static-pressure differential across each coil.
 - b. See NADCA ACR 2006, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing Coil Cleaning Verification (see applicable NADCA ACR 2006).
 - c. Coil drain pans shall be subject to NADCA ACR 2006, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
 - d. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
 - e. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations when available.
 - f. Rinse thoroughly with clean water to remove any latent residues.
15. Antimicrobial Agents, Coatings, and Sanitizers:
- a. Apply antimicrobial agents, coatings, and sanitizers if active fungal growth is reasonably suspected or where unacceptable levels of fungal contamination have been verified. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
 - b. When used, antimicrobial treatments, coatings, and sanitizers shall be applied after the system is rendered clean.
 - c. Apply antimicrobial agents, coatings, and sanitizers directly onto surfaces of interior ductwork. Fogging is prohibited.
 - d. Sanitizing agent products shall be registered by the EPA as specifically intended for use in HVAC systems and ductwork.
- D. Cleanliness Verification
1. Verify cleanliness according to NADCA ACR 2006, "Verification of HVAC System Cleanliness" Section.
 2. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents, coatings, and sanitizers.
 3. Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.
 4. Additional Verification:
 - a. Perform surface comparison testing or NADCA vacuum test.
 - b. Conduct NADCA vacuum gravimetric test analysis for nonporous surfaces.
 5. Verification of Coil Cleaning:
 - a. Measure static-pressure differential across each coil.



- b. Coil will be considered clean if cleaning restored the coil static-pressure differential within 10 percent of <Insert inches wg (Pa)>, the differential measured when the coil was first installed.

OR

Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.

- 6. Prepare a written cleanliness verification report. At a minimum, include the following:
 - a. Written documentation of the success of the cleaning.
 - b. Site inspection reports, initialed by supervisor, including notation on areas of inspection, as verified through visual inspection.
 - c. Surface comparison test results if required.
 - d. Gravimetric analysis (nonporous surfaces only).
 - e. System areas found to be damaged.
- 7. Photographic Documentation: Comply with requirements listed in Scope of Work.

E. Restoration

- 1. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR 2006, "Restoration and Repair of Mechanical Systems" Section.
- 2. Restore service openings capable of future reopening. Comply with requirements in Division 23 Section "Metal Ducts". Include location of service openings in Project closeout report.
- 3. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Division 23 Section(s) "Metal Ducts" AND "Nonmetal Ducts"
- 4. Replace damaged insulation according to Division 23 Section "Hvac Insulation",
- 5. Ensure that closures do not hinder or alter airflow.
- 6. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.
- 7. Reseal fibrous-glass ducts. Comply with requirements in Division 23 Section "Nonmetal Ducts".

END OF SECTION 23 01 30 51



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 01 30 51	23 01 10 91	Sequence Of Operation
23 01 30 51	23 01 10 91a	Testing, Adjusting, And Balancing



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SECTION 23 01 50 61 - CAST-IRON BOILERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for cast-iron boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged cast-iron boilers, trim, and accessories for generating hot water or steam with the following configurations and burners:
 - a. Factory and Field assembled.
 - b. Atmospheric gas, Sealed-combustion, gas, Forced-draft, gas, Oil, and Combination gas and oil burner.

C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
 - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
5. I=B=R Compliance: Boilers shall be tested and rated according to HI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.
6. UL Compliance: Test boilers for compliance with UL 726, "Oil-Fired Boiler Assemblies **OR** UL 726, "Oil-Fired Boiler Assemblies," and UL 795, "Commercial-Industrial Gas Heating



Equipment **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace controls and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Controls: Two years from date of Final Completion.
 - b. Warranty Period for Heat Exchangers: Five **OR** 10 **OR** 20, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units

1. Description: Factory fabricated and assembled **OR** field assembled, **as directed**.
 - a. Cast-iron sections shall be sealed pressure tight and held together with tie rods set on an insulated steel base, **as directed**; including insulated jacket and flue-gas vent connection.
OR
Ship cast-iron sections disassembled with all materials and equipment, including seals, tie rods, and insulated jacket and flue-gas vent connection for field assembly.
2. Cast-Iron Section Design:
 - a. Configuration: Wet base **OR** back **OR** leg, **as directed**.
 - b. Number of Passes: Single **OR** Multiple, **as directed**.
 - c. Sectional Joints: High-temperature sealant to seal flue-gas passages not in contact with heating medium, tapered cast-iron push nipples, **OR** O-ring gaskets, **OR** fiber roping, **as directed**, and held together with tie rods.
 - d. Drain and blowdown tappings.
 - e. Return injection tube to equalize water flow to all sections.
 - f. Crown inspection tappings with brass plugs.
 - g. Built-in air separator.
3. Combustion Chamber: Equipped with ceramic-fiber target wall **OR** refractory **OR** insulation, **as directed**, and flame observation ports, front and back.
4. Casing:
 - a. Jacket: Sheet metal **OR** Galvanized sheet metal, **as directed**, with snap-in or interlocking closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
 - b. Insulation: Minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, mineral-fiber insulation surrounding the heat exchanger.
 - c. Combustion Chamber Access: Refractory lined, hinged, front.
 - d. Access: For cleaning between cast-iron sections.
 - e. Draft Hood: Flue canopy and top **OR** rear, **as directed**, flue connection shall be constructed of aluminized **OR** stainless, **as directed**, steel containing adjustable outlet damper assembly.
 - f. Insulated base constructed of aluminized steel to permit boiler to be installed on combustible floor.
 - g. Mounting Frame: Steel rails to mount assembled boiler package on concrete base.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
 - h. Control Cabinet: Sheet metal casing shall cover all controls, gas train, and burner.
5. Draft Diverter: Steel assembly integral with boiler casing **OR** Separate galvanized-steel assembly, **as directed**.

B. Burner: For Atmospheric Gas Burners.



1. Burner Tubes and Orifices: Stainless steel **OR** Cast iron, **as directed**, for natural **OR** propane, **as directed**, gas.
 2. Gas Train: Control devices and full-modulation **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
OR
Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
 3. Pilot: Standing **OR** Intermittent-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
- C. Burner: For Residential-Size Boilers With Sealed-Combustion Burners.
1. Burner Tubes and Orifices: Stainless steel **OR** Cast iron, **as directed**, for natural **OR** propane, **as directed**, gas.
 2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 3. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
 4. Pilot: Standing **OR** Intermittent-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
- D. Burner: For Forced-Draft Burners.
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for natural **OR** propane, **as directed**, gas.
 2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 3. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 4. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
 5. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - a. Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
- E. Burner: For Oil Burners.
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil.
 2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 3. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 - a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.



- 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
4. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid using cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
 5. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - a. Maximum Oxides of Nitrogen Emissions: 30 ppm.
- F. Burner: For Combination Gas And Oil Burners.
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and natural **OR** propane, **as directed**, gas.
 2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 3. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 - a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
 - 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
 4. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 5. Gas Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
 6. Oil Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
 7. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - a. Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
- G. Trim: For Hot-Water Boilers.
1. Include devices sized to comply with ANSI B31.9, "Building Services Piping."
 2. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
 3. Safety Relief Valve: ASME rated.
 4. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
 5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
 6. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
 7. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of cast-iron sections and sealed with fiber gasket.
 - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.



- H. Trim: For Steam Boilers.
1. Include devices sized to comply with ANSI B31.9, "Building Services Piping."
 2. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
 3. Safety Relief Valve:
 - a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
 - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
 4. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure about 50 percent of full range.
 5. Water Column: Minimum 12-inch (300-mm) glass gage with shutoff cocks.
 6. Drain Valves: Minimum NPS 3/4 (DN 20) or nozzle size with hose-end connection.
 7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle.
 8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size as or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
 9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
 10. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of cast-iron sections and sealed with fiber gasket.
 - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
- I. Controls
1. Refer to Division 23 Section "Instrumentation And Control For Hvac".
OR
Boiler operating controls shall include the following devices and features:
 - a. Control transformer.
 - b. Set-Point Adjust: Set points shall be adjustable.
 - c. Operating Pressure Control for Steam Boilers: Factory wired and mounted to cycle burner.
 - d. Low-Water Cutoff and Pump Control for Steam Boilers: Cycle feedwater pump(s) for makeup water control.
 - e. Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
OR
Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).
 - f. Sequence of Operation for Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
 - 1) Include automatic, alternating-firing sequence for multiple boilers.
 2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
 - a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature **OR** pressure, **as directed**.



- b. Low-Water Cutoff Switch: Electronic for hot-water boilers or Float and electronic for steam boilers probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
- c. Blocked Vent Safety Switch for Atmospheric Burners: Manual-reset switch factory mounted on draft diverter.
- d. Rollout Safety Switch for Atmospheric Burners: Factory mounted on boiler combustion chamber.
- e. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- 3. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
 - 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
 - b. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

J. Electrical Power

- 1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22..
- 2. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 - a. House in NEMA 250, Type 1 enclosure.
 - b. Wiring shall be numbered and color-coded to match wiring diagram.
 - c. Install factory wiring outside of an enclosure in a metal raceway.
 - d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - e. Provide branch power circuit to each motor and to controls with disconnect switch or circuit breaker, **as directed**.
 - f. Provide each motor with overcurrent protection.

K. Source Quality Control

- 1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
- 2. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- 3. Allow the Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

1.3 EXECUTION

A. Boiler Installation

- 1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac" and concrete materials and installation requirements are specified in Division 31..
- 2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are



specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

3. Install gas-fired boilers according to NFPA 54.
4. Install oil-fired boilers according to NFPA 31.
5. Assemble boiler sections in sequence and seal between each section if boiler is not delivered fully assembled.
6. Assemble and install boiler trim.
7. Install electrical devices furnished with boiler but not specified to be factory mounted.
8. Install control wiring to field-mounted electrical devices.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
4. Connect oil piping full size to burner inlet with shutoff valve and union.
5. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
6. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
7. Install piping from safety relief valves to nearest floor drain, for hot-water boilers.
8. Install piping from safety valves to drip-pan elbow and to nearest floor drain, for steam boilers.
9. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
10. Connect breeching full size to boiler outlet. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for venting materials.
11. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for recirculation duct materials.
12. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
13. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Perform installation and startup checks according to manufacturer's written instructions.
 - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 1) Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
 - 2) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature **OR** steam pressure, **as directed**.
 - 3) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
3. Remove and replace malfunctioning units and retest as specified above.
4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.



5. Performance Tests, **as directed**:
 - a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
 - c. Perform field performance tests to determine capacity and efficiency of boilers.
 - 1) For dual-fuel boilers, perform tests for each fuel.
 - 2) Test for full capacity.
 - 3) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
 - d. Repeat tests until results comply with requirements indicated.
 - e. Provide analysis equipment required to determine performance.
 - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
 - g. Notify the Owner in advance of test dates.
 - h. Document test results in a report and submit to the Owner.

D. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 23 01 50 61



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 01 50 61	22 11 16 00c	Hydronic Piping



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SECTION 23 01 60 71 - CONDENSING UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for condensing units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes air-cooled and water-cooled condensing units.

C. Submittals

1. Product Data: For each condensing unit, include rated capacities, operating characteristics, furnished specialties, and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Shop Drawings: Signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.
 - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that condensing units, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.
7. LEED Submittal:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Code for Mechanical Refrigeration."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. ASME Compliance: Fabricate and label water-cooled condensing units to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Compressor failure.
 - 2) Condenser coil leak.



- b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Final Completion.
- c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Final Completion.
- d. Warranty Period (Condenser Coil Only): Five years from date of Final Completion.

1.2 PRODUCTS

A. Condensing Units, Air Cooled, 1 To 5 Tons (3.5 TO 17.6 kW)

1. Description: Factory assembled and tested, consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.
2. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.
 - a. Motor: Single **OR** Two, **as directed**, speed, and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - b. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
 - c. Accumulator: Suction tube.
 - d. Refrigerant Charge: R-407C **OR** R-410A, **as directed**.
3. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.
4. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings, **as directed**.
5. Accessories:
 - a. Coastal Filter: Mesh screen to protect condenser coil from salt damage.
 - b. Crankcase heater.
 - c. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
 - d. Electronic programmable thermostat **OR** Low-voltage thermostat and subbase, **as directed**, to control condensing unit and evaporator fan.
 - e. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
 - f. Filter-dryer.
 - g. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
 - h. Liquid-line solenoid.
 - i. Low Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F (minus 18 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
OR
Low Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F (minus 29 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
 - j. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
 - k. PE mounting base to provide a permanent foundation.
 - l. Precharged and insulated suction and liquid tubing.
 - m. Sound Hood: Wraps around sound attenuation cover for compressor.
 - n. Thermostatic expansion valve.
 - o. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
6. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

B. Condensing Units, Air Cooled, 6 To 120 Tons (21 TO 422 kW)

1. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.



2. Compressor: Hermetic or semihermetic compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.
 - a. Capacity Control: Cylinder unloading **OR** Hot-gas bypass, **as directed**.
 - b. Refrigerant Charge: R-407C **OR** R-410A **OR** HFC-134a, **as directed**.
 3. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.
 4. Condenser Fans: Propeller-type vertical discharge; either directly or belt driven. Include the following:
 - a. Permanently lubricated ball-bearing motors.
 - b. Separate motor for each fan.
 - c. Dynamically and statically balanced fan assemblies.
 5. Operating and safety controls include the following:
 - a. Manual-reset, high-pressure cutout switches.
 - b. Automatic-reset, low-pressure cutout switches.
 - c. Low oil pressure cutout switch.
 - d. Compressor-winding thermostat cutout switch.
 - e. Three-leg, compressor-overload protection.
 - f. Control transformer.
 - g. Magnetic contactors for compressor and condenser fan motors.
 - h. Timer to prevent excessive compressor cycling.
 6. Accessories:
 - a. Electronic programmable thermostat **OR** Low-voltage thermostat and subbase, **as directed**, to control condensing unit and evaporator fan.
 - b. Low Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F (minus 18 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
OR
Low Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F (minus 29 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
 - c. Gage Panel: Package with refrigerant circuit suction and discharge gages.
 - d. Hot-gas bypass kit.
 - e. Part-winding-start timing relay, circuit breakers, and contactors.
 7. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:
 - a. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
 - b. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
 - c. Gasketed control panel door.
 - d. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.
 - e. Condenser coil hail guard **OR** grille, **as directed**, to protect coil from physical damage.
- C. Condensing Units, Water Cooled
1. Description: Factory assembled and tested, water cooled; consisting of compressors, water-cooled condensers, bases, and unit controls.
 2. Compressor: Hermetic or serviceable hermetic type; with oil pump, operating oil charge, and suction and discharge shutoff valves. Factory mounted on base using spring isolators. Include the following:
 - a. Thermally protected compressor motor.
 - b. Crankcase heater.
 - c. Capacity control using cylinder unloading, suction pressure controlled and discharge pressure operated, designed for unloaded start.
 - d. Refrigerant Charge: R-407C **OR** R-410A **OR** HFC-134a, **as directed**.



3. Condenser: Single-pass, tube-in-tube coaxial type; with seamless, integral-finned, copper tube and steel outer shell with water-regulating valve.
OR
Condenser: Multipass, shell-and-tube type; with replaceable, seamless, integral-finned copper tubes; positive-liquid subcooling circuit; pressure relief device; liquid-level test cock; purge connection; liquid-line shutoff valve; and angle valve for connection of water-regulating valve.
 - a. Unit Construction: ASME stamped, **as directed**, for refrigerant-side working pressure of 385 psig (2650 kPa) and water-side working pressure of 250 psig (1720 kPa).
4. Accessories include the following:
 - a. Discharge-line muffler.
 - b. Gage panel containing gages for suction, discharge, and oil pressure.
 - c. Electric solenoid cylinder unloaders.
 - d. Pump-down relay package.
 - e. Crankcase cover plates with equalizer connections.
5. Controls: Factory-mounted and -wired panel with the following:
 - a. Timer to prevent short cycling.
 - b. High- and low-refrigerant-pressure safety controls.
 - c. Power- and control-circuit terminal blocks.
 - d. Compressor motor starter.
 - e. Control-circuit on-off switch.
 - f. Control-circuit fuse.

D. Motors

1. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.

E. Source Quality Control

1. Verification of Performance: Rate condensing units according to ARI 210/240, ARI 340/360, or ARI 365.
 - a. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
2. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

1.3 EXECUTION

A. Installation

1. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
2. Install condensing units on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac" and concrete materials and installation requirements are specified in Division 31.
3. Concrete Bases:
 - a. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of the base.
 - b. For equipment supported on structural slab, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.



- d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 4. Install roof-mounting units on equipment supports specified in Division 07.
 5. Vibration Isolation: Mount condensing units on rubber pads with a minimum deflection of 1/4 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
OR
Vibration Isolation: Mount condensing units on restrained spring isolators with a minimum deflection specified by the Owner. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 6. Maintain manufacturer's recommended clearances for service and maintenance.
 7. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.
- B. Connections
1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to machine to allow service and maintenance.
 3. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.
 4. Connect refrigerant piping to air-cooled condensing units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Division 23 Section "Refrigerant Piping".
 5. Connect refrigerant and condenser-water piping to water-cooled condensing units. Maintain clear tube removal space. Refrigerant piping and specialties are specified in Division 23 Section "Refrigerant Piping" and condenser-water piping and specialties are specified in Division 22 Section(s) "Domestic Water Piping" OR Division 23 Section(s) "Hydronic Piping", **as directed**.
- C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
 - a. Perform electrical test and visual and mechanical inspection.
 - b. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - e. Verify proper airflow over coils.
 2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
 3. Remove and replace malfunctioning condensing units and retest as specified above.
- D. Startup Service
1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for physical damage to unit casing.
 - b. Verify that access doors move freely and are weathertight.
 - c. Clean units and inspect for construction debris.
 - d. Verify that all bolts and screws are tight.
 - e. Adjust vibration isolation and flexible connections.
 - f. Verify that controls are connected and operational.
 2. Lubricate bearings on fans.
 3. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
 4. Adjust fan belts to proper alignment and tension.



-
5. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
 6. Measure and record airflow over coils.
 7. Verify proper operation of condenser capacity control device.
 8. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
 9. After startup and performance test, lubricate bearings and adjust belt tension, **as directed**.

E. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units.

END OF SECTION 23 01 60 71



SECTION 23 05 13 00 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common motor requirements for HVAC equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

C. Coordination

1. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - a. Motor controllers.
 - b. Torque, speed, and horsepower requirements of the load.
 - c. Ratings and characteristics of supply circuit and required control sequence.
 - d. Ambient and environmental conditions of installation location.

1.2 PRODUCTS

A. General Motor Requirements

1. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
2. Comply with NEMA MG 1 unless otherwise indicated.
3. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics

1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
 - a. For motors with 2:1 speed ratio, consequent pole, single winding.
 - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:
 - a. Motors 15 HP and Larger: NEMA starting Code F or Code G.



- b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- 11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Polyphase Motors With Additional Requirements

- 1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- 2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- 3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors

- 1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split phase.
 - c. Capacitor start, inductor run.
 - d. Capacitor start, capacitor run.
- 2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- 3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- 4. Motors 1/20 HP and Smaller: Shaded-pole type.
- 5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.3 EXECUTION (Not Applicable)

END OF SECTION 23 05 13 00



SECTION 23 05 16 00 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for expansion fittings and loops for HVAC piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Flexible, ball-joint, packed expansion joints.
 - b. Slip-joint packed expansion joints.
 - c. Expansion-compensator packless expansion joints.
 - d. Flexible-hose packless expansion joints.
 - e. Metal-bellows packless expansion joints.
 - f. Rubber packless expansion joints.
 - g. Grooved-joint expansion joints.
 - h. Pipe loops and swing connections.
 - i. Alignment guides and anchors.

C. Performance Requirements

1. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
2. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

D. Submittals

1. Product Data: For each type of product indicated.
2. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - b. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - c. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - d. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
3. Welding certificates.
4. Product Certificates: For each type of expansion joint, from manufacturer.
5. Maintenance Data: For expansion joints to include in maintenance manuals.

E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. ASME Boiler and Pressure Vessel Code: Section IX.

1.2 PRODUCTS

A. Packed Expansion Joints

1. Flexible, Ball-Joint, Packed Expansion Joints:



- a. Standards: ASME Boiler and Pressure Vessel Code: Section II, "Materials"; and ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
 - b. Material: Carbon-steel assembly with asbestos-free composition packing.
 - c. Design: For 360-degree rotation and angular deflection.
 - d. Minimum Pressure Rating: 250 psig at 400 deg F (1725 kPa at 204 deg C).
 - e. Angular Deflection for NPS 6 (DN 150) and Smaller: 30 degree minimum.
 - f. Angular Deflection for NPS 8 (DN 200) and Larger: 15 degree minimum.
 - g. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 - h. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.
2. Slip-Joint Packed Expansion Joints:
 - a. Standard: ASTM F 1007.
 - b. Material: Carbon steel with asbestos-free PTFE packing.
 - c. Design: With internal guide and injection device for repacking under pressure. Include drip connection if used for steam piping.
 - d. Configuration: Single joint **OR** Single joint with base and double joint with base, **as directed**, class(es) unless otherwise indicated.
 - e. End Connections: Flanged or weld ends to match piping system.
- B. Packless Expansion Joints
1. Metal, Expansion-Compensator Packless Expansion Joints:
 - a. Minimum Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa), **as directed**, unless otherwise indicated.
 - b. Configuration for Copper Tubing: Two-ply, phosphor-bronze bellows with copper pipe ends.
 - 1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
 - 2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Threaded.
 - c. Configuration for Steel Piping: Two-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
 - 1) End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
 - 2) End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged **OR** Weld, **as directed**.
 2. Rubber, Expansion-Compensator Packless Expansion Joints:
 - a. Material: Twin reinforced-rubber spheres with external restraining cables.
 - b. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C) unless otherwise indicated.
 - c. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 3. Flexible-Hose Packless Expansion Joints:
 - a. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
 - b. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
 - c. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
 - 1) Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
 - 2) Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
 - d. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
 - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.



- 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.
- e. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.
 - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
 - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.
- f. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.
 - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
 - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
- g. Expansion Joints for Steel Piping NPS 8 to NPS 12 (DN 200 to DN 300): Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.
 - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.
 - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.
- h. Expansion Joints for Steel Piping NPS 14 (DN 350) and Larger: Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.
 - 1) Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.
4. Metal-Bellows Packless Expansion Joints:
 - a. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
 - b. Type: Circular, corrugated bellows with external tie rods.
 - c. Minimum Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa), **as directed**, unless otherwise indicated.
 - d. Configuration: Single joint **OR** Single joint with base and double joint with base, **as directed**, class(es) unless otherwise indicated.
 - e. Expansion Joints for Copper Tubing: Single **OR** Multi, **as directed**,-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
 - 1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
 - 2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Solder joint or threaded.
 - 3) End Connections for Copper Tubing NPS 5 (DN 125) and Larger: Flanged.
 - f. Expansion Joints for Steel Piping: Single **OR** Multi, **as directed**,-ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.
 - 1) End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
 - 2) End Connections for Steel Pipe NPS 2-1/2 (DN 65) and Larger: Flanged **OR** Weld, **as directed**.
5. Rubber Packless Expansion Joints:
 - a. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
 - b. Material: Fabric-reinforced rubber complying with FSA-NMEJ-703.



- c. Arch Type: Single **OR** Multiple, **as directed**, arches with external control rods, **as directed**.
- d. Spherical Type: Single **OR** Multiple, **as directed**, spheres with external control rods, **as directed**.
- e. Minimum Pressure Rating for NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C).
- f. Minimum Pressure Rating for NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C).
- g. Minimum Pressure Rating for NPS 8 to NPS 12 (DN 200 to DN 300): 140 psig (966 kPa) at 180 deg F (82 deg C).
- h. Material for Fluids Containing Acids, Alkalies, or Chemicals: BR **OR** CSM **OR** EPDM, **as directed**.
- i. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N **OR** CR, **as directed**.
- j. Material for Water: BR **OR** Buna-N **OR** CR **OR** CSM **OR** EPDM **OR** NR, **as directed**.
- k. End Connections: Full-faced, integral steel flanges with steel retaining rings.

C. Grooved-Joint Expansion Joints

- 1. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- 2. Standard: AWWA C606, for grooved joints.
- 3. Nipples: Galvanized, **as directed**, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
- 4. Couplings: Five **OR** Seven **OR** 10 **OR** 12, **as directed**, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water **OR** EPDM gasket suitable for cold and hot water, **as directed**, and bolts and nuts.

D. Alignment Guides And Anchors

- 1. Alignment Guides:
 - a. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.
- 2. Anchor Materials:
 - a. Steel Shapes and Plates: ASTM A 36/A 36M.
 - b. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
 - c. Washers: ASTM F 844, steel, plain, flat washers.
 - d. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - 1) Stud: Threaded, zinc-coated carbon steel.
 - 2) Expansion Plug: Zinc-coated steel.
 - 3) Washer and Nut: Zinc-coated steel.
 - e. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - 1) Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - 2) Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
 - 3) Washer and Nut: Zinc-coated steel.

1.3 EXECUTION

A. Expansion-Joint Installation

- 1. Install expansion joints of sizes matching sizes of piping in which they are installed.



2. Install packed-type expansion joints with packing suitable for fluid service.
 3. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
 4. Install rubber packless expansion joints according to FSA-NMEJ-702.
 5. Install grooved-joint expansion joints to grooved-end steel piping
- B. Pipe Loop And Swing Connection Installation
1. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
 2. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.
 3. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.
 4. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.
- C. Alignment-Guide And Anchor Installation
1. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
 2. Install one **OR** two, **as directed**, guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
 3. Attach guides to pipe and secure guides to building structure.
 4. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
 5. Anchor Attachments:
 - a. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - b. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
 6. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - a. Anchor Attachment to Steel Structural Members: Attach by welding.
 - b. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
 7. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 23 05 16 00



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Task	Specification	Specification Description
23 05 17 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 05 17 00	07 63 00 00	Common Work Results for Fire Suppression
23 05 17 00	07 63 00 00a	Common Work Results for Plumbing
23 05 17 00	07 63 00 00b	Common Work Results for HVAC
23 05 19 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 05 19 00	07 63 00 00	Common Work Results for Fire Suppression
23 05 19 00	07 63 00 00a	Common Work Results for Plumbing
23 05 19 00	07 63 00 00b	Common Work Results for HVAC
23 05 19 00	21 05 19 00a	Meters and Gages for Plumbing Piping
23 05 19 00	21 05 19 00b	Meters and Gages for HVAC Piping
23 05 23 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 05 23 00	21 05 19 00	Water Distribution
23 05 23 00	22 05 23 00a	General-Duty Valves for Plumbing Piping
23 05 23 00	22 13 19 33	General-Duty Valves for HVAC Piping
23 05 23 00	22 05 76 00a	Storm Drainage Piping Specialties
23 05 23 00	22 11 16 00c	Hydronic Piping
23 05 23 00	22 11 16 00e	Refrigerant Piping
23 05 23 00	22 11 23 23a	Hydronic Pumps
23 05 23 00	22 11 16 00f	General-Service Compressed-Air Piping



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SECTION 23 05 29 00 - STEAM DISTRIBUTION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for steam distribution. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes underground piping outside the building for distribution of steam and condensate.

C. Performance Requirements

1. Provide components and installation capable of producing steam piping systems with the following minimum working-pressure ratings:
 - a. Steam Piping: 15 psig (104 kPa) **OR** 125 psig (860 kPa), **as directed**.
 - b. Condensate Piping: 100 psig (690 kPa).

D. Submittals

1. Product Data:
2. Shop Drawings:
3. Welding certificates.
4. Source quality-control test reports.
5. Field quality-control test reports.

E. Quality Assurance

1. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.
2. ASME Compliance: Comply with ASME B31.1, "Power Piping" **OR** ASME B31.9, "Building Services Piping," **as directed**, for materials, products, and installation.
3. ASME Compliance: Safety valves and pressure vessels shall bear appropriate ASME labels.

F. Project Conditions

1. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed utility interruptions.
 - b. Do not proceed with utility interruptions without written permission.

1.2 PRODUCTS

A. Piping Materials

1. Refer to Article 1.3 "Piping Application" for applications of pipes, tubes, fittings, and joining methods.
2. Refer to Division 33 Section "Common Work Results For Utilities" for commonly used joining materials.

B. Steel Pipes And Fittings

1. Steel Pipe: ASTM A 53/A 53M, Type E, Grade A, Standard Weight; with plain ends.
2. Nipples: ASTM A 733, Standard Weight, seamless, carbon-steel pipe complying with ASTM A 53/A 53M.



3. Malleable-Iron, Threaded Fittings: ASME B16.3, Classes 150 and 300, with threads according to ASME B1.20.1.
4. Cast-Iron, Threaded Fittings: ASME B16.4, Classes 125 and 250, standard pattern, with threads according to ASME B1.20.1.
5. Steel Welding Fittings: ASME B16.9 and ASTM A 234/A 234M, seamless or welded.

C. Conduit Piping

1. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade A with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
 - a. Mineral-Wool Pipe Insulation: ASTM C 547, Type I, molded.
 - 1) Apparent Thermal Conductivity (k-Value): 0.31 at 200 deg F (0.044 at 93 deg C) mean temperature.
 - 2) Density: Maximum 10 lb/cu. ft. (160 kg/cu. m) average.
 - 3) Compressive Strength: 10 psig (69 kPa) minimum at 5 percent deformation.
 - 4) Bands: ASTM A 666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.
 - b. Calcium Silicate Pipe Insulation: ASTM C 533, Type I; preformed, incombustible, inorganic, with non-asbestos fibrous reinforcement.
 - 1) Thermal Conductivity (k-Value): 0.60 at 500 deg F (0.087 at 260 deg C).
 - 2) Dry Density: 15 lb/cu. ft. (240 kg/cu. m) maximum.
 - 3) Compressive Strength: 60 psig (414 kPa) minimum at 5 percent deformation.
 - 4) Bands: ASTM A 666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.
 - c. Polyisocyanurate Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
 - 1) Thermal Conductivity (k-Value): 0.14 at 75 deg F (0.020 at 24 deg C).
 - 2) Service Temperature: Minus 250 to plus 400 deg F (Minus 156 to plus 204 deg C).
 - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
 - 4) Minimum 90 percent closed cell.
 - 5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
 - 6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
 - 7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
 - d. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
 - 1) Thermal Conductivity (k-Value): 0.13 at 75 deg F (0.019 at 24 deg C).
 - 2) Service Temperature: Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C).
 - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
 - 4) Minimum 90 percent closed cell.
 - 5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
 - 6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
 - 7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
4. Minimum Clearance:
 - a. Between Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
 - b. Between Insulation of Multiple Carrier Pipes: 3/16 inch (4.75 mm).
 - c. Between Bottom of Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
 - d. Between Bottom of Bare, Carrier Pipe and Casing: 1-3/8 inches (35 mm).
5. Conduit: Spiral wound, steel. Finish conduit with 2 coats of fusion-bonded epoxy, minimum 20 mils (0.50 mm) thick. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article, **as directed**.
6. Conduit: Spiral wound, bare steel. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article.



7. Carrier Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of 10 feet (3 m).
8. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees shall be factory fabricated and insulated, and shall be compatible with the carrier pipe.
9. Expansion Offsets and Loops: Size casing to contain piping expansion.
10. Conduit accessories include the following:
 - a. Water Shed: Terminal end protector for carrier pipes entering building through floor, 3 inches (75 mm) deep and 2 inches (50 mm) larger than casing; terminate casing 20 inches (500 mm) above the floor level.
 - b. Guides and Anchors: Steel plate welded to carrier pipes and to casing, complete with vent and drainage openings inside casing.
 - c. End Seals: Steel plate welded to carrier pipes and to casing, complete with drain and vent openings on vertical centerline.
 - d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of casing, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
 - e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.
11. Source Quality Control: Factory test the conduit to 15 psig (105 kPa) for a minimum of 2 minutes with no change in pressure. Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

D. Cased Piping

1. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade A with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
 - a. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
 - 1) Thermal Conductivity (k-Value): 0.13 at 75 deg F (0.019 at 24 deg C).
 - 2) Service Temperature: Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C).
 - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
 - 4) Minimum 90 percent closed cell.
 - 5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
 - 6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
 - 7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
4. Casing: High-density polyethylene **OR** Filament-wound, fiberglass-reinforced polyester resin **OR** PVC, **as directed**.
5. Casing accessories include the following:
 - a. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
 - b. Expansion Blanket: Elastomeric foam, formed to fit over piping.
 - c. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.
6. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

E. Loose-Fill Insulation

1. Granular, Loose-Fill Insulation: Inorganic, nontoxic, nonflammable, sodium potassium aluminum silicate with calcium carbonate filler. Include chemical treatment that renders insulation hydrophobic.
 - a. Thermal Conductivity (k-Value): 0.60 at 175 deg F (0.087 at 79 deg C) and 0.65 at 300 deg F (0.094 at 149 deg C).
 - b. Application Temperature Range: 35 to 800 deg F (2 to 426 deg C).
 - c. Dry Density: 40 to 42 lb/cu. ft. (640 to 672 kg/cu. m).
 - d. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).



2. Powder, Loose-Fill Insulation: Inert, nontoxic, nonflammable, calcium carbonate particles. Include chemical treatment that renders insulation hydrophobic.
 - a. Thermal Conductivity (k-Value): ASTM C 177, 0.58 at 100 deg F (0.084 at 37 deg C) and 0.68 at 300 deg F (0.098 at 149 deg C).
 - b. Application Temperature Range: Minus 273 to plus 480 deg F (Minus 169 to plus 250 deg C).
 - c. Dry Density: Approximately 60 lb/cu. ft. (960 kg/cu. m).
 - d. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).

1.3 EXECUTION

- A. Earthwork: Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
- B. Piping Application
 1. Steam Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.
 2. Steam Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated, **unless directed otherwise to be coated and insulated**, conduit.
 - a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 3. Condensate Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel welding fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.
 4. Condensate Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
 - a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 5. Condensate Piping: Cased piping with polyurethane carrier-pipe insulation.
- C. Piping Installation
 1. General Locations and Arrangements: Drawings indicate general location and arrangement of piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved.
 2. Remove any standing water in the bottom of trench.
 3. Bed the pipe on a minimum 6-inch (150-mm) layer of granular fill material with a minimum 6-inch (150-mm) clearance between the pipes.
 4. Do not insulate piping or backfill piping trench until field quality-control testing has been completed and results approved.
 5. Install piping at uniform grade of 0.2 percent downward in direction of flow or as indicated.
 6. Install condensate piping at uniform grade of 0.4 percent downward in direction of flow.
 7. Install components with pressure rating equal to or greater than system operating pressure.
 8. Install piping free of sags and bends.
 9. Install fittings for changes in direction and branch connections.
 10. Refer to Division 23 Section "Common Work Results For Hvac" for sleeves and mechanical sleeve seals through exterior building walls.
 11. Secure anchors with concrete thrust blocks. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
 12. Connect to steam and condensate piping where it passes through the building wall. Steam and condensate piping inside the building is specified in Division 23 Section "Steam And Condensate Heating Piping".



- D. Loose-Fill Insulation Installation
1. Do not disturb the bottom of trench, or compact and stabilize it to ensure proper support.
 2. Remove any standing water in the bottom of trench.
 3. Form insulation trench by excavation or by installing drywall side forms to establish the required height and width of the insulation.
 4. Support piping with proper pitch, separation, and clearance to backfill or side forms using temporary supporting devices that can be removed after back filling with insulation.
 5. Place insulation and backfill after field quality-control testing has been completed and results approved.
 6. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. Refer to Division 03 Section "Cast-in-place Concrete" for concrete and reinforcement.
 7. Wrap piping at expansion loops and offsets with mineral-wool insulation of thickness appropriate for calculated expansion amount.
 8. Pour loose-fill insulation to required dimension agitating insulation to eliminate voids around piping.
 9. Remove temporary hangers and supports.
 10. Cover loose-fill insulation with polyethylene sheet a minimum of 4 mils (0.10 mm) thick, and empty loose-fill insulation bags on top.
 11. Manually backfill 6 inches (150 mm) of clean backfill. If mechanical compaction is required manually backfill to 12 inches (300 mm) before using mechanical-compaction equipment.
- E. Joint Construction
1. Refer to Division 33 Section "Common Work Results For Utilities" for basic piping joint construction.
 2. Keyed-Coupling Joints: Cut- or roll-groove pipes. Assemble joints with keyed couplings, gaskets, lubricant, and bolts.
 3. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation, exterior jacket sleeve, and apply shrink-wrap seals as required by manufacturer's written installation instructions.
- F. Identification: Install continuous plastic underground warning tapes during back filling of trenches for underground steam and condensate distribution piping. Locate 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping. Refer to Division 31 Section "Earth Moving" for warning-tape materials and devices and their installation.
- G. Field Quality Control
1. Prepare steam and condensate piping for testing according to ASME B31.1 and ASME B31.9 and as follows:
 - a. Leave joints, including welds, uninsulated and exposed for examination during test.
 - b. Isolate equipment. Do not subject equipment to test pressure.
 - c. Install relief valve set at pressure no more than one-third higher than test pressure.
 - d. Fill system with temperature water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
 - e. Use vents installed at high points to release trapped air while filling system. Use drip legs installed at low points for complete removal of liquid.
 2. Test steam and condensate piping as follows:
 - a. Subject steam and condensate piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
 - b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
 3. Test conduit as follows:
 - a. Seal vents and drains and subject conduit to 15 psig (105 kPa) for 4 hours with no loss of pressure. Repair leaks and retest as required.
 4. Prepare a written report of testing.



END OF SECTION 23 05 29 00



SECTION 23 05 29 00a - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for hangers and supports for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Metal pipe hangers and supports.
 - b. Trapeze pipe hangers.
 - c. Fiberglass pipe hangers.
 - d. Metal framing systems.
 - e. Fiberglass strut systems.
 - f. Thermal-hanger shield inserts.
 - g. Fastener systems.
 - h. Pipe stands.
 - i. Equipment supports.

C. Definitions

1. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

D. Performance Requirements

1. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - a. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - b. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - c. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - a. Trapeze pipe hangers.
 - b. Metal framing systems.
 - c. Fiberglass strut systems.
 - d. Pipe stands.
 - e. Equipment supports.
3. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of trapeze hangers.
 - b. Design Calculations: Calculate requirements for designing trapeze hangers.



4. Welding certificates.

F. Quality Assurance

1. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.2 PRODUCTS

A. Metal Pipe Hangers And Supports

1. Carbon-Steel Pipe Hangers and Supports:
 - a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - b. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - c. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - d. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
2. Stainless-Steel Pipe Hangers and Supports:
 - a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - b. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - c. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
3. Copper Pipe Hangers:
 - a. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
 - b. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel **OR** stainless steel, **as directed**.

B. Trapeze Pipe Hangers

1. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

C. Fiberglass Pipe Hangers

1. Clevis-Type, Fiberglass Pipe Hangers:
 - a. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
 - b. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass, polyurethane or stainless steel.
2. Strap-Type, Fiberglass Pipe Hangers:
 - a. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
 - b. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

D. Metal Framing Systems

1. MFMA Manufacturer Metal Framing Systems:
 - a. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
 - b. Standard: MFMA-4.
 - c. Channels: Continuous slotted steel channel with inturned lips.



- d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
 - f. Metallic Coating: Electroplated zinc **OR** Hot-dipped galvanized **OR** Mill galvanized **OR** In-line, hot galvanized **OR** Mechanically-deposited zinc, **as directed**.
OR
Paint Coating: Vinyl **OR** Vinyl alkyd **OR** Epoxy **OR** Polyester **OR** Acrylic **OR** Amine **OR** Alkyd, **as directed**.
OR
Plastic Coating: PVC **OR** Polyurethane **OR** Epoxy **OR** Polyester, **as directed**.
OR
Combination Coating: as directed by the Owner.
2. Non-MFMA Manufacturer Metal Framing Systems:
- a. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
 - b. Standard: Comply with MFMA-4.
 - c. Channels: Continuous slotted steel channel with inturned lips.
 - d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
 - f. Coating: Zinc **OR** Paint **OR** PVC, **as directed**.
- E. Fiberglass Strut Systems
- 1. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
 - a. Channels: Continuous slotted fiberglass or other plastic channel with inturned lips.
 - b. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - c. Hanger Rods: Continuous-thread rod, nuts, and washer made of fiberglass **OR** stainless steel, **as directed**.
- F. Thermal-Hanger Shield Inserts
- 1. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
 - 2. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa), ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
 - 3. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
 - 4. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
 - 5. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.
- G. Fastener Systems
- 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated **OR** stainless-, **as directed**, steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- H. Pipe Stands



1. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
 2. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 3. Low-Type, Single-Pipe Stand: One-piece plastic **OR** stainless-steel, **as directed**, base unit with plastic roller, for roof installation without membrane penetration.
 4. High-Type, Single-Pipe Stand:
 - a. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - b. Base: Plastic **OR** Stainless steel, **as directed**.
 - c. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - d. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
 5. High-Type, Multiple-Pipe Stand:
 - a. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - b. Bases: One or more; plastic.
 - c. Vertical Members: Two or more protective-coated-steel channels.
 - d. Horizontal Member: Protective-coated-steel channel.
 - e. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
 6. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.
- I. Equipment Supports
1. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.
- J. Miscellaneous Materials
1. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
 2. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - a. Properties: Nonstaining, noncorrosive, and nongaseous.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

1.3 EXECUTION

A. Hanger And Support Installation

1. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
2. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - a. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - b. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
3. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.



4. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
5. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
6. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
7. Fastener System Installation:
 - a. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - b. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
8. Pipe Stand Installation:
 - a. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - b. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.
9. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
10. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
11. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
12. Install lateral bracing with pipe hangers and supports to prevent swaying.
13. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
14. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
15. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
16. Insulated Piping:
 - a. Attach clamps and spacers to piping.
 - 1) Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - 2) Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - 3) Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - b. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - c. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - d. Shield Dimensions for Pipe: Not less than the following:
 - 1) NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - 2) NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - 3) NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.



- 4) NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - 5) NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
 - e. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - f. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
- B. Equipment Supports
1. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
 2. Grouting: Place grout under supports for equipment and make bearing surface smooth.
 3. Provide lateral bracing, to prevent swaying, for equipment supports.
- C. Metal Fabrications
1. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
 2. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
 3. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - b. Obtain fusion without undercut or overlap.
 - c. Remove welding flux immediately.
 - d. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.
- D. Adjusting
1. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
 2. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).
- E. Painting
1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

OR

Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 07 OR Division 09 Section(s) "High-performance Coatings", **as directed**.
 2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.
- F. Hanger And Support Schedule
1. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
 2. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
 3. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.



4. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
5. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
6. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant attachments for hostile environment applications.
7. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
8. Use padded hangers for piping that is subject to scratching.
9. Use thermal-hanger shield inserts for insulated piping and tubing.
10. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - a. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - b. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 - c. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 - d. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 - e. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 - f. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 - g. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - h. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - i. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - j. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 - k. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 - l. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - m. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - n. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - o. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 - p. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 - q. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
 - r. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.



- s. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 - t. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 - u. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
11. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
- a. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 - b. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
12. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
- a. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 - b. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 - c. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 - d. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 - e. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
13. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
- a. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - b. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 - c. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - d. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - e. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - f. C-Clamps (MSS Type 23): For structural shapes.
 - g. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 - h. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 - i. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 - j. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 - k. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 - l. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - 1) Light (MSS Type 31): 750 lb (340 kg).
 - 2) Medium (MSS Type 32): 1500 lb (680 kg).
 - 3) Heavy (MSS Type 33): 3000 lb (1360 kg).
 - m. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 - n. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 - o. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.



14. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - a. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - b. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - c. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
15. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - a. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 - b. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 - c. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 - d. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 - e. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 - f. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 - g. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 - h. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - 1) Horizontal (MSS Type 54): Mounted horizontally.
 - 2) Vertical (MSS Type 55): Mounted vertically.
 - 3) Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
16. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
17. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
18. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29 00a



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 29 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 05 29 00	07 63 00 00	Common Work Results for Fire Suppression
23 05 29 00	07 63 00 00a	Common Work Results for Plumbing
23 05 29 00	07 63 00 00b	Common Work Results for HVAC
23 05 29 00	22 05 29 00	Hangers and Supports for Plumbing Piping and Equipment
23 05 33 00	07 72 56 00c	Heat Tracing for HVAC Piping



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SECTION 23 05 48 00 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of vibration and seismic controls for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Isolation pads.
 - b. Isolation mounts.
 - c. Restrained elastomeric isolation mounts.
 - d. Freestanding and Restrained spring isolators.
 - e. Housed spring mounts.
 - f. Elastomeric hangers.
 - g. Spring hangers.
 - h. Spring hangers with vertical-limit stops.
 - i. Pipe riser resilient supports.
 - j. Resilient pipe guides.
 - k. Freestanding and Restrained air-mounting system.
 - l. Restrained vibration isolation roof-curb rails.
 - m. Seismic snubbers.
 - n. Restraining braces and cables.
 - o. Steel and Inertia, vibration isolation equipment bases.

C. Definitions

1. IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. Performance Requirements

1. Wind-Restraint Loading:
 - a. Basic Wind Speed: As required to meet Project requirements.
 - b. Building Classification Category: **I OR II OR III OR IV, as directed.**
 - c. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
2. Seismic-Restraint Loading:
 - a. Site Class as Defined in the IBC: **A OR B OR C OR D OR E OR F, as directed.**
 - b. Assigned Seismic Use Group or Building Category as Defined in the IBC: **I OR II OR III, as directed.**
 - 1) Component Importance Factor: **1.0 OR 1.5, as directed.**
 - 2) Component Response Modification Factor: **1.5 OR 2.5 OR 3.5 OR 5.0, as directed.**
 - 3) Component Amplification Factor: **1.0 OR 2.5, as directed.**
 - c. Design Spectral Response Acceleration at Short Periods (0.2 Second): Percentage as directed.
 - d. Design Spectral Response Acceleration at 1-Second Period: Percentage as directed.

E. Submittals

1. Product Data: For each product indicated.



2. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Qualification Data: For professional engineer.
5. Field quality-control test reports.

F. Quality Assurance

1. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.2 PRODUCTS

A. Vibration Isolators

1. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
 - a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
3. Restrained Mounts: All-directional mountings with seismic restraint.
 - a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
4. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
 - a. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - b. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - c. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - d. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - e. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).



- f. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
5. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
 - a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - b. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
 - c. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - d. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - e. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - f. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
 - a. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
 - b. Base: Factory drilled for bolting to structure.
 - c. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel up or down before contacting a resilient collar.
7. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
8. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
 - a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 - g. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
9. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
 - a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - g. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 - h. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.



10. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.
11. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

B. Air-Mounting Systems

1. Air Mounts: Freestanding, single or multiple, compressed-air bellows.
 - a. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.
 - b. Maximum Natural Frequency: 3 Hz.
 - c. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).
 - d. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
 - e. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).
2. Restrained Air Mounts: Housed compressed-air bellows.
 - a. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.
 - b. Maximum Natural Frequency: 3 Hz.
 - c. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).
 - d. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
 - e. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).

C. Restrained Vibration Isolation Roof-Curb Rails

1. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind, **as directed**, forces.
2. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind, **as directed**, forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches (50 mm) of rigid, glass-fiber insulation on inside of assembly.
3. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- (6-mm-) thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
 - a. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind, **as directed**, restraint.
 - 1) Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
 - 2) Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3) Minimum Additional Travel: 50 percent of the required deflection at rated load.



- 4) Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5) Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - b. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - 1) Resilient Material: Oil- and water-resistant standard neoprene **OR** natural rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
 4. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch (6 mm) thick.
 5. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.
- D. Vibration Isolation Equipment Bases
1. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
 - a. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - 1) Include supports for suction and discharge elbows for pumps.
 - b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
 - c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 2. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
 - a. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - 1) Include supports for suction and discharge elbows for pumps.
 - b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
 - c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 - d. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.
- E. Seismic-Restraint Devices
1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
 2. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - a. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 - b. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - c. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.
 3. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.



4. Restraint Cables: ASTM A 603 galvanized-steel **OR** ASTM A 492 stainless-steel, **as directed**, cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
5. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
6. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
7. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
8. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
9. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
10. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

F. Factory Finishes

1. Finish

- a. Manufacturer's standard prime-coat finish ready for field painting.

OR

Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

- 1) Powder coating on springs and housings.
- 2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
- 3) Baked enamel or powder coat for metal components on isolators for interior use.
- 4) Color-code or otherwise mark vibration isolation and seismic-control and wind-control, **as directed**, devices to indicate capacity range.

1.3 EXECUTION

A. Applications

1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Vibration-Control And Seismic-Restraint Device Installation

1. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
2. Equipment Restraints:



- a. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - b. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
 3. Piping Restraints:
 - a. Comply with requirements in MSS SP-127.
 - b. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - c. Brace a change of direction longer than 12 feet (3.7 m).
 4. Install cables so they do not bend across edges of adjacent equipment or building structure.
 5. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
 6. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
 7. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
 8. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
 9. Drilled-in Anchors:
 - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - e. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.
- C. Accommodation Of Differential Seismic Motion
1. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 23 Section "Hydronic Piping" for piping flexible connections.
- D. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.



- b. Schedule test with the Owner before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - c. Obtain approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - d. Test at least four of each type and size of installed anchors and fasteners selected.
 - e. Test to 90 percent of rated proof load of device.
 - f. Measure isolator restraint clearance.
 - g. Measure isolator deflection.
 - h. Verify snubber minimum clearances.
 - i. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - j. Air-Mounting System Operational Test: Test the compressed-air leveling system.
 - k. Test and adjust air-mounting system controls and safeties.
 - l. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
3. Remove and replace malfunctioning units and retest as specified above.
 4. Prepare test and inspection reports.

E. Adjusting

1. Adjust isolators after piping system is at operating weight.
2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
3. Adjust air-spring leveling mechanism.
4. Adjust active height of spring isolators.
5. Adjust restraints to permit free movement of equipment within normal mode of operation.

F. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems.

END OF SECTION 23 05 48 00



Task	Specification	Specification Description
23 05 48 00	01 22 16 00	No Specification Required
23 05 48 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 05 48 00	21 05 48 13	Vibration And Seismic Controls For Fire-Suppression Piping And Equipment
23 05 48 00	22 05 48 13	Vibration And Seismic Controls For Plumbing Piping And Equipment
23 05 48 00	22 11 16 00c	Hydronic Piping
23 05 48 00	22 11 16 00d	Steam And Condensate Piping
23 05 48 00	22 11 16 00e	Refrigerant Piping
23 05 48 00	22 11 16 00f	General-Service Compressed-Air Piping



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**SECTION 23 05 53 00 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for identification for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Equipment labels.
 - b. Warning signs and labels.
 - c. Pipe labels.
 - d. Duct labels.
 - e. Stencils.
 - f. Valve tags.
 - g. Warning tags.

C. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Equipment Labels

1. Metal Labels for Equipment:
 - a. Material and Thickness: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - b. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 - c. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - d. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
 - e. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
2. Plastic Labels for Equipment:
 - a. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
 - b. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - c. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - d. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 - e. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 - f. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - g. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.



- h. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
3. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
 4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.
- B. Warning Signs And Labels
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
 2. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 3. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
 9. Label Content: Include caution and warning information, plus emergency notification instructions.
- C. Pipe Labels
1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
 2. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover **OR** cover full, **as directed**, circumference of pipe and to attach to pipe without fasteners or adhesive.
 3. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
 4. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - a. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - b. Lettering Size: At least 1-1/2 inches (38 mm) high.
- D. Duct Labels
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
 2. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 3. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.



9. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
 - a. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
 - b. Lettering Size: At least 1-1/2 inches (38 mm) high.

E. Stencils

1. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
 - a. Stencil Material: Aluminum **OR** Brass **OR** Fiberboard, **as directed**.
 - b. Stencil Paint: Exterior, gloss, alkyd enamel **OR** acrylic enamel, **as directed**, black unless otherwise indicated. Paint may be in pressurized spray-can form.
 - c. Identification Paint: Exterior, alkyd enamel **OR** acrylic enamel, **as directed**, in colors according to ASME A13.1 unless otherwise indicated.

F. Valve Tags

1. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
 - a. Tag Material: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - b. Fasteners: Brass wire-link chain **OR** beaded chain **OR** S-hook, **as directed**.
2. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - a. Valve-tag schedule shall be included in operation and maintenance data.

G. Warning Tags

1. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - a. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum **OR** Approximately 4 by 7 inches (100 by 178 mm), **as directed**.
 - b. Fasteners: Brass grommet and wire **OR** Reinforced grommet and wire or string, **as directed**.
 - c. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - d. Color: Yellow background with black lettering.

1.3 EXECUTION

A. Preparation

1. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

B. Equipment Label Installation

1. Install or permanently fasten labels on each major item of mechanical equipment.
2. Locate equipment labels where accessible and visible.

C. Pipe Label Installation

1. Piping Color-Coding: Painting of piping is specified in Division 09 Section(s) "Interior Painting" **OR** "High-performance Coatings", **as directed**.



2. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles **OR** complying with ASME A13.1, **as directed**, on each piping system.
 - a. Identification Paint: Use for contrasting background.
 - b. Stencil Paint: Use for pipe marking.
 3. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - a. Near each valve and control device.
 - b. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - c. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - d. At access doors, manholes, and similar access points that permit view of concealed piping.
 - e. Near major equipment items and other points of origination and termination.
 - f. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
 - g. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
 4. Pipe Label Color Schedule:
 - a. Chilled-Water Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - b. Condenser-Water Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **asa directed**.
 - c. Heating Water Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - d. Refrigerant Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - e. Low-Pressure Steam Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - f. High-Pressure Steam Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - g. Steam Condensate Piping:
 - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
 - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
- D. Duct Label Installation
1. Install plastic-laminated **OR** self-adhesive, **as directed**, duct labels with permanent adhesive on air ducts in the following color codes:
 - a. Blue: For cold-air supply ducts.
 - b. Yellow: For hot-air supply ducts.
 - c. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
 - d. ASME A13.1 Colors and Designs: For hazardous material exhaust.
 2. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.
 3. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.



E. Valve-Tag Installation

1. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
2. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - a. Valve-Tag Size and Shape:
 - 1) Chilled Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 2) Condenser Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 3) Refrigerant: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 4) Hot Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 5) Gas: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 6) Low-Pressure Steam: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 7) High-Pressure Steam: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - 8) Steam Condensate: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
 - b. Valve-Tag Color:
 - 1) Chilled Water: Natural **OR** Green, **as directed**.
 - 2) Condenser Water: Natural **OR** Green, **as directed**.
 - 3) Refrigerant: Natural **OR** Green, **as directed**.
 - 4) Hot Water: Natural **OR** Green, **as directed**.
 - 5) Gas: Natural **OR** Yellow, **as directed**.
 - 6) Low-Pressure Steam: Natural **OR** Yellow, **as directed**.
 - 7) High-Pressure Steam: Natural **OR** Green, **as directed**.
 - 8) Steam Condensate: Natural **OR** Green, **as directed**.
 - c. Letter Color:
 - 1) Chilled Water: Black **OR** White, **as directed**.
 - 2) Condenser Water: Black **OR** White, **as directed**.
 - 3) Refrigerant: Black **OR** White, **as directed**.
 - 4) Hot Water: Black **OR** White, **as directed**.
 - 5) Gas: Black **OR** White, **as directed**.
 - 6) Low-Pressure Steam: Black **OR** White, **as directed**.
 - 7) High-Pressure Steam: Black **OR** White, **as directed**.
 - 8) Steam Condensate: Black **OR** White, **as directed**.

F. Warning-Tag Installation

1. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 05 53 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 05 53 00	22 05 53 00	Identification for Plumbing Piping and Equipment
23 05 53 00	23 01 10 91	Sequence Of Operation
23 05 93 00	01 71 23 16	Cutting and Patching
23 05 93 00	02 41 19 13	Selective Demolition
23 05 93 00	23 01 10 91	Sequence Of Operation
23 05 93 00	23 01 10 91a	Testing, Adjusting, And Balancing



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SECTION 23 07 13 00 - HVAC INSULATION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC insulation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Insulation Materials:
 - 1) Calcium silicate.
 - 2) Cellular glass.
 - 3) Flexible elastomeric.
 - 4) Mineral fiber.
 - 5) Phenolic.
 - 6) Polyisocyanurate.
 - 7) Polyolefin.
 - 8) Polystyrene.
 - b. Fire-rated insulation systems.
 - c. Insulating cements.
 - d. Adhesives.
 - e. Mastics.
 - f. Lagging adhesives.
 - g. Sealants.
 - h. Factory-applied jackets.
 - i. Field-applied fabric-reinforcing mesh.
 - j. Field-applied cloths.
 - k. Field-applied jackets.
 - l. Tapes.
 - m. Securements.
 - n. Corner angles.

C. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:
 - a. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - b. Detail attachment and covering of heat tracing inside insulation.
 - c. Detail insulation application at pipe expansion joints for each type of insulation.
 - d. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - e. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - f. Detail application of field-applied jackets.
 - g. Detail application at linkages of control devices.
 - h. Detail field application for each equipment type.
4. Field quality-control reports.



D. Quality Assurance

1. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - a. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - b. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

E. Delivery, Storage, And Handling

1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.2 PRODUCTS

A. Insulation Materials

1. Comply with requirements in Part 1.3 schedule articles for where insulating materials shall be applied.
2. Products shall not contain asbestos, lead, mercury, or mercury compounds.
3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
6. Calcium Silicate:
 - a. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - b. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - c. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
7. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - a. Block Insulation: ASTM C 552, Type I.
 - b. Special-Shaped Insulation: ASTM C 552, Type III.
 - c. Board Insulation: ASTM C 552, Type IV.
 - d. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 - e. Preformed Pipe Insulation with Factory-Applied ASJ **OR** ASJ-SSL, **as directed**: Comply with ASTM C 552, Type II, Class 2.
 - f. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
8. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
9. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I **OR** II with factory-applied vinyl jacket **OR** III with factory-applied FSK jacket **OR** III with factory-applied FSP jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
10. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.



11. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. For equipment applications, provide insulation without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
12. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.
13. Mineral-Fiber, Preformed Pipe Insulation:
 - a. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - b. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
14. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.
15. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ **OR** FSK jacket, **as directed**, complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
16. Phenolic:
 - a. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 - b. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 - c. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 - d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - 1) Preformed Pipe Insulation: None **OR** ASJ, **as directed**.
 - 2) Board for Duct and Plenum Applications: None **OR** ASJ, **as directed**.
 - 3) Board for Equipment Applications: None **OR** ASJ, **as directed**.
17. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
 - a. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
 - b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E 84.
 - c. Fabricate shapes according to ASTM C 450 and ASTM C 585.
 - d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - 1) Pipe Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
 - 2) Equipment Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
18. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
19. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed



0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

B. Fire-Rated Insulation Systems

1. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F (927 deg C). Comply with ASTM C 656, Type II, Grade 6. tested and certified to provide a 1-hour **OR** 2-hour, **as directed**, fire rating by a NRTL acceptable to authority having jurisdiction.
2. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1-hour **OR** 2-hour, **as directed**, fire rating by a NRTL acceptable to authority having jurisdiction.

C. Insulating Cements

1. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

D. Adhesives

1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
2. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).
 - a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
7. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. PVC Jacket Adhesive: Compatible with PVC jacket.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Mastics

1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - a. For indoor applications, use mastics that have an approved VOC content or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - a. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.



- b. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
- c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
- d. Color: White.
3. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
 - a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
 - b. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 - c. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - d. Color: White.
4. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
 - a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
 - b. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 - c. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - d. Color: White.
5. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - a. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 - b. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
 - c. Solids Content: 63 percent by volume and 73 percent by weight.
 - d. Color: White.

F. Lagging Adhesives

1. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - a. For indoor applications, use lagging adhesives that have an approved VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
 - c. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
 - d. Color: White.

G. Sealants

1. Joint Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Permanently flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 - d. Color: White or gray.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. FSK and Metal Jacket Flashing Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Fire- and water-resistant, flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - d. Color: Aluminum.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Fire- and water-resistant, flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - d. Color: White.
 - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

H. Factory-Applied Jackets



1. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 - b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 - c. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 - d. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
 - e. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
 - f. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
 - g. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

- I. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

- J. Field-Applied Fabric-Reinforcing Mesh
 1. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
 2. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.
 3. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for duct, equipment, and pipe.

- K. Field-Applied Cloths
 1. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

- L. Field-Applied Jackets
 1. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
 2. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
 3. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - a. Adhesive: As recommended by jacket material manufacturer.
 - b. Color: White **OR** Color-code jackets based on system. Color as selected by the Owner, **as directed**.
 - c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - 1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 - d. Factory-fabricated tank heads and tank side panels.
 4. Metal Jacket:



- a. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - 1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
 - 2) Finish and thickness are indicated in field-applied jacket schedules.
 - 3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 5) Factory-Fabricated Fitting Covers:
 - a) Same material, finish, and thickness as jacket.
 - b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c) Tee covers.
 - d) Flange and union covers.
 - e) End caps.
 - f) Beveled collars.
 - g) Valve covers.
 - h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- b. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - 1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
 - 2) Material, finish, and thickness are indicated in field-applied jacket schedules.
 - 3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
 - 5) Factory-Fabricated Fitting Covers:
 - a) Same material, finish, and thickness as jacket.
 - b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c) Tee covers.
 - d) Flange and union covers.
 - e) End caps.
 - f) Beveled collars.
 - g) Valve covers.
 - h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
5. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
6. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white **OR** stucco-embossed, **as directed**, aluminum-foil facing.
7. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
8. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
9. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.



M. Tapes

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - a. Width: 3 inches (75 mm).
 - b. Thickness: 11.5 mils (0.29 mm).
 - c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - d. Elongation: 2 percent.
 - e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - f. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - a. Width: 3 inches (75 mm).
 - b. Thickness: 6.5 mils (0.16 mm).
 - c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - d. Elongation: 2 percent.
 - e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - f. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
3. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - a. Width: 2 inches (50 mm).
 - b. Thickness: 6 mils (0.15 mm).
 - c. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 - d. Elongation: 500 percent.
 - e. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
4. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - a. Width: 2 inches (50 mm).
 - b. Thickness: 3.7 mils (0.093 mm).
 - c. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 - d. Elongation: 5 percent.
 - e. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
5. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - a. Width: 3 inches (75 mm).
 - b. Film Thickness: 4 mils (0.10 mm).
 - c. Adhesive Thickness: 1.5 mils (0.04 mm).
 - d. Elongation at Break: 145 percent.
 - e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.
6. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - a. Width: 3 inches (75 mm).
 - b. Film Thickness: 6 mils (0.15 mm).
 - c. Adhesive Thickness: 1.5 mils (0.04 mm).
 - d. Elongation at Break: 145 percent.
 - e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

N. Securements

1. Bands:
 - a. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
 - b. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
 - c. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
2. Insulation Pins and Hangers:



- a. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated.
 - b. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - c. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 1) Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - 2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - 3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 - d. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 1) Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - 2) Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - 3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 - e. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 1) Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - 2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - 3) Adhesive-backed base with a peel-off protective cover.
 - f. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - 1) Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 - g. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
3. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
 4. Wire: 0.080-inch (2.0-mm) nickel-copper alloy **OR** 0.062-inch (1.6-mm) soft-annealed, stainless steel **OR** 0.062-inch (1.6-mm) soft-annealed, galvanized steel, **as directed**.
- O. Corner Angles
1. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.



2. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.
3. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**.

1.3 EXECUTION

A. Preparation

1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
OR
Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - b. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
3. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

B. General Installation Requirements

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
4. Install insulation with longitudinal seams at top and bottom of horizontal runs.
5. Install multiple layers of insulation with longitudinal and end seams staggered.
6. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
7. Keep insulation materials dry during application and finishing.
8. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
9. Install insulation with least number of joints practical.
10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - a. Install insulation continuously through hangers and around anchor attachments.
 - b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.



- d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
11. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
12. Install insulation with factory-applied jackets as follows:
 - a. Draw jacket tight and smooth.
 - b. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - c. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, o.c.
 - 1) For below ambient services, apply vapor-barrier mastic over staples.
 - d. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - e. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
16. For above ambient services, do not install insulation to the following:
 - a. Vibration-control devices.
 - b. Testing agency labels and stamps.
 - c. Nameplates and data plates.
 - d. Manholes.
 - e. Handholes.
 - f. Cleanouts.

C. Penetrations

1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - a. Seal penetrations with flashing sealant.
 - b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - d. Seal jacket to roof flashing with flashing sealant.
2. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - a. Seal penetrations with flashing sealant.
 - b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - c. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 - d. Seal jacket to wall flashing with flashing sealant.



4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
 5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
 - a. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
 6. Insulation Installation at Floor Penetrations:
 - a. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
 - b. Pipe: Install insulation continuously through floor penetrations.
 - c. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping".
- D. Equipment, Tank, And Vessel Insulation Installation
1. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
 - a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of tank and vessel surfaces.
 - b. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 - c. Protect exposed corners with secured corner angles.
 - d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - 1) Do not weld anchor pins to ASME-labeled pressure vessels.
 - 2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - 3) On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
 - 4) Do not overcompress insulation during installation.
 - 5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - 6) Impale insulation over anchor pins and attach speed washers.
 - 7) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 - f. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
 - g. Stagger joints between insulation layers at least 3 inches (75 mm).
 - h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.



- i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
- j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
 - a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 - b. Seal longitudinal seams and end joints.
3. Insulation Installation on Pumps:
 - a. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
 - b. Fabricate boxes from galvanized steel **OR** aluminum **OR** stainless steel, **as directed**, at least 0.040 inch (1.0 mm) **OR** 0.050 inch (1.3 mm) **OR** 0.060 inch (1.6 mm), **as directed**, thick.
 - c. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

E. General Pipe Insulation Installation

1. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
2. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - a. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 - b. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - c. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - d. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 - e. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 - f. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 - g. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 - h. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and



- unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
- i. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
3. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
 4. Install removable insulation covers at locations indicated. Installation shall conform to the following:
 - a. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 - b. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 - c. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 - d. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 - e. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

F. Calcium Silicate Insulation Installation

1. Insulation Installation on Boiler Breechings and Ducts:
 - a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation material.
 - b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
 - c. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.
2. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
 - b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
 - c. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.
3. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.



- c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
 - d. Finish flange insulation same as pipe insulation.
 - 4. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 - b. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
 - c. Finish fittings insulation same as pipe insulation.
 - 5. Insulation Installation on Valves and Pipe Specialties:
 - a. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - b. Install insulation to flanges as specified for flange insulation application.
 - c. Finish valve and specialty insulation same as pipe insulation.
- G. Cellular-Glass Insulation Installation
 - 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
 - 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
 - d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
 - 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 - b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
 - 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed sections of cellular-glass insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
- H. Flexible Elastomeric Insulation Installation
 - 1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 - 2. Insulation Installation on Pipe Flanges:
 - a. Install pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.



- c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install mitered sections of pipe insulation.
 - b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - b. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
 - d. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- I. Mineral-Fiber Insulation Installation
 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - c. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
 - d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available.
 - b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed sections of same material as straight segments of pipe insulation when available.
 - b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
 - c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - d. Install insulation to flanges as specified for flange insulation application.
 5. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.



- a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of duct and plenum surfaces.
 - b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - c. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - 1) On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - 2) On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - 3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - 4) Do not overcompress insulation during installation.
 - 5) Impale insulation over pins and attach speed washers.
 - 6) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - d. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - 1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - 2) Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
 - e. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
 - f. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 - g. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.
6. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of duct and plenum surfaces.
 - b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - c. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - 1) On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - 2) On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.



- 3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - 4) Do not overcompress insulation during installation.
 - 5) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
- d. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - 1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - 2) Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
 - e. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 - f. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

J. Phenolic Insulation Installation

1. General Installation Requirements:
 - a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
 - b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
2. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - d. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
3. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
5. Insulation Installation on Valves and Pipe Specialties:



- a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
- K. Polyisocyanurate Insulation Installation
- 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
 - b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
 - c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
 - 2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.
 - 3. Insulation Installation on Fittings and Elbows:
 - a. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
 - 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed sections of polyisocyanurate insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.
- L. Polyolefin Insulation Installation
- 1. Insulation Installation on Straight Pipes and Tubes:
 - a. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 - 2. Insulation Installation on Pipe Flanges:
 - a. Install pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
 - d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 - 3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install mitered sections of polyolefin pipe insulation.
 - b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
 - 4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install cut sections of polyolefin pipe and sheet insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.



- d. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

M. Polystyrene Insulation Installation

1. Insulation Installation on Straight Pipes and Tubes:
 - a. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
 - b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
 - c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
 - a. Install preformed pipe insulation to outer diameter of pipe flange.
 - b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
 - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.
3. Insulation Installation on Pipe Fittings and Elbows:
 - a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
4. Insulation Installation on Valves and Pipe Specialties:
 - a. Install preformed section of polystyrene insulation to valve body.
 - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - c. Install insulation to flanges as specified for flange insulation application.

N. Field-Applied Jacket Installation

1. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - a. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 - b. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
 - c. Completely encapsulate insulation with coating, leaving no exposed insulation.
2. Where FSK jackets are indicated, install as follows:
 - a. Draw jacket material smooth and tight.
 - b. Install lap or joint strips with same material as jacket.
 - c. Secure jacket to insulation with manufacturer's recommended adhesive.
 - d. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
3. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 - a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
4. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.
5. Where PVDC jackets are indicated, install as follows:



- a. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
 - b. Wrap factory-presizes jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
 - c. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
 - d. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
 - e. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.
- O. Fire-Rated Insulation System Installation
1. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
 2. Insulate duct access panels and doors to achieve same fire rating as duct.
 3. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping".
- P. Finishes
1. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 07.
 - a. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - 1) Finish Coat Material: Interior, flat, latex-emulsion size.
 2. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
 3. Color: Final color as selected by the Owner. Vary first and second coats to allow visual inspection of the completed Work.
 4. Do not field paint aluminum or stainless-steel jackets.
- Q. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Inspect ductwork, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
 - b. Inspect field-insulated equipment, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
 - c. Inspect pipe, fittings, strainers, and valves, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations



of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

3. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

R. Boiler Breeching Insulation Schedule

1. Round, exposed breeching and connector insulation shall be one of the following:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
2. Round, concealed breeching and connector insulation shall be one of the following:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
3. Rectangular, exposed breeching and connector insulation shall be one of the following:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
4. Rectangular, concealed breeching and connector insulation shall be one of the following:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.

S. Duct Insulation Schedule, General

1. Plenums and Ducts Requiring Insulation:
 - a. Indoor, concealed supply and outdoor air.
 - b. Indoor, exposed supply and outdoor air.
 - c. Indoor, concealed return located in nonconditioned space.
 - d. Indoor, exposed return located in nonconditioned space.
 - e. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
 - f. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
 - g. Indoor, concealed oven and warewash exhaust.
 - h. Indoor, exposed oven and warewash exhaust.
 - i. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - j. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - k. Outdoor, concealed supply and return.
 - l. Outdoor, exposed supply and return.
2. Items Not Insulated:
 - a. Fibrous-glass ducts.
 - b. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 - c. Factory-insulated flexible ducts.
 - d. Factory-insulated plenums and casings.
 - e. Flexible connectors.
 - f. Vibration-control devices.
 - g. Factory-insulated access panels and doors.



T. Indoor Duct And Plenum Insulation Schedule

1. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
2. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
3. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
4. Concealed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
5. Concealed, rectangular, supply-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.



6. Concealed, rectangular, return-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm), **as directed**, thick.
7. Concealed, rectangular, outdoor-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm), **as directed**, thick.
8. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
9. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket **OR** board, **as directed**; thickness as required to achieve 2-hour fire rating.
10. Concealed, supply-air plenum insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
11. Concealed, return-air plenum insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.



- d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- e. Polyolefin: 1 inch (25 mm) thick.
- 12. Concealed, outdoor-air plenum insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 13. Concealed, exhaust-air plenum insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 14. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
- 15. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
- 16. Exposed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
- 17. Exposed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.



- b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
18. Exposed, rectangular, supply-air duct insulation shall be one of the following:
- a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96 kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
19. Exposed, rectangular, return-air duct insulation shall be one of the following:
- a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
20. Exposed, rectangular, outdoor-air duct insulation shall be one of the following:
- a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
21. Exposed, rectangular, exhaust-air duct insulation shall be one of the following:
- a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
22. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket **OR** board, **as directed**; thickness as required to achieve 2-hour fire rating.



23. Exposed, supply-air plenum insulation shall be one of the following:
- Flexible Elastomeric: 1 inch (25 mm) thick.
 - Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - Polyolefin: 1 inch (25 mm) thick.
24. Exposed, return-air plenum insulation shall be one of the following:
- Flexible Elastomeric: 1 inch (25 mm) thick.
 - Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - Polyolefin: 1 inch (25 mm) thick.
25. Exposed, outdoor-air plenum insulation shall be one of the following:
- Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
26. Exposed, exhaust-air plenum insulation shall be one of the following:
- Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- U. Aboveground, Outdoor Duct And Plenum Insulation Schedule
- Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
 - Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
 - Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
 - Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.



- b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
- c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 4. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 5. Concealed, rectangular, supply-air duct insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 6. Concealed, rectangular, return-air duct insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 7. Concealed, supply-air plenum insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 8. Concealed, return-air plenum insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 9. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
- 10. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:



- a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
- b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
- c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
11. Exposed, rectangular, supply-air duct insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
12. Exposed, rectangular, return-air duct insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
13. Exposed, supply-air plenum insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
14. Exposed, return-air plenum insulation shall be one of the following:
 - a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
 - b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.

V. Equipment Insulation Schedule

1. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
2. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
3. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:
 - a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
4. Heat-exchanger (water-to-water for cooling service) insulation shall be one of the following:



- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
5. Heat-exchanger (water-to-water for heating service) insulation shall be one of the following:
- a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
6. Steam-to-hot-water converter insulation shall be one of the following:
- a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
7. Hot-water-to-steam converter insulation shall be one of the following:
- a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
8. Chilled-water pump insulation shall be one of the following:
- a. Cellular Glass: 3 inches (75 mm) thick.
 - b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 2 inches (50 mm) thick.
 - d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.
9. Condenser-water pump insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1 inch (25 mm) thick.
 - d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.
10. Dual-service heating and cooling pump insulation shall be one of the following:
- a. Cellular Glass: 3 inches (75 mm) thick.
 - b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 2 inches (50 mm) thick.
 - d. Polyisocyanurate: 1 inch (25 mm) thick.
11. Heating-hot-water pump insulation shall be one of the following:
- a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
12. Heat-recovery pump insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Phenolic: 1 inch (25 mm) thick.
 - d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.



13. Steam condensate pump and boiler feedwater pump insulation shall be one of the following:
 - a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
14. Chilled-water expansion/compression tank insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
15. Condenser-water expansion/compression tank insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
16. Dual-service heating and cooling expansion/compression tank insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
17. Heating-hot-water expansion/compression tank insulation shall be one of the following:
 - a. Calcium Silicate: 2 inches (50 mm) thick.
 - b. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
18. Heat-recovery expansion/compression tank insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
19. Chilled-water air-separator insulation shall be one of the following:
 - a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.



- f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
20. Condenser-water air-separator insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
21. Dual-service heating and cooling air-separator insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
22. Heating-hot-water air-separator insulation shall be one of the following:
- a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
23. Heat-recovery air-separator insulation shall be one of the following:
- a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
 - e. Phenolic: 1 inch (25 mm) thick.
 - f. Polyisocyanurate: 1 inch (25 mm) thick.
 - g. Polyolefin: 1 inch (25 mm) thick.
24. Thermal storage tank (brine, water, ice) insulation shall be one of the following:
- a. Cellular Glass: 4 inches (100 mm) thick.
 - b. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Pipe and Tank: 3 inches (75 mm) thick.
 - d. Phenolic: 3 inches (75 mm) thick.
 - e. Polyisocyanurate (Outdoor Application Only): 3 inches (75 mm) thick.
 - f. Polystyrene (Outdoor Application Only): 3 inches (75 mm) thick.
25. Deaerator insulation shall be one of the following:
- a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
26. Steam condensate tank and receiver insulation shall be one of the following:
- a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.



27. Steam flash-tank, flash-separator, and blow-off-tank insulation shall be one of the following:
 - a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 28. Piping system filter-housing insulation shall be one of the following:
 - a. Cellular Glass: 3 inches (75 mm) thick.
 - b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 29. Outdoor, aboveground, heated, fuel-oil storage tank insulation shall be one of the following:
 - a. Cellular Glass: 3 inches (75 mm) thick.
 - b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
 - c. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 - d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.
- W. Piping Insulation Schedule, General
1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
 2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - a. Drainage piping located in crawl spaces.
 - b. Underground piping.
 - c. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
- X. Indoor Piping Insulation Schedule
1. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
 2. Chilled Water and Brine, 40 Deg F (5 Deg C) and below:
 - a. NPS 3 (DN 80) and Smaller: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 3) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
 - b. NPS 4 (DN 100) to NPS 12 (DN 300): Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
 - c. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.



- 2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.
3. Chilled Water and Brine, above 40 Deg F (5 Deg C):
- a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 4) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
 - b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 2) Mineral-Fiber Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.
4. Condenser-Water Supply and Return:
- a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 4) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
 - b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 2) Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.
5. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and below:
- a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 2) Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 3) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
 - b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 2) Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.



6. Heating-Hot-Water Supply and Return, above 200 Deg F (93 Deg C):
 - a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
 - 1) Calcium Silicate: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 2) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
 - 1) Calcium Silicate: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
 - 2) Cellular Glass: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
7. Steam and Steam Condensate, 350 Deg F (177 Deg C) and below:
 - a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
 - 1) Calcium Silicate: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 2) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
 - 1) Calcium Silicate: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
 - 2) Cellular Glass: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
8. Steam and Steam Condensate, above 350 Deg F (177 Deg C):
 - a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
 - 1) Calcium Silicate: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 2) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
 - 1) Calcium Silicate: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
 - 2) Cellular Glass: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
9. Refrigerant Suction and Hot-Gas Piping:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
10. Refrigerant Suction and Hot-Gas Flexible Tubing:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 2) Polyolefin: 1 inch (25 mm) thick.
11. Dual-Service Heating and Cooling, 40 to 200 Deg F (5 to 93 Deg C):
 - a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 2) Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
 - 3) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
 - b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.



- 2) Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
 - 4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.
12. Heat-Recovery Piping:
- a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - 4) Phenolic: 1 inch (25 mm) thick.
 - 5) Polyisocyanurate: 1 inch (25 mm) thick.
 - 6) Polyolefin: 1 inch (25 mm) thick.
13. Hot Service Drains:
- a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
 - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch (25 mm) thick.
14. Hot Service Vents:
- a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
 - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch (25 mm) thick.

Y. Outdoor, Aboveground Piping Insulation Schedule

1. Chilled Water and Brine:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 3 inches (75 mm) thick.
 - 2) Flexible Elastomeric: 3 inches (75 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 3 inches (75 mm) thick.
 - 4) Phenolic: 2 inches (50 mm) thick.
 - 5) Polyisocyanurate: 2 inches (50 mm) thick.
 - 6) Polyolefin: 3 inches (75 mm) thick.
 - 7) Polystyrene: 2 inches (50 mm) thick.
2. Condenser-Water Supply and Return:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Flexible Elastomeric: 2 inches (50 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 4) Phenolic: 2 inches (50 mm) thick.
 - 5) Polyisocyanurate: 2 inches (50 mm) thick.
 - 6) Polyolefin: 2 inches (50 mm) thick.
 - 7) Polystyrene: 2 inches (50 mm) thick.
3. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and below:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 3 inches (75 mm) thick.
 - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 3) Phenolic: 2 inches (50 mm) thick.
 - 4) Polyisocyanurate: 2 inches (50 mm) thick.
4. Heating-Hot-Water Supply and Return, above 200 Deg F (93 Deg C):
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 3 inches (75 mm) thick.
 - 2) Cellular Glass: 3 inches (75 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: 2 inches (50 mm) thick.
5. Steam and Steam Condensate, 350 Deg F (177 Deg C) and below:



- a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 4 inches (100 mm) thick.
 - 2) Cellular Glass: 4 inches (100 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: 3 inches (75 mm) thick.
 6. Steam and Steam Condensate, above 350 Deg F (177 Deg C):
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 5 inches (125 mm) thick.
 - 2) Cellular Glass: 5 inches (125 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: 4 inches (100 mm) thick.
 7. Refrigerant Suction and Hot-Gas Piping:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Flexible Elastomeric: 2 inches (50 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 4) Phenolic: 2 inches (50 mm) thick.
 - 5) Polyisocyanurate: 2 inches (50 mm) thick.
 - 6) Polyolefin: 2 inches (50 mm) thick.
 - 7) Polystyrene: 2 inches (50 mm) thick.
 8. Refrigerant Suction and Hot-Gas Flexible Tubing:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Flexible Elastomeric: 2 inches (50 mm) thick.
 - 2) Polyolefin: 2 inches (50 mm) thick.
 9. Heat-Recovery Piping:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Flexible Elastomeric: 2 inches (50 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 4) Phenolic: 2 inches (50 mm) thick.
 - 5) Polyisocyanurate: 2 inches (50 mm) thick.
 - 6) Polyolefin: 2 inches (50 mm) thick.
 - 7) Polystyrene: 2 inches (50 mm) thick.
 10. Dual-Service Heating and Cooling:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 3 inches (75 mm) thick.
 - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - 3) Phenolic: 2 inches (50 mm) thick.
 - 4) Polyisocyanurate: 2 inches (50 mm) thick.
 11. Hot Service Drains:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
 - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 12. Hot Service Vents:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
 - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 3) Mineral-Fiber, Preformed Pipe Insulation, Type II: 1 inch (25 mm) thick.
 13. Fuel Oil Piping, Heated:
 - a. All Pipe Sizes: Insulation shall be one of the following:
 - 1) Cellular Glass: 2 inches (50 mm) thick.
 - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
- Z. Outdoor, Underground Piping Insulation Schedule
1. Loose-fill insulation, for belowground piping, is specified in Division 28.
 2. Chilled Water, All Sizes: Cellular glass, 2 inches (50 mm) thick.
 3. Condenser-Water Supply and Return, All Sizes: Cellular glass, 2 inches (50 mm) thick.



4. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F (93 Deg C) and below: Cellular glass, 3 inches (75 mm) thick.
 5. Heating-Hot-Water Supply and Return, All Sizes, above 200 Deg F (93 Deg C):
 - a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Cellular Glass: 3 inches (75 mm) thick.
 6. Steam and Steam Condensate, All Sizes, 350 Deg F (177 Deg C) and below:
 - a. Calcium Silicate: 4 inches (100 mm) thick.
 - b. Cellular Glass: 4 inches (100 mm) thick.
 7. Steam and Steam Condensate, All Sizes, above 350 Deg F (177 Deg C):
 - a. Calcium Silicate: 5 inches (125 mm) thick.
 - b. Cellular Glass: 5 inches (125 mm) thick.
 8. Dual-Service Heating and Cooling, All Sizes, 40 to 200 Deg F (4 to 93 Deg C): Cellular glass, 3 inches (75 mm) thick.
 9. Fuel Oil Piping, All Sizes, Heated: Cellular glass, 2 inches (50 mm) thick.
- AA. Indoor, Field-Applied Jacket Schedule
1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 2. If more than one material is listed, selection from materials listed is Contractor's option.
 3. Ducts and Plenums, Concealed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
 4. Ducts and Plenums, Exposed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
 5. Equipment, Concealed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.



- e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 - a. None.
 - b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
8. Piping, Concealed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
9. Piping, Exposed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

BB. Outdoor, Field-Applied Jacket Schedule



1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Ducts and Plenums, Concealed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Ducts and Plenums, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 - a. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - b. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
5. Ducts and Plenums, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 - a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Equipment, Concealed:
 - a. None.
 - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
 - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
 - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
 - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 - a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm)



- OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm) OR 0.040 inch (1.0 mm), as directed, thick.**
- b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed** with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
8. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
- a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
- b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
9. Piping, Concealed:
- a. None.
- b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
- c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
- d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
- e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
10. Piping, Exposed:
- a. PVC: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm) **OR** 40 mils (1.0 mm), **as directed**, thick.
- b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
- c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
- CC. Underground, Field-Installed Insulation Jacket
1. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 23 07 13 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 07 16 00	23 07 13 00	HVAC Insulation



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**SECTION 23 09 00 00 - HVAC INSTRUMENTATION AND CONTROLS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC instrumentation and controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

C. Definitions

1. DDC: Direct digital control.
2. I/O: Input/output.
3. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
4. MS/TP: Master slave/token passing.
5. PC: Personal computer.
6. PID: Proportional plus integral plus derivative.
7. RTD: Resistance temperature detector.

D. System Performance

1. Comply with the following performance requirements:
 - a. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 - b. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 - c. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
 - d. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
 - e. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - f. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
 - g. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
 - h. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - 1) Water Temperature: Plus or minus 1 deg F (0.5 deg C).
 - 2) Water Flow: Plus or minus 5 percent of full scale.
 - 3) Water Pressure: Plus or minus 2 percent of full scale.
 - 4) Space Temperature: Plus or minus 1 deg F (0.5 deg C).
 - 5) Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
 - 6) Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
 - 7) Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
 - 8) Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
 - 9) Relative Humidity: Plus or minus 5 percent.
 - 10) Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
 - 11) Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
 - 12) Airflow (Terminal): Plus or minus 10 percent of full scale.



- 13) Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
- 14) Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
- 15) Carbon Monoxide: Plus or minus 5 percent of reading.
- 16) Carbon Dioxide: Plus or minus 50 ppm.
- 17) Electrical: Plus or minus 5 percent of reading.

E. Submittals

1. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
 - a. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 - b. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
 - c. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Bill of materials of equipment indicating quantity, manufacturer, and model number.
 - b. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
 - c. Wiring Diagrams: Power, signal, and control wiring.
 - d. Details of control panel faces, including controls, instruments, and labeling.
 - e. Written description of sequence of operation.
 - f. Schedule of dampers including size, leakage, and flow characteristics.
 - g. Schedule of valves including flow characteristics.
 - h. DDC System Hardware:
 - 1) Wiring diagrams for control units with termination numbers.
 - 2) Schematic diagrams and floor plans for field sensors and control hardware.
 - 3) Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
 - i. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
 - j. Controlled Systems:
 - 1) Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - 2) Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
 - 3) Written description of sequence of operation including schematic diagram.
 - 4) Points list.
3. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.
4. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.
5. Software and Firmware Operational Documentation: Include the following:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 - c. Device address list.
 - d. Printout of software application and graphic screens.
 - e. Software license required by and installed for DDC workstations and control systems.



6. Software Upgrade Kit: For the Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
7. Field quality-control test reports.
8. Operation and maintenance data.

F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with ASHRAE 135 for DDC system components.

G. Delivery, Storage, And Handling

1. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
2. System Software: Update to latest version of software at Project completion.

1.2 PRODUCTS

A. Control System

1. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.
2. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.
3. Control system shall include the following:
 - a. Building intrusion detection system specified in Division 28 Section "Intrusion Detection".
 - b. Building clock control system specified in Division 27 Section "Clock Systems".
 - c. Building lighting control system specified in Division 26 Section "Network Lighting Controls".
 - d. Fire alarm system specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System", **as directed**.

B. DDC Equipment

1. Operator Workstation: One **OR** Two, **as directed**, PC-based microcomputer(s) with minimum configuration as follows:
 - a. Motherboard: With 8 integrated USB 2.0 ports, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.
 - b. Processor: Intel Pentium 4, **<Insert clock speed>** MHz.
 - c. Random-Access Memory: 512 MB.
 - d. Graphics: Video adapter, minimum 1280 x 1024 **OR** 1600 x 1200, **as directed**, pixels, 64-MB video memory, with TV out.
 - e. Monitor: 17 inches (430 mm) **OR** 19 inches (480 mm), **as directed**, LCD color.
 - f. Keyboard: QWERTY, 105 keys in ergonomic shape.
 - g. Floppy-Disk Drive: 1.44 MB.
 - h. Hard-Disk Drive: 80 GB.
 - i. CD-ROM Read/Write Drive: 48x24x48.
 - j. Mouse: Three button, optical.
 - k. Uninterruptible Power Supply: 2 kVa.
 - l. Operating System: Microsoft Windows XP Professional with high-speed Internet access.
 - 1) ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.



- 2) LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
- m. Printer: Black-and-white, laser-jet type as follows:
 - 1) Print Head: 1200 x 1200 dpi resolution.
 - 2) Paper Handling: Minimum of 250 sheet trays.
 - 3) Print Speed: Minimum of 120 characters per second.
- n. Printer: Color, ink-jet type as follows:
 - 1) Print Head: 4800 x 1200 dpi optimized color resolution.
 - 2) Paper Handling: Minimum of 100 sheets.
 - 3) Print Speed: Minimum of 17 ppm in black and 12 ppm in color.
- o. Application Software:
 - 1) I/O capability from operator station.
 - 2) System security for each operator via software password and access levels.
 - 3) Automatic system diagnostics; monitor system and report failures.
 - 4) Database creation and support.
 - 5) Automatic and manual database save and restore.
 - 6) Dynamic color graphic displays with up to 10 screen displays at once.
 - 7) Custom graphics generation and graphics library of HVAC equipment and symbols.
 - 8) Alarm processing, messages, and reactions.
 - 9) Trend logs retrievable in spreadsheets and database programs.
 - 10) Alarm and event processing.
 - 11) Object and property status and control.
 - 12) Automatic restart of field equipment on restoration of power.
 - 13) Data collection, reports, and logs. Include standard reports for the following:
 - a) Current values of all objects.
 - b) Current alarm summary.
 - c) Disabled objects.
 - d) Alarm lockout objects.
 - e) Logs.
 - 14) Custom report development.
 - 15) Utility and weather reports.
 - 16) Workstation application editors for controllers and schedules.
 - 17) Maintenance management.
- p. Custom Application Software:
 - 1) English language oriented.
 - 2) Full-screen character editor/programming environment.
 - 3) Allow development of independently executing program modules with debugging/simulation capability.
 - 4) Support conditional statements.
 - 5) Support floating-point arithmetic with mathematic functions.
 - 6) Contains predefined time variables.
2. Diagnostic Terminal Unit: Portable notebook-style, PC-based microcomputer terminal capable of accessing system data by connecting to system network with minimum configuration as follows:
 - a. System: With one integrated USB 2.0 port, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.
 - b. Processor: Intel Pentium 4, <Insert clock speed> MHz.
 - c. Random-Access Memory: 128 MB.
 - d. Graphics: Video adapter, minimum 800 x 600 **OR** 1024 x 768, **as directed**, pixels, 64-MB video memory.
 - e. Monitor: 17 inches (430 mm) **OR** 19 inches (480 mm), **as directed**, LCD color.
 - f. Keyboard: QWERTY 105 keys in ergonomic shape.
 - g. Floppy-Disk Drive: 1.44 MB.
 - h. Hard-Disk Drive: 800 MB.
 - i. CD-ROM Read/Write Drive: 48x24x48.
 - j. Pointing Device: Touch pad or other internal device.



3. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
 - a. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
 - b. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - 1) Global communications.
 - 2) Discrete/digital, analog, and pulse I/O.
 - 3) Monitoring, controlling, or addressing data points.
 - 4) Software applications, scheduling, and alarm processing.
 - 5) Testing and developing control algorithms without disrupting field hardware and controlled environment.
 - c. Standard Application Programs:
 - 1) Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
 - 2) HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
 - 3) Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
 - 4) Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
 - 5) Remote communications.
 - 6) Maintenance management.
 - 7) Units of Measure: Inch-pound and SI (metric).
 - d. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
 - e. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
 - f. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
4. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
 - a. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
 - b. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - 1) Global communications.
 - 2) Discrete/digital, analog, and pulse I/O.
 - 3) Monitoring, controlling, or addressing data points.
 - c. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
 - d. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
 - e. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
5. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
 - a. Binary Inputs: Allow monitoring of on-off signals without external power.
 - b. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 - c. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.



- d. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights, **as directed**.
- e. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer, **as directed**.
- f. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
- g. Universal I/Os: Provide software selectable binary or analog outputs.
- 6. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
 - a. Output ripple of 5.0 mV maximum peak to peak.
 - b. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
 - c. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- 7. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
 - a. Minimum dielectric strength of 1000 V.
 - b. Maximum response time of 10 nanoseconds.
 - c. Minimum transverse-mode noise attenuation of 65 dB.
 - d. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

C. Unitary Controllers

- 1. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
 - a. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
 - b. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock, **as directed**. Perform automatic system diagnostics; monitor system and report failures.
 - c. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
 - d. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.
 - e. Enclosure: Dustproof rated for operation at 32 to 120 deg F (0 to 50 deg C).
 - f. Enclosure: Waterproof rated for operation at 40 to 150 deg F (5 to 65 deg C).

D. Alarm Panels

- 1. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels, **as directed**.
- 2. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.
 - a. Alarm Condition: Indicating light flashes and horn sounds.
 - b. Acknowledge Switch: Horn is silent and indicating light is steady.
 - c. Second Alarm: Horn sounds and indicating light is steady.
 - d. Alarm Condition Cleared: System is reset and indicating light is extinguished.
 - e. Contacts in alarm panel allow remote monitoring by independent alarm company.



E. Analog Controllers

1. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
2. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F (minus 23 to plus 21 deg C), and single- or double-pole contacts.
3. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
 - a. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.
4. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.
5. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.
 - a. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig (21 to 90 kPa).
 - b. Proportional band shall extend from 2 to 20 percent for 5 psig (35 kPa).
 - c. Authority shall be 20 to 200 percent.
 - d. Air-supply pressure of 18 psig (124 kPa), input signal of 3 to 15 psig (21 to 103 kPa), and output signal of zero to supply pressure.
 - e. Gages: 1-1/2 inches (38 mm) **OR** 2-1/2 inches (64 mm) **OR** 3-1/2 inches (89 mm), **as directed**, in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

F. Time Clocks

1. Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
2. Solid-state, programmable time control with 4 **OR** 8, **as directed**, separate programs each with up to 100 on-off operations; 1-second resolution; lithium battery backup; keyboard interface and manual override; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; system fault alarm; and communications package allowing networking of time controls and programming from PC.

G. Electronic Sensors

1. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
2. Thermistor Temperature Sensors and Transmitters:
 - a. Accuracy: Plus or minus 0.5 deg F (0.3 deg C) **OR** 0.36 deg F (0.2 deg C), **as directed**, at calibration point.
 - b. Wire: Twisted, shielded-pair cable.
 - c. Insertion Elements in Ducts: Single point, 8 inches (200 mm) **OR** 18 inches (460 mm), **as directed**, long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
 - d. Averaging Elements in Ducts: 36 inches (915 mm) long, flexible **OR** 72 inches (1830 mm) long, flexible **OR** 18 inches (460 mm) long, rigid, **as directed**; use where prone to temperature stratification or where ducts are larger than 10 sq. ft. (1 sq. m).
 - e. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64 mm).
 - f. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - 1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
 - 2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.



- 3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
- 4) Color: As selected from manufacturer's full range.
- 5) Orientation: Vertical **OR** Horizontal, **as directed**.
- g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
- h. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
3. RTDs and Transmitters:
 - a. Accuracy: Plus or minus 0.2 percent at calibration point.
 - b. Wire: Twisted, shielded-pair cable.
 - c. Insertion Elements in Ducts: Single point, 8 inches (200 mm) **OR** 18 inches (460 mm), **as directed**, long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
 - d. Averaging Elements in Ducts: 18 inches (460 mm) long, rigid **OR** 24 inches (610 mm) long, rigid **OR** 48 inches (1200 mm) long, rigid **OR** 24 feet (7.3 m) long, flexible, **as directed**; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (0.84 sq. m); length as required.
 - e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
 - f. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - 1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
 - 2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
 - 3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
 - 4) Color: As selected from manufacturer's full range.
 - 5) Orientation: Vertical **OR** Horizontal, **as directed**.
 - g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
 - h. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
4. Humidity Sensors: Bulk polymer sensor element.
 - a. Accuracy: 5 **OR** 2, **as directed**, percent full range with linear output.
 - b. Room Sensor Range: 20 to 80 percent relative humidity.
 - c. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - 1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
 - 2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
 - 3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
 - 4) Color: As selected from manufacturer's full range.
 - 5) Orientation: Vertical **OR** Horizontal, **as directed**.
 - d. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
 - e. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 32 to 120 deg F (0 to 50 deg C) **OR** minus 22 to plus 185 deg F (minus 30 to plus 85 deg C) **OR** minus 40 to plus 170 deg F (minus 40 to plus 76 deg C), **as directed**.
 - f. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
5. Pressure Transmitters/Transducers:
 - a. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - 1) Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - 2) Output: 4 to 20 mA.
 - 3) Building Static-Pressure Range: 0- to 0.25-inch wg (0 to 62 Pa).
 - 4) Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).



- b. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.
 - c. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
 - d. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
 - e. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.
 6. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - a. Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
 - b. Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
 - c. Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
 - d. Color: As selected from manufacturer's full range.
 - e. Orientation: Vertical **OR** Horizontal, **as directed**.
 7. Room sensor accessories include the following:
 - a. Insulating Bases: For sensors located on exterior walls.
 - b. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base **OR** Metal wire, tamperproof **OR** Locking, solid metal, ventilated, **as directed**.
 - c. Adjusting Key: As required for calibration and cover screws.
- H. Pneumatic Sensors
1. Pneumatic Transmitters: Vibration and corrosion resistant.
 - a. Space-Temperature Sensors: Linear-output type, 50 to 100 deg F (10 to 38 deg C) range, with blank locking covers matching room thermostats.
 - b. Room Return-Air Temperature Sensors: Linear-output type with bimetal sensing element and corrosion-proof construction, 50 to 100 deg F (10 to 38 deg C) range, designed to be mounted in light troffers.
 - c. Duct-Mounted or Immersion-Type Temperature Sensors: Range as required for 3- to 15-psig (21- to 103-kPa) output signal.
 - d. Temperature Transmitters: Rigid-stem type with bimetal sensing elements unless averaging is required, 3- to 15-psig (21- to 103-kPa) output signal.
 - 1) Averaging-Element Sensors: Single- or multiple-unit capillary elements.
 - 2) Tamperproof Sensors: Corrosion-resistant construction, suitable for mounting on vibrating surface with exposed capillary protected with temperature-compensated armor or protective tubing.
 - 3) Pipe-Mounted Temperature-Sensing Elements: Rod-and-tube type; with separable wells filled with heat-conductive compound.
 - 4) Outdoors: Provide bulb shield with mounting bracket.
 - e. Space and Duct Humidity Transmitters: One pipe, directly proportional, with minimum sensing span of 20 to 80 percent relative humidity for 3- to 15-psig (21- to 103-kPa) output signal, corrosion resistant and temperature compensated, and with factory-calibrated adjustment.
 - 1) Space Mounting: With covers to match thermostats.
 - f. Differential-Pressure Transmitters: One pipe, direct acting for gas, liquid, or steam service; pressure sensor and transmitter of linear-output type; with range of 0 to 50 psig (0 to 344 kPa), and 3- to 15-psig (21- to 103-kPa) output signal.
 - g. Differential-Air-Pressure Transmitters: One pipe, direct acting, double bell; unidirectional with suitable range for expected input; and temperature compensated.
 - 1) Accuracy: 5 percent of full range and 2 percent of full scale at midrange.
 - 2) Output Signal: 3 to 15 psig (21 to 103 kPa).
 2. Digital-to-Pneumatic Transducers: Convert plus or minus 12-V dc pulse-width-modulation outputs, or continuous proportional current or voltage to 0 to 20 psig (0 to 140 kPa).
 3. Pneumatic Valve/Damper Position Indicator: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.



- I. Status Sensors
1. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).
 2. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.
 3. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
 4. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
 5. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
 6. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
 7. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 8. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.
- J. Gas Detection Equipment
1. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F (0 to 40 deg C); with 2 factory-calibrated alarm levels at 50 and 100 **OR** 35 and 200, **as directed**, ppm.
 2. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C) and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.
 3. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of minus 32 to plus 1100 deg F (0 to 593 deg C) and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.
 4. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.
- K. Flow Measuring Stations
1. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.
 - a. Casing: Galvanized-steel frame.
 - b. Flow Straightener: Aluminum honeycomb, 3/4-inch (20-mm) parallel cell, 3 inches (75 mm) deep.
 - c. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.
- L. Thermostats
1. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.
 - a. Label switches "FAN ON-OFF" **OR** "FAN HIGH-LOW-OFF" **OR** "FAN HIGH-MED-LOW-OFF", **as directed**.
 - b. Mount on single electric switch box.
 2. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
 - a. Automatic switching from heating to cooling.
 - b. Preferential rate control to minimize overshoot and deviation from set point.
 - c. Set up for four separate temperatures per day.
 - d. Instant override of set point for continuous or timed period from 1 hour to 31 days.
 - e. Short-cycle protection.



- f. Programming based on weekday, Saturday, and Sunday **OR** every day of week, **as directed**.
 - g. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
 - h. Battery replacement without program loss.
 - i. Thermostat display features include the following:
 - 1) Time of day.
 - 2) Actual room temperature.
 - 3) Programmed temperature.
 - 4) Programmed time.
 - 5) Duration of timed override.
 - 6) Day of week.
 - 7) System mode indications include "heating," "off," "fan auto," and "fan on."
3. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
 4. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
 - a. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
 - b. Selector Switch: Integral, manual on-off-auto.
 5. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
 - a. Bulbs in water lines with separate wells of same material as bulb.
 - b. Bulbs in air ducts with flanges and shields.
 - c. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
 - d. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
 - e. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
 - f. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
 6. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature, and the following:
 - a. Reset: Manual.
OR
Reset: Automatic, with control circuit arranged to require manual reset at central control panel; with pilot light and reset switch on panel labeled to indicate operation.
 7. Pneumatic Room Thermostats: One **OR** Two **OR** Three, **as directed**, pipe(s), fully proportional with adjustable throttling range and tamperproof locking settings, direct or reverse acting as required. Factory calibrated at 2.5 psig/deg F (17.2 kPa/deg C).
 - a. Factory Calibration: 2.5 psig/deg F (17.2 kPa/deg C).
 - b. Range: 45 to 85 deg F (7 to 30 deg C).
 - c. Sensitivity Adjustment Range: 1 to 4 psig/deg F (7 to 27.6 kPa/deg C).
 - d. Dual-Temperature Thermostats: Automatic changeover from normal setting to lower setting for unoccupied cycles, with manual-reset lever to permit return to normal temperatures during unoccupied cycles, with automatic reset to normal during next cycle of operation.
 - e. Limits: Field adjustable, to limit setting cooling set point below 75 deg F (24 deg C), and heating set point above 75 deg F (24 deg C).
 - f. Room Thermostat Cover Construction: Manufacturer's standard locking covers.
 - 1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.



- 2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
 - 3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
 - 4) Color: As selected from manufacturer's full range.
 - 5) Orientation: Vertical **OR** Horizontal, **as directed**.
- g. Room thermostat accessories include the following:
- 1) Insulating Bases: For thermostats located on exterior walls.
 - 2) Thermostat Guards: Locking; heavy-duty, transparent plastic; mounted on separate base **OR** Metal wire, tamperproof **OR** Locking, solid metal, ventilated, **as directed**.
 - 3) Adjusting Key: As required for calibration and cover screws.
 - 4) Aspirating Boxes: For flush-mounted aspirating thermostats.
 - 5) Set-Point Adjustment: 1/2-inch- (13-mm-) diameter, adjustment knob.
8. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
 9. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.
 10. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-, **as directed**, reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.
 - a. Bulb Length: Minimum 20 feet (6 m).
 - b. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.
 11. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-, **as directed**, reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.
 - a. Bulb Length: Minimum 20 feet (6 m).
 - b. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.
 12. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig (172 kPa), and cast housing with position indicator and adjusting knob.
- M. Humidistats
1. Pneumatic Room Humidistats: Wall-mounting, proportioning type with adjustable throttling range, 20 to 90 **OR** 55 to 95 **OR** 25 to 65, **as directed**, percent operating range, and cover matching room thermostat cover.
 2. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.
 3. Pneumatic Duct-Mounting Humidistats: Proportioning type with adjustable throttling range, 20 to 90 **OR** 55 to 95 **OR** 25 to 65, **as directed**, percent operating range, in galvanized-steel duct box.
- N. Actuators
1. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - a. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - b. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - c. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 - d. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
 - e. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).



- f. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
 2. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - a. Valves: Size for torque required for valve close off at maximum pump differential pressure.
 - b. Dampers: Size for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - 2) Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - 3) Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
 - 4) Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
 - c. Coupling: V-bolt and V-shaped, toothed cradle.
 - d. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - e. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
 - f. Power Requirements (Two-Position Spring Return): 24 **OR** 120 **OR** 230, **as directed**, -V ac.
 - g. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
 - h. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 - i. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) **OR** 40 to 104 deg F (5 to 40 deg C), **as directed**.
 - j. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).
 - k. Run Time: 12 seconds open, 5 seconds closed **OR** 30 seconds **OR** 60 seconds **OR** 120 seconds, **as directed**.
 3. Pneumatic Valve Operators: Rolling-diaphragm, spring-loaded, piston type with spring range as required and start-point adjustment and positioning relay, **as directed**. Operator shall maintain full shutoff at maximum pump differential pressure.
 4. Pneumatic Damper Operators: Rolling-diaphragm, piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Where actuators operate in sequence, provide pilot positioners.
 - a. Pilot Positioners: With the following characteristics:
 - 1) Start Point: Adjustable from 2 to 12 psig (14 to 83 kPa).
 - 2) Operating Span: Adjustable from 5 to 13 psig (35 to 90 kPa).
 - 3) Linearity: Plus or minus 10 percent of output signal span.
 - 4) Hysteresis: 3 percent of span.
 - 5) Response: 0.25-psig (1723-Pa) input change.
 - 6) Maximum Pilot Signal Pressure: 20 psig (140 kPa).
 - 7) Maximum Control Air-Supply Pressure: 60 psig (410 kPa).
 - b. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 deg F (10 to 60 deg C) unless located in return-air plenums, **as directed**.
 - c. Inlet-Vane Operators: High pressure, with pilot positioners.
- O. Control Valves
1. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
 2. Hydronic system globe valves shall have the following characteristics:



- a. NPS 2 (DN 50) and Smaller: Class 125 **OR** 250, **as directed**, bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
 - b. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
 - c. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
 - 1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
 - 2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
 - d. Sizing: 3-psig (21-kPa) **OR** 5-psig (35-kPa), **as directed**, maximum pressure drop at design flow rate or the following:
 - 1) Two Position: Line size.
 - 2) Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
 - 3) Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
 - e. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
 - f. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
3. Steam system globe valves shall have the following characteristics:
- a. NPS 2 (DN 50) and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
 - b. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
 - c. Internal Construction: Replaceable plugs and stainless-steel seats.
 - 1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
 - 2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
 - d. Sizing: For pressure drop based on the following services:
 - 1) Two Position: 20 percent of inlet pressure.
 - 2) Modulating 15-psig (103-kPa) Steam: 80 percent of inlet steam pressure.
 - 3) Modulating 16- to 50-psig (110- to 350-kPa) Steam: 50 percent of inlet steam pressure.
 - 4) Modulating More Than 50-psig (350-kPa) Steam: As indicated.
 - e. Flow Characteristics: Modified linear characteristics.
 - f. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.
4. Butterfly Valves: 200-psig (1380-kPa), 150-psig (1034-kPa) maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
- a. Body Style: Wafer **OR** Lug **OR** Grooved, **as directed**.
 - b. Disc Type: Nickel-plated ductile iron **OR** Aluminum bronze **OR** Elastomer-coated ductile iron **OR** Epoxy-coated ductile iron, **as directed**.
 - c. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.
5. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
- a. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
 - b. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.



- c. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
 6. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
 - a. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
 - b. Thermostatic Operator: Wax **OR** Liquid, **as directed**,-filled integral **OR** remote, **as directed**, sensor with integral **OR** remote, **as directed**, adjustable dial.
- P. Dampers
1. Dampers: AMCA-rated, parallel **OR** opposed, **as directed**,-blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
 - a. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze **OR** nylon, **as directed**, blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 - b. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 - c. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
OR
Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.
- Q. Air Supply
1. Control and Instrumentation Tubing: Copper tubing complying with ASTM B 88, Type K (ASTM B 88M, Type A) or ASTM B 280 Type ACR.
 - a. Fittings: Cast-bronze solder fittings complying with ASME B16.18; or wrought-copper solder fittings complying with ASME B16.22, except forged-brass compression-type fittings at connections to equipment.
 - b. Joining Method: Soldered or brazed.
OR
Control and Instrumentation Tubing: ASTM D 2737 Type FR plenum-rated polyethylene, flame-retardant, nonmetallic tubing rated for 30 psig (207 kPa) and ambient temperature range of 10 to 150 deg F (minus 13 to plus 65 deg C) with flame-retardant harness for multiple tubing.
 - c. Fittings: Compression or push-on polyethylene fittings.
 2. Tank: ASME storage tank with drain test cock, automatic moisture removal trap, tank relief valve, and rubber-cork vibration isolation mounting pads.
 3. Duplex Air Compressor: Capacity to supply compressed air to temperature-control system.
 - a. Pressure control with adjustable electric contacts, set to start and stop both compressors at different pressures.
 - b. Electrical alternation set with motor starters and disconnect to operate compressors alternately or on time schedule.
 4. Simplex Air Compressor: Tank-mounting compressor with capacity to supply compressed air to temperature-control system, with starter and disconnect.
 - a. Pressure control with adjustable electric contacts, set to start and stop compressor.
 5. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
 6. Size compressor and tank to operate compressor not more than 20 **OR** 30, **as directed**, minutes during a 60-minute period.
 7. Compressor Accessories: Low-resistance intake-air filter, and belt guards.



8. System Accessories: Air filter rated for 97 percent efficiency at rated airflow, and combination filter/pressure-reducing station or separate filter and pressure-reducing station.
9. Refrigerated Air Dryer: Self-contained, refrigerated air dryer complete with heat exchangers, moisture separator, internal wiring and piping, and with manual bypass valve.
 - a. Heat Exchangers: Air-to-refrigerant coils with centrifugal-type moisture separator and automatic trap assembly.
 - b. Refrigeration Unit: Hermetically sealed, operating to maintain dew point of 13 deg F (minus 11 deg C) at 20 psig (140 kPa), housed in steel cabinet with access door and panel.
 - c. Accessories: Air-inlet temperature gage, air-inlet pressure gage, on-off switch, high-temperature light, power-on light, refrigerant gage on back, air-outlet temperature gage, air-outlet pressure gage, and with contacts for remote indication of power status and high-temperature alarm.
10. Desiccant Dryer: Obtains dew point in pneumatic air piping between compressor and tank at least 15 deg F (minus 9 deg C) below inlet-air dew point at design conditions.
11. Pressure Gages: Black letters on white background, 2-1/2 inches (64 mm) in diameter, flush or surface mounting, with front calibration screw to match sensor, and having a graduated scale in psig (kPa).
12. Instrument Pressure Gages: Black letters on white background, 1-1/2 inches (38 mm) in diameter, stem mounted, with suitable dial range.
13. Diaphragm Control and Instrument Valves: 1/4-inch (6-mm) forged-brass body with reinforced polytetrafluoroethylene diaphragm, stainless-steel spring, and color-coded phenolic handle.
14. Gage Cocks: Tee or level handle, bronze, rated for 125 psig (860 kPa).
15. Relays: For summing, reversing, and amplifying highest or lowest pressure selection; with adjustable I/O ratio.
16. Switches: With indicating plates and accessible adjustment; calibrated and marked.
17. Pressure Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve.
18. Particle Filters: Zinc or aluminum castings with 97 percent filtration efficiency at rated airflow, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.
19. Combination Filter/Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve; with threaded pipe connections, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.
20. Airborne Oil Filter: Filtration efficiency of 99.9 percent for airborne lubricating oil particles of 0.025 micron or larger.
21. Pressure Relief Valves: ASME rated and labeled.
 - a. High Pressure: Size for installed capacity.
 - b. Low Pressure: Size for installed capacity of pressure regulators and set at 20 percent above low pressure.
22. Pressure-Reducing Stations: Two parallel pressure regulators.

R. Control Cable

1. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling".

1.3 EXECUTION

A. Installation

1. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
2. Connect and configure equipment and software to achieve sequence of operation specified.



3. Mount compressor and tank unit on elastomeric mounts **OR** spring isolators with 1-inch (25 mm) static deflection **OR** restrained spring isolators with 1-inch (25-mm) static deflection, **as directed**. Vibration isolators are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Isolate air supply with wire-braid-reinforced rubber hose. Secure and anchor according to manufacturer's written instructions and seismic-control requirements.
 - a. Pipe manual and automatic drains to nearest floor drain.
 - b. Supply instrument air from compressor units through filter, pressure-reducing valve, and pressure relief valve, with pressure gages and shutoff and bypass valves.
 4. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1530 mm), **as directed**, above the floor.
 - a. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
 5. Install guards on thermostats in the following locations:
 - a. Entrances.
 - b. Public areas.
 - c. Where indicated.
 6. Install automatic dampers according to Division 23 Section "Air Duct Accessories".
 7. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
 8. Install labels and nameplates to identify control components according to Division 23 Section "Identification For Hvac Piping And Equipment".
 9. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping".
 10. Install steam and condensate instrument wells, valves, and other accessories according to Division 23 Section "Steam And Condensate Heating Piping".
 11. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping".
 12. Install duct volume-control dampers according to Division 21 specifying air ducts.
 13. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling".
- B. Pneumatic Piping Installation
1. Install piping in mechanical equipment rooms inside mechanical equipment enclosures, in pipe chases, or suspended ceilings with easy access.
 - a. Install copper tubing with maximum unsupported length of 36 inches (915 mm), for tubing exposed to view.
 - b. Install polyethylene tubing in metallic raceways or electrical metallic tubing. Electrical metallic tubing materials and installation requirements are specified in Division 26 Section "Underfloor Raceways For Electrical Systems".
 2. Install terminal single-line connections, less than 18 inches (460 mm) in length, with copper or polyethylene tubing run inside flexible steel protection.
 3. In concealed locations such as pipe chases and suspended ceilings with easy access, install copper **OR** polyethylene bundled and sheathed **OR** polyethylene tubing in electrical metallic, **as directed**, tubing. Electrical metallic tubing materials and installation requirements are specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
 4. In concrete slabs, furred walls, or ceilings with no access, install copper or polyethylene tubing in electrical metallic tubing or vinyl-jacketed polyethylene tubing.
 - a. Protect embedded-copper and vinyl-jacketed polyethylene tubing with electrical metallic tubing extending 6 inches (150 mm) above finished slab and 6 inches (150 mm) into slab. Pressure test tubing before and after pour for leak and pinch.
 - b. Install polyethylene tubing in electrical metallic tubing extending 6 inches (150 mm) above floor line; pull tubing into electrical metallic tubing after pour.
 5. Install tubing with sufficient slack and flexible connections to allow for vibration of piping and equipment.
 6. Purge tubing with dry, oil-free compressed air before connecting control instruments.



- a. Bridge cabinets and doors with flexible connections fastened along hinge side; protect against abrasion. Tie and support tubing.
 7. Number-code or color-code control air piping for future identification and service of control system, except local individual room control tubing.
 8. Pressure Gages or Test Plugs: Install on branch lines at each receiver controller and on signal lines at each transmitter, except individual room controllers.
- C. Electrical Wiring And Connection Installation
1. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway And Boxes For Electrical Systems".
 2. Install building wire and cable according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
 3. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling".
 - a. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - b. Install exposed cable in raceway.
 - c. Install concealed cable in raceway.
 - d. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - e. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - f. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - g. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
 4. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
 5. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
- D. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
 - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 - b. Test and adjust controls and safeties.
 - c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - d. Pressure test control air piping at 30 psig (207 kPa) or 1.5 times the operating pressure for 24 hours, with maximum 5-psig (35-kPa) loss.
 - e. Pressure test high-pressure control air piping at 150 psig (1034 kPa) and low-pressure control air piping at 30 psig (207 kPa) for 2 hours, with maximum 1-psig (7-kPa) loss.
 - f. Test calibration of pneumatic **OR** electronic, **as directed**, controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - g. Test each point through its full operating range to verify that safety and operating control set points are as required.
 - h. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 - i. Test each system for compliance with sequence of operation.
 - j. Test software and hardware interlocks.
 2. DDC Verification:
 - a. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 - b. Check instruments for proper location and accessibility.
 - c. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.



- d. Check instrument tubing for proper fittings, slope, material, and support.
- e. Check installation of air supply for each instrument.
- f. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
- g. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
- h. Check temperature instruments and material and length of sensing elements.
- i. Check control valves. Verify that they are in correct direction.
- j. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
- k. Check DDC system as follows:
 - 1) Verify that DDC controller power supply is from emergency power supply, if applicable.
 - 2) Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - 3) Verify that spare I/O capacity has been provided.
 - 4) Verify that DDC controllers are protected from power supply surges.
- 3. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

E. Adjusting

- 1. Calibrating and Adjusting:
 - a. Calibrate instruments.
 - b. Make three-point calibration test for both linearity and accuracy for each analog instrument.
 - c. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
 - d. Control System Inputs and Outputs:
 - 1) Check analog inputs at 0, 50, and 100 percent of span.
 - 2) Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - 3) Check digital inputs using jumper wire.
 - 4) Check digital outputs using ohmmeter to test for contact making or breaking.
 - 5) Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
 - e. Flow:
 - 1) Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - 2) Manually operate flow switches to verify that they make or break contact.
 - f. Pressure:
 - 1) Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - 2) Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
 - g. Temperature:
 - 1) Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - 2) Calibrate temperature switches to make or break contacts.
 - h. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
 - i. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
 - j. Provide diagnostic and test instruments for calibration and adjustment of system.
 - k. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- 2. Adjust initial temperature and humidity set points.



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3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

F. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

END OF SECTION 23 09 00 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 13 56	23 09 00 00	HVAC Instrumentation And Controls



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SECTION 23 09 23 00 - ENCLOSED CONTROLLERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for enclosed controllers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes the following enclosed controllers rated 600 V and less:
 - a. Full-voltage manual.
 - b. Full-voltage magnetic.
 - c. Reduced-voltage magnetic.
 - d. Reduced-voltage solid state.
 - e. Multispeed.

C. Definitions

1. CPT: Control power transformer.
2. MCCB: Molded-case circuit breaker.
3. MCP: Motor circuit protector.
4. N.C.: Normally closed.
5. N.O.: Normally open.
6. OCPD: Overcurrent protective device.
7. SCR: Silicon-controlled rectifier.

D. Performance Requirements

1. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
2. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
 - a. Show tabulations of the following:
 - 1) Each installed unit's type and details.
 - 2) Factory-installed devices.
 - 3) Nameplate legends.
 - 4) Short-circuit current rating of integrated unit.
 - 5) Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - 6) Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Qualification Data: For qualified testing agency.
4. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.



- b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 5. Field quality-control reports.
 6. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. Include the following:
 - a. Routine maintenance requirements for enclosed controllers and installed components.
 - b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
 - c. Manufacturer's written instructions for setting field-adjustable overload relays.
 - d. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.
 7. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
 8. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.
- F. Quality Assurance
1. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
 2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 3. Comply with NFPA 70.
 4. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
- G. Delivery, Storage, And Handling
1. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
 2. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller **OR** connect factory-installed space heaters to temporary electrical service, **as directed**.
- H. Project Conditions
1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2010 m).
 2. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical systems.
 - b. Indicate method of providing temporary utilities.
 - c. Do not proceed with interruption of electrical systems without the Owner's written permission.
 - d. Comply with NFPA 70E.



- I. Coordination
 1. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
 2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
 3. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.2 PRODUCTS

A. Full-Voltage Controllers

1. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
2. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
 - a. Configuration: Nonreversing **OR** Reversing **OR** Two speed, **as directed**.
 - b. Flush **OR** Surface, **as directed**, mounting.
 - c. Red **OR** Green, **as directed**, pilot light.
 - d. Additional Nameplates: FORWARD and REVERSE for reversing switches **OR** HIGH and LOW for two-speed switches, **as directed**.
3. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - a. Configuration: Nonreversing **OR** Two speed, **as directed**.
 - b. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type **OR** melting alloy type, **as directed**.
 - c. Flush **OR** Surface, **as directed**, mounting.
 - d. Red **OR** Green, **as directed**, pilot light.
 - e. Additional Nameplates: HIGH and LOW for two-speed controllers.
4. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - a. Configuration: Nonreversing **OR** Reversing **OR** Two speed, **as directed**.
 - b. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type **OR** melting alloy type, **as directed**.
 - c. Flush **OR** Surface, **as directed**, mounting.
 - d. Red **OR** Green, **as directed**, pilot light.
 - e. Additional Nameplates: FORWARD and REVERSE for reversing controllers **OR** HIGH and LOW for two-speed controllers, **as directed**.
 - f. N.O. **OR** N.C., **as directed**, auxiliary contact.
5. Magnetic Controllers: Full voltage, across the line, electrically held.
 - a. Configuration: Nonreversing **OR** Reversing, **as directed**.
 - b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
 - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - c. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - d. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
 - e. Melting Alloy Overload Relays:



- 1) Inverse-time-current characteristic.
- 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
- 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
- f. Bimetallic Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 4) Ambient compensated.
 - 5) Automatic resetting.
- g. Solid-State Overload Relay:
 - 1) Switch or dial selectable for motor running overload protection.
 - 2) Sensors in each phase.
 - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 5) Analog communication module.
- h. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
- i. External overload reset push button.
6. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
 - a. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 - b. Nonfusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 - c. MCP Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
 - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
 - d. MCCB Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.



- 5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.
- B. Reduced-Voltage Magnetic Controllers
1. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.
 2. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
 - a. Configuration:
 - 1) Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
 - 2) Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
 - 3) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
 - b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
 - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - c. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - d. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
 - e. Melting Alloy Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - f. Bimetallic Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 4) Ambient compensated.
 - 5) Automatic resetting.
 - g. Solid-State Overload Relay:
 - 1) Switch or dial selectable for motor running overload protection.
 - 2) Sensors in each phase.
 - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 5) Analog communication module.
 - h. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
 - i. External overload reset push button.
 3. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
 - a. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.



- 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 - b. Nonfusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 - c. MCP Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
 - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
 - d. MCCB Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - 5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.
- C. Reduced-Voltage Solid-State Controllers
1. General Requirements for Reduced-Voltage Solid-State Controllers: Comply with UL 508.
 2. Reduced-Voltage Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
 - a. Configuration: Standard duty **OR** Severe duty, **as directed**; nonreversible **OR** reversible, **as directed**.
 - b. Starting Mode: Voltage ramping **OR** Current limit **OR** Torque control **OR** Torque control with voltage boost, **as directed**; field selectable, **as directed**.
 - c. Stopping Mode: Coast to stop **OR** Adjustable torque deceleration **OR** Adjustable braking, **as directed**; field selectable, **as directed**.
 - d. Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
 - e. Shorting and Input Isolation, **as directed**, Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors, **as directed**.
 - f. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
 - g. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) CPT Spare Capacity: 100 **OR** 200, **as directed**, VA.



- h. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
- i. SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with **OR** without, **as directed**, external feedback from the motor or driven equipment.
- j. Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
 - 1) Adjusting motor full-load amperes, as a percentage of the controller's rating.
 - 2) Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
 - 3) Adjusting linear acceleration and deceleration ramps, in seconds.
 - 4) Initial torque, as a percentage of the nominal motor torque.
 - 5) Adjusting torque limit, as a percentage of the nominal motor torque.
 - 6) Adjusting maximum start time, in seconds.
 - 7) Adjusting voltage boost, as a percentage of the nominal supply voltage.
 - 8) Selecting stopping mode, and adjusting parameters.
 - 9) Selecting motor thermal overload protection class between 5 and 30.
 - 10) Activating and de-activating protection modes.
 - 11) Selecting or activating communication modes.
- k. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
 - 1) Controller Condition: Ready, starting, running, stopping.
 - 2) Motor Condition: Amperes, voltage, power factor, power, and thermal state.
 - 3) Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.
- l. Controller Diagnostics and Protection:
 - 1) Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 - 2) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
 - 3) Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component or when the motor is stopped.
OR
Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.
- m. Remote Output Features:
 - 1) All outputs prewired to terminal blocks.
 - 2) Form C status contacts that change state when controller is running.
 - 3) Form C alarm contacts that change state when a fault condition occurs.
- n. Optional Features:
 - 1) Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc **OR** 4 to 20-mA dc, **as directed**.
 - 2) Additional field-assignable Form C contacts, as indicated, for alarm outputs.
 - 3) Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - 4) Full-voltage bypass contactor operating automatically **OR** manually, with NORMAL/BYPASS selector switch, **as directed**. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.
 - 5) Melting Alloy Overload Relays:
 - a) Inverse-time-current characteristic.
 - b) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.



- c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 6) Bimetallic Overload Relays:
 - a) Inverse-time-current characteristic.
 - b) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
 - 7) Solid-State Overload Relay:
 - a) Switch or dial selectable for motor running overload protection.
 - b) Sensors in each phase.
 - c) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - e) Analog communication module.
 - 8) N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
 - 9) External overload reset push button.
- 3. Combination Reduced-Voltage Solid-State Controller: Factory-assembled combination of reduced-voltage solid-state controller, OCPD, and disconnecting means.
 - a. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class L **OR** indicated, **as directed**, fuses.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 - b. MCP Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
 - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
 - c. MCCB Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - 5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.
 - d. Molded-Case Switch Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.



- 3) Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
- 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when molded-case switch has tripped.

D. Multispeed Magnetic Controllers

1. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
2. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held.
 - a. Configuration: Nonreversing **OR** Reversing, **as directed**; consequent pole **OR** two winding, **as directed**.
 - b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
 - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - c. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - d. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
 - e. Compelling relays shall ensure that motor will start only at low speed.
 - f. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
 - g. Decelerating timer relays shall ensure automatically timed deceleration through each speed.
 - h. Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.
 - i. Melting Alloy Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - j. Bimetallic Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 4) Ambient compensated.
 - 5) Automatic resetting.
 - k. Solid-State Overload Relay:
 - 1) Switch or dial selectable for motor running overload protection.
 - 2) Sensors in each phase.
 - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 5) Analog communication module.
 - l. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
 - m. External overload reset push button.
3. Combination Multispeed Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
 - a. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.



- 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- b. Nonfusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- c. MCP Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
 - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
- d. MCCB Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - 5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.

E. Enclosures

1. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
 - a. Dry and Clean Indoor Locations: Type 1.
 - b. Outdoor Locations: Type 3R **OR** Type 4X, **as directed**.
 - c. Kitchen **OR** Wash-Down, **as directed**, Areas: Type 4X, stainless steel.
 - d. Other Wet or Damp Indoor Locations: Type 4.
 - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
 - f. Hazardous Areas Indicated on Drawings: Type 7 **OR** Type 9, **as directed**.

F. Accessories

1. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
 - a. Push Buttons, Pilot Lights, and Selector Switches: Heavy **OR** Standard, **as directed**, -duty, oiltight, **as directed**, type.
 - 1) Push Buttons: Covered **OR** Lockable **OR** Recessed **OR** Shielded **OR** Shrouded **OR** Unguarded, **as directed**, types; maintained **OR** momentary, **as directed**, as indicated.
 - 2) Pilot Lights: Incandescent **OR** LED **OR** Neon **OR** Resistor **OR** Transformer, **as directed**, types; colors as indicated; push to test, **as directed**.
 - 3) Selector Switches: Rotary type.
 - b. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable **OR** resettable, **as directed**.



- c. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.
2. N.C. **OR** N.O. **OR** Reversible N.C./N.O., **as directed**, auxiliary contact(s).
3. Control Relays: Auxiliary and adjustable pneumatic **OR** solid-state, **as directed**, time-delay relays.
4. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
5. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 **OR** Type 4X **OR** Type 7 **OR** Type 9, **as directed**, enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
6. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R **OR** Type 4X **OR** Type 12, **as directed**, enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
7. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
8. Cover gaskets for Type 1 enclosures.
9. Terminals for connecting power factor correction capacitors to the line **OR** load, **as directed**, side of overload relays.
10. Spare control wiring terminal blocks, quantity as indicated; unwired **OR** wired, **as directed**.

1.3 EXECUTION

A. Examination

1. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
2. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers And Supports For Electrical Systems".
2. Floor-Mounted Controllers: Install enclosed controllers on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in each fusible-switch enclosed controller.
6. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses".
7. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.



8. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
9. Install power factor correction capacitors. Connect to the line **OR** load, **as directed**, side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
10. Comply with NECA 1.

C. Identification

1. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
 - a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - b. Label each enclosure with engraved nameplate.
 - c. Label each enclosure-mounted control and pilot device.

D. Control Wiring Installation

1. Install wiring between enclosed controllers and remote devices and facility's central control system, **as directed**. Comply with requirements in Division 26 Section "Control-voltage Electrical Power Cables".
2. Bundle, train, and support wiring in enclosures.
3. Connect selector switches and other automatic-control selection devices where applicable.
 - a. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
 - b. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

E. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Perform tests and inspections.
3. Acceptance Testing Preparation:
 - a. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
 - b. Test continuity of each circuit.
4. Tests and Inspections:
 - a. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment, **as directed**.
 - b. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
 - c. Test continuity of each circuit.
 - d. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify the Owner before starting the motor(s).
 - e. Test each motor for proper phase rotation.
 - f. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - g. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - h. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
 - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
 - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multi-pole enclosed controller 11 months after date of Final Completion.



- 3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - i. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 5. Enclosed controllers will be considered defective if they do not pass tests and inspections.
 6. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- F. Adjusting
1. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
 2. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
 3. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify the Owner before increasing settings.
 4. Set the taps on reduced-voltage autotransformer controllers at 50 **OR** 65 **OR** 80, **as directed**, percent.
 5. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.
 6. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study", **as directed**.
- G. Protection
1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
 2. Replace controllers whose interiors have been exposed to water or other liquids prior to Final Completion.
- H. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage solid-state controllers, **as directed**.

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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 09 23 00	23 09 00 00	HVAC Instrumentation And Controls



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**SECTION 23 11 23 00 - RELIEF WELLS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for relief wells. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Shop Drawings: Submit shop drawings.
2. Statements
 - a. Before installation, all well screen shall be approved.
 - b. The filter pack material and its gradation shall be approved before it is placed.
 - c. Submit the cement grout mixture proportion to be used in plugging abandoned wells.
3. Reports: Submit sampling and testing reports for each relief well, logs of the borings, well screen and riser pipe, backfill material, and pump tests. Register each well with the state as required by the state in which the well is installed.

- C. Regulatory Requirements: The state statutory and regulatory requirements form a part of this specification.

1.2 PRODUCTS

- A. Well Screen: The Contractor may, at its option, furnish and install well screen of any of the alternate types specified. The clear inside diameter of the screen shall be as directed by the Owner. Screen openings shall be uniform in size and pattern, and shall be spaced approximately equally around the circumference of the pipe.

1. PVC Pipe Screen: Pipe, fittings, and screen shall be of the size and types specified. Pipe, fittings, and screen shall conform to ASTM D 1784, ASTM D 1785, ASTM D 2466, or ASTM D 2467. All joints in the PVC pipe shall include couplings and shall be glued with a solvent cement conforming to ASTM D 2564. The PVC pipe strength properties shall be equivalent to PVC 1120 Schedule 40 **OR** 80, **as directed**, unthreaded plastic pipe.
 - a. Couplings: Couplings shall be bonded socket **OR** threaded, **OR** certilock, **as directed**, type. Fittings shall be produced of the same material and equal quality as specified for plastic pipe screen. Socket type fitting connections of pipe sections shall be bonded with solvent cement. The determination of the proportions and preparation of adhesives, the method of application, and the procedure used for making and curing the connections shall be the responsibility of the Contractor. The system for making joints at the relief well site shall provide a curing period adequate to develop the ultimate strength of the solvent cement. Self-tapping screws or other devices for holding pipe in the couplings during the setting period may be utilized as long as the screws do not penetrate the inside of the pipe. In no case shall a newly-made joint in the casing be stressed, lowered into the relief well, or be submerged in water prior to complete curing of the solvent cement adhesive.
 - b. Perforations: The PVC well screen shall be mill slot **OR** continuous wire wrapped rod base **OR** continuous wire wrapped rod base on perforated pipe **OR** continuous wire wrapped on perforated pipe screen **OR** similar to that manufactured by Johnson Well Equipment, Inc., Pensacola, FL, telephone (904) 453-3131, **as directed**. All well screen shall have smooth, sharp-edged openings free of burns, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.



2. **Fiberglass Pipe Screen:** Fiberglass pipe screen and fittings shall be manufactured from thermosetting epoxy resins and glass fiber by either a centrifugal casting process or by a filament winding process. Glass fiber used shall be continuous filament, electrical glass with a finish compatible with epoxy resins. Each glass fiber or filament shall be thoroughly impregnated with epoxy resin. Fiberglass pipe wall thickness, strength and durability requirements shall be equivalent to the Fiberglass/Epoxy pipe produced by Fiberglass Resources Corporation of Farmingdale, New York or Burgess Well Company, Inc., Minden, Nebraska, telephone (308) 832-1642. All fiberglass pipe and fittings shall be round and straight, of uniform quality and workmanship, and free from all defects including indentation, delamination, bends, cracks, blisters, porosity, dry spots, resin segregation and resin-starved areas. The inside of the pipe and fittings shall be smooth and uniform. The impregnation of the glass fiber with resin shall be such that when the pipe is cut or slotted, no fraying or looseness of glass fiber occurs.
 - a. **Couplings:** Couplings for fiberglass pipe sections shall be socket threaded or mechanical key-type couplings. The couplings shall be manufactured of the same materials used for the fiberglass pipe specified herein and may be either cast integrally with the pipe sections or as separate components for attachment to the pipe in the manufacturers plant. Key-type couplings shall consist of male and female halves designed for joining and locking together by means of a key strip inserted in grooves in the coupling halves. The minimum wall thickness remaining at any grooved section shall not be less than the minimum thickness specified for pipe. Key strips and locking strips shall be of fiberglass, plastic or other non-corrosive material capable of withstanding shearing and bearing stresses equivalent to the design load for the coupling. Socket type fitting connections of the pipe sections shall be bonded with epoxy adhesive. The epoxy materials and bonding agents shall be as recommended by the pipe manufacturer. Self-tapping screws or other devices for holding adhesive-joined pipe in the couplings during the curing period may be utilized. In no case shall a newly-made joint in the casing pipe be lowered into the relief well, or be submerged in water prior to complete curing of the adhesive.
 - b. **Perforations:** All fiberglass well screen shall be mill slot **OR** continuous wire wrapped rod base, **as directed**. All relief well screen shall have smooth, sharp-edged openings free of burrs, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.
3. **Steel Pipe Screen:** Steel well screen shall consist of perforated or slotted sections of steel pipe conforming to the requirements of ASTM A 53.
 - a. **Couplings:** Couplings for steel pipe screen shall be welded joints or threaded couplings. Welding shall be performed in accordance with requirements in ASME B31.9. Couplings shall meet the material requirements specified for steel pipe screen, except perforations shall be omitted. All threaded pipe and fittings shall be threaded in accordance with ASME B1.20.1. All threaded pipe sections may be field connected. Couplings shall be given the same protection against corrosion as specified for the well screen pipe. Protective coatings damaged while making couplings shall have the areas recoated.
 - b. **Perforations:** All steel pipe to be used as relief well screen shall be provided with perforations which shall consist of either machine-cut slots; drilled or punched openings. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe. The pattern of the openings shall be uniformly spaced around the periphery of the pipe.
4. **Stainless Steel Well Screen:** The perforated well screen and fittings shall be fabricated entirely from stainless steel conforming to ASTM A 312/A 312M, Type 304, 304-L, 316 or 316-L. The well screen shall be of stainless steel with a keystone wire-wrapped continuous slot strainer equivalent to that manufactured by Howard Smith Screen Company, Houston, TX, telephone (713) 869-5771 or Johnson Screens, St. Paul, MN 55164, telephone (612) 636-3900.
 - a. **Couplings:** Couplings for the stainless steel well screen shall consist of the same material as the well screen and shall be threaded, flanged, and/or fitted with a welding ring. The



couplings shall conform in design to the couplings recommended by the manufacturer of the well screen.

- b. Tailpipe for Well Screen: The tailpipe for each well screen shall be made of the same material and at least the same minimum thickness as the riser pipe and shall include a bottom plug.
- B. Riser Pipe: The relief well riser pipe material and method of manufacture shall conform to the requirements specified in paragraph WELL SCREEN, except that the screen perforations or opening shall be omitted. The relief well riser pipe diameter and discharge details shall be as directed. Couplings to the well screen and between riser pipe sections shall be as specified in paragraph COUPLING.
- C. Filter Pack: Material for the filter pack around the riser pipes and screens shall be a washed grave, **OR** washed sand **OR** dry processed sand, **as directed**, composed of hard, tough, and durable particles free from adherent coating. The filter pack shall not be crushed stone. The filter pack material shall contain no detrimental quantities of organic matter nor soft, friable, thin, or elongated particles in accordance with the quality requirements in ASTM C 33, Table 1 and Table 3, Class 5S, and in ASTM E 11, Table 1.
- D. Outlet For Relief Well: Check Valve.
 - 1. The check valve shall be a one piece reinforced all rubber (neoprene) check valve with an integral elastomer flange similar and equal to the Red Valve Series 35, manufactured by Red Valve Company, Inc., 700 North Bell Ave., Pittsburgh, PA 15106, telephone (412) 279-0044. The backup ring for the check valve shall be stainless steel. Stainless steel bolts, washers, and nuts shall be used to fasten the valves onto the flanged end of the pipes. The check valve shall be installed with the flared end duck bill in a vertical position.
OR
Fabricate check valves of brass **OR** stainless steel **OR** aluminum, **as directed**, plate, threaded fasteners and rods. Fabricate sealing disc of silicone sponge rubber free of porous areas, foreign materials, and visible defects.
 - 2. Workmanship and metalwork fabrication of check valves shall be as directed. Install check valves accurately vertically and adjust to the required elevation.
- E. Concrete: Concrete shall conform to the requirements specified in Division 03 Section "Cast-in-place Concrete".

1.3 EXECUTION

- A. Drilling: Wells may be drilled by the reverse rotary circulation method or other method approved, which will ensure proper placement of the well screen, riser pipe, and filter pack. Methods which involve radical displacement of the formation, or which may reduce the yield of the well, will not be permitted. Excavated material shall be disposed of as directed.
 - 1. Reverse Circulation Method: If the reverse circulation method is used for drilling wells, all of the drilling fluid shall be removed from the filter pack and the natural pervious formation. If in the opinion of the Owner the walls of the hole above the top of the filter pack require support during development operations, a temporary casing similar to that specified in paragraph TEMPORARY CASING shall be placed so as to extend from the ground surface to at least 3 ft (1 m) below the top of the filter pack. The diameter of the hole shall be such as will permit the placement of the minimum thickness of filter pack as specified in paragraph FILTER PACK PLACEMENT. The drilling fluid shall be a suspension of fine grained soil or shall be a commercial product of a recognized manufacturer, shall be approved by the Owner, and shall have the characteristic of being readily removable from the filter pack and the walls of the formation by development as specified in paragraph DEVELOPMENT. The use of bentonite will not be permitted.
 - 2. Temporary Casing: Temporary well casing of either iron or steel of sufficient length to case to the bottom of all borings shall be available at the construction site. the Owner will direct the use of a temporary casing to the bottom of the boring during drilling and placement of screen, riser, and



filter pack when it believes it is necessary to provide adequate support to the sides of the hole. When the walls of the boring will require support only during development operations a temporary casing will be required to extend only to a depth 3 ft (3 m) below the top of the filter pack. The temporary casing, shall have sufficient thickness to retain its shape and maintain a true section throughout its depth, and may be in sections of any convenient length. The temporary casing shall be such as to permit its removal without disturbing the filter pack, riser, or well screen. The setting of temporary casing shall be such that no cavity will be created outside of it at any point along its length. In the event the temporary casing should become unduly distorted or bent it shall be discarded and a new casing shall be used during installation of any additional relief wells.

B. Installation Of Riser Pipe And Screen

1. **Assembly:** All riser pipe and screen shall be in good condition before installation and all couplings and other accessory parts shall be securely fastened in place. The successive lengths of pipe shall be arranged to provide accurate placement of the screen sections in the bore hole. The riser-pipe shall be provided with an approved cap and a flanged top section, the top of which shall be set at the elevation directed. Centralizers shall be attached to the assembled riser pipe and screen in such numbers and of a type that they will satisfactorily center the riser pipe and screen in the well and will hold it securely in position while the filter pack material is being placed.
2. **Joints:** Sections of relief well pipe shall be joined together as specified in paragraph COUPLINGS. Joints shall be designed and constructed to have the strength of the pipe and where possible a strength capable to support the weight of the relief well stem as it is lowered into the hole. When not practicable to construct joints that will support the weight of the relief well stem, the stem shall be supported at the lower end by any approved means that will assure that the joints do not open while being lowered into place in the well.
3. **Installation:** The assembled riser pipe and screen shall be placed in the bore hole in such manner as to avoid jarring impacts and to ensure that the assembly is centered and not damaged or disconnected. The screen shall be suspended in the hole and not resting on the bottom of the hole. After the screen and riser pipe have been placed, a filter pack shall be constructed around the screen section as specified in paragraph FILTER PACK PLACEMENT and the well developed as specified in paragraph DEVELOPMENT. The top of the riser pipe shall be held at the designated elevation during placement of the filter pack.
4. **Check for Plumbness and Alignment:** The well shall be constructed and all casing set round, plumb, and true. The Contractor shall perform the following tests after the installation of the well but prior to backfilling, and before its acceptance. Additional tests may be made during the performance of the work at the option of the Contractor. Should the Contractor fail to correct, at no additional cost to the Owner, any faulty alignment or plumbness disclosed as a result of these tests, the Owner may refuse to accept the well. the Owner may waive the requirements for plumbness if in its judgement the Contractor has exercised all possible care in constructing the well and the defect is due to circumstances beyond its control or if the utility of the completed well is not materially affected or if the cost of necessary remedial measures will be excessive. In no event will the provisions with respect to alignment be waived.
 - a. **Plumbness:** Plumbness shall be tested by use of a plumb line. The plummet shall be suspended from a small diameter wire rope and its point of suspension shall be in the exact center of the plummet. The plummet shall be sufficiently heavy to stretch the wire rope taut. The wire rope shall pass over a guide sheave which shall be positioned above the top of the well and adjusted horizontally so that the plummet hangs in the center of the well. Displacement of the wire rope during the plumbness check shall be measured by means of a transparent plastic sheet on which a number of concentric circles shall be scribed or drawn, and which is centered on the top of the well. The exact center of these circles shall be marked, and then a slot, slightly larger than the plumb line and extending from this center to the edge, shall be cut in the plastic sheet. As the plummet is lowered, any out-of-plumb condition of the well will be indicated by the wire rope tending to drift away from the center, and the plastic sheet shall be rotated until the slot is oriented in the direction of this drift, while at all times maintaining the center of the concentric circles coincident with the center of the well. Measurement of the amount of drift shall be made



- along the edge of the slot for each increment by which the plummet is lowered into the well. Drift at any depth shall be determined by multiplying the measured plumb line displacement by the total length of the plumb line and dividing the result by the fixed distance between the guide sheave and the top of the well. If desired, alignment may be calculated from the plumbness data in lieu of the alignment check described in paragraph ALIGNMENT. Should the well vary from the vertical in excess of allowable, the plumbness of the well shall be corrected by the Contractor at no additional cost to the Owner.
- b. Alignment: Alignment shall be tested by lowering into the well a section of cylinder or a dummy of the same length. The outside diameter of cylinder shall be smaller than the inside diameter of the well. Should the cylinder fail to move freely throughout the length of the well, the alignment of the well shall be corrected by the Contractor at no additional expense to the Owner.
- C. Filter Pack Placement: After the well screen and riser pipe have been installed, the filter pack material shall be placed by tremie, when using a well graded material, in an approved manner such that segregation will not occur. When using a uniform graded filter material, the material may be poured around the well screen at a rate that will prevent bridging of the material. The material shall be placed around all sides of the screen to assure that the screen is not pushed against the side of the bore hole causing the screen to come in contact with foundation material or prevent the proper thickness of filter from being placed uniformly around the screen. The filter pack shall be placed at a constant rate from the start of placement until it has reached the elevation directed. If a tremie is required, a double string of tremie pipe shall be used. The pipes shall be placed on opposite sides of the screen and/or casing, that is, 180 degrees apart, and shall be guided in such a manner that they will remain in this position throughout the placing process. The tremie pipes shall be set in place, filled completely with filter pack prior to being lifted off the bottom of the hole. The filter pack in the tremie pipe shall be kept above the water surface in the well throughout the placing process. In no case shall the gradation of the filter pack fall outside of the range specified in paragraph FILTER PACK.
- D. Development
1. General: Following placement of filter pack materials, the Contractor shall develop the relief well by jetting, surging, intermittent pumping, or other approved methods as may be necessary to give the maximum yield of water. At the time of development of any relief well, the well shall be free of drawdown or surcharge effects due to pump testing, developing or drilling at another location. The Contractor shall be responsible for maintaining at the relief well the needed access and work area and clearance in the relief well necessary to accomplish development. The Contractor shall furnish, install, or construct the necessary discharge line and troughs to conduct and dispose of the discharge a sufficient distance from the work areas to prevent damage. Development shall be conducted to achieve a stable well of maximum efficiency and shall be continued until a satisfactory sand test, as specified in paragraph SAND TEST, is obtained. As development proceeds, filter pack material shall be added to the annular space around the screen to maintain the top elevation of the filter pack to the specified elevation. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well under all conditions. If at any time during the development process it becomes apparent in the opinion of the Owner that the well may be damaged, development operations shall be immediately terminated. the Owner may require a change in method if the method selected does not accomplish the desired results. the Owner may order that wells which continue to produce excessive amounts of fines after development for 6 hours be abandoned, plugged, and backfilled, and may require the Contractor to construct new wells nearby. All materials pulled into the well by the development process shall be removed prior to performing the pumping test.
- a. Jetting: Jetting should be performed using either a single or double ring jet. The jetting tool shall be constructed of high-strength material and conservatively designed and proportioned so that it will withstand high pressures. The jetting tool shall have two hydraulically balanced nozzles spaced 180 degrees **OR** four diameter holes spaced 90 degrees, **as directed**, apart and which shall exert the jetting force horizontally through the screen slots. The rings shall be constructed such that the tips of the jets shall be within 1/2 in. (13 mm) from the inner surface of the well screen. The pump used in conjunction with



the jetting tool shall be capable of providing a minimum jetting fluid exit velocity of 150 feet per second (45 meters per second). Prior to commencing jetting, and following each jetting cycle, all sand and/or other materials shall be removed from inside the screen. All wells shall be pumped during the jetting cycle to remove incoming sand and other material. Such pumping shall be at a rate not less than 115 percent of the rate at which fluid is introduced through the jetting tool. This will allow a flow of material into the well as it is being developed. Water used for development shall be free of sand. the Owner may require other means of developing the well such as intermittent pumping method, variation of the intermittent pumping method, or surge block if it appears that the development of the well is not producing the desired results.

- b. Intermittent Pumping: Intermittent pumping shall be performed by pumping the well at a capacity sufficient to produce a rapid drawdown, stopping the pump (backflow through pump will not be permitted) to permit the water surface to rise to its former elevation, and repeating this procedure. Cycle time for this procedure will vary as directed but will not be more than 3 cycles per minute. A deep well turbine pump, or electric submersible pump with check valve, shall be used with any attachment necessary to accomplish rapid starting and stopping for intermittent pumping. The intake shall be set below the maximum expected drawdown in the well. Prior to commencing intermittent pumping, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. The amount of drawdown may be decreased if, in the opinion of the Owner, the efficiency of the well might otherwise be impaired.
 - c. Surging: Surging of the well shall require use of a circular block which is smaller in diameter than the inside diameter of the relief well and is constructed of a material which will not damage the screen if the block comes in contact with the screen, and a bailer or pump to remove materials drawn into the well. The surging shall be continued for a period of approximately one hour or until little or no additional material from the foundation or filter pack can be pulled through the screen. The surge block shall be moved by a steady motion up and down the full length of the well screen. Prior to commencing surging, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. All materials pulled into the well by the surging process shall be removed by the Contractor.
- E. Backfilling: After the well has been developed, additional filter pack shall be added if necessary to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the annular space above the filter pack, shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with grout or concrete. The concrete backfill shall be placed to a depth at least equal to the existing impervious blanket. For PVC riser pipe, after the well has been developed, additional filter pack shall be added if necessary for it to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the remaining annular space above the filter pack shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with bentonite. The temporary casing, if used, shall be withdrawn in increments as the backfill is placed. The Contractor shall fill with impervious material to original grade all pits such as those incidental to the reverse rotary circulation method of drilling.
- F. Plugging Of Abandoned Wells: The Contractor has the option of attempting to remove the well screen. If the well screen can be removed, the Contractor will grout the bore hole starting from the bottom of the hole. The grouting shall start at the elevation of the bottom of the tailpipe of the well. If the well screen can not be removed or breaks off during the removal attempt, the Contractor shall still be responsible for grouting the well from the bottom of the tailpipe to within 3 ft (1 m) of ground surface. Either of the above abandonment procedures may require the Contractor to redrill the hole so that the bore hole can be grouted. The well shall be grouted from the bottom of the tailpipe. After the grout has setup the riser pipe shall be cutoff. Then the hole shall be backfilled. The cement grout mixture proportion to be used shall be submitted for approval.



G. Tests

1. Pump Test: Upon completion but before acceptance, each well shall be subjected to a pump test of which a sand test will form a part. The Contractor shall provide a deep well turbine pump, capable of producing the specified drawdowns over periods of time sufficient to satisfactorily perform the pump test specified herein. The intake shall be set below the maximum expected drawdown in the well. The amount of sand shall be measured after each test. The pump shall be complete with either gasoline, diesel, or electric motor of adequate size. In case an electric motor is used, the Contractor shall provide, without additional cost to the Owner, the electric power and the necessary wiring. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well. The Contractor shall furnish and install an orifice meter of approved design or other approved equipment for the purpose of measuring the discharge from the well during the pumping test. The Contractor shall furnish, install, or construct the necessary pipe discharge line, troughs, or ditches necessary to dispose of the pumping test discharge a sufficient distance from the work area to prevent damage. The tests will be conducted under the direction of the Owner and may be made as soon as each well is completed. Test data will be recorded by the Owner. The Contractor shall test each well by pumping continuously for a minimum of 6 hours. Prior to starting the pump test all material shall be removed from the bottom of the well. If the test is interrupted, other than by order of the Owner, prior to the completion of the specified period of continuous operation, the test shall be re-run. In addition to the required pumping test, the Owner may direct the Contractor to perform additional pump tests. Such additional testing shall conform in general to the requirements specified herein except that the duration of the tests and the approximate draw-down will be determined by the Owner. In the event that sand or other material collects in the well as a result of the pump test, accurate measurements shall be taken as to the quantity of material in the well and all such material shall be removed by the Contractor. Upon completion of the pump test, the Contractor shall remove all equipment, discharge lines, electrical lines, lumber, and debris, and shall backfill any excavated areas with impervious material.
2. Sand Test: As part of each Pump Test or at the end of each intermittent pumping a determination of the amount of sand (filter pack and/or foundation material) a well is producing shall be performed. Prior to starting the sand test all material shall be removed from the bottom of the tailpipe. After the pump is at the desired pumping rate the flow from the discharge shall be diverted into a container that will collect all the sand being carried by the water **OR** through a Rossum Sand Tester, **as directed**. Upon completion of the test the amount of sand in the tailpipe shall be determined to verify that no material is being deposited in the bottom of the well.
3. Filter Pack Sampling and Testing: The Contractor shall verify that all materials conform to the specifications before delivery to the project. The particle size distribution of the filter pack shall be sampled and tested by the Contractor in accordance with ASTM C 136 and ASTM D 75. Within 48 hours before being placed in the relief well to be back-filled, the filter pack shall be sampled from the material stockpiled at the project site. There shall be at least one particle size distribution test on the filter pack for each well. A pump test shall be performed in accordance with technical provisions herein specified.
4. Reports: Reports shall include, for each relief well, logs of the boring, elevations of the well screen, top of riser pipe, bottom of the tailpipe, filter pack gradation, quantity of filter pack added during development, pump test, sand test, and report of backfilling. The log of backfill material shall include the filter pack particle size distribution test data, and notes concerning installation and development of the relief well. The pump test log shall include the duration of the test and the draw-down response data with time in the pumped well, in adjacent wells, and in nearby piezometers. The relief well log and the pump test log shall be submitted to the Owner. The Contractor shall also submit a report of the well installation to the appropriate public agency and in the form required by state statutory and/or regulatory requirements specified in paragraph REGULATORY REQUIREMENTS.

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**SECTION 23 11 23 00a - MONITORING WELLS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for monitoring wells including drilling, casing, well screen, gravel packing, grouting, development, monitoring device, and incidental related work complete and ready for operation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. General Requirements

1. Each system, including equipment, materials, installation, and performance, shall be in accordance with local, State, and Federal regulations, ASTM D 5092, and EPA 600-4-89-034 except as modified herein. Consider the advisory or recommended provisions to be mandatory, as though the word "shall" has been substituted for the word "should" wherever it appears. Reference to the "Project Representative" and the "Owner" shall be interpreted to mean the Owner. Additional requirements are included under Division 01 Section "Temporary Facilities And Controls". Mark and secure monitoring wells to avoid unauthorized access and tampering.

C. Submittals:

1. Shop Drawings: Well construction.
2. Product Data
 - a. Well casing
 - b. Well screen
 - c. Filter pack
 - d. Neat cement grout
 - e. Bentonite seal
3. Certificates
 - a. Well Drilling/Development Material Handling Plan
 - b. Health and Safety Plan
 - c. Field Sampling and Laboratory Testing Plan
 - d. Treatment facility permit
 - e. Installation Survey Report
 - f. Well Development Report
 - g. Borehole Analysis Report
4. Closeout Submittals
 - a. Well Construction Permit
 - b. Shipment manifests
 - c. Delivery certificates
 - d. Treatment and disposal certificates

D. Delivery, Storage, And Handling

1. Deliver materials in an undamaged condition. Unload and store with minimal handling. Store materials in on-site enclosures or under protective coverings. Store plastic piping and jointing materials, and rubber gaskets under cover, out of direct sunlight. Store materials off the ground. Keep insides of pipes and fittings free of dirt and debris. Replace defective or damaged materials with new materials.

E. Quality Assurance

1. Required Drawings: Submit well construction drawings showing components and details of well casing, well screen, filter pack, annular seal, and associated items. Drawings shall be prepared by a State certified professional geologist or hydrogeologist, or by a State registered professional



- civil engineer, hereafter referred to as the Contractor's Professional Consultant (CPC). Drawings shall be sealed.
2. Well Drilling/Development Material Handling Plan: A material handling plan shall be furnished by the Contractor 15 days prior to initiation of the work that describes phases of dealing with the potentially contaminated soil and groundwater, including the following: a schedule to be employed in the well drilling and development stages, a sequence of operations, the method of drilling and development, material hauling, proposed equipment, handling of the contaminated materials, soil and water testing requirements, and safety precautions and requirements.
 3. Health and Safety Plan (HASP): Describe safety precautions for each phase of the project as specifically related to handling of soil and water removed during well drilling and development operations. Identify appropriate requirements of 29 CFR 1910 and COE EM-385-1-1. Identify safety equipment and procedures to be available and used during the project. Furnish the name and qualifications based on education, training, and work experience of the proposed Health and Safety Officer (HASO) and the members of the drill crew. The CPC may perform the responsibilities of the HASO if properly qualified.
 4. Field Sampling and Laboratory Testing Plan: Describe field sampling methods and quality control procedures. Identify laboratory and laboratory methods to be used for contamination testing. Sample reports shall show sample identification for location, date, time, sample method, contamination level, name of individual sampler, identification of laboratory, and quality control procedures.
 5. Treatment Facility Permit: Verification that the proposed treatment facility is permitted to accept the contaminated materials specified, prior to the start of excavation.
 6. Well Development Report: Provide report, containing the following data for each well: project name and location, well designation, date and time of well installation, date and time of well development, static water level from top of well casing before development and 24 hours after development, field measurements of pH, temperature, and specific conductivity, depth of well from top of casing to bottom of well, screen length, description of development methodology size/capacity of pump or bailer, pumping rate, and recharge rate.
 7. Well Construction Permit: Submit a completed permit application and a proposed method of construction to the appropriate state agency prior to construction of the well. Construction of the wells will not be allowed until an approved Well Construction Permit has been submitted to the Owner.
 8. Shipment Manifests: Copies of manifests and other documentation required for shipment of waste materials within 24 hours after removal of waste from the site. Shipment manifests shall be signed by the Owner.
 9. Delivery Certificates: Verification that the wastes were actually delivered to the approved treatment facility, within 7 days of shipment.
 10. Treatment and Disposal Certificates: Verification that the wastes were successfully treated and remediated to the levels specified herein.

1.2 PRODUCTS

A. Well Casing

1. Stainless Steel Piping: ASTM A 312/A 312M, Type 304, Schedule 40S, with flush threaded joint end fittings. Threaded joints shall be wrapped with fluoropolymer tape, and provided with nitrile O-ring gaskets.
2. PVC Piping: ASTM F 480, Type 1, Grade 1, PVC 12454, NSF wc or NSF pw, Schedule 40 **OR** 80, **as directed**, with flush threaded joint fittings. Threaded joints shall be wrapped with fluoropolymer tape, and provided with nitrile O-ring gaskets.

- ### B. Well Screen: Well screens shall be located as directed. The length of each screen shall be as directed. Slot size shall be as required to meet project requirements. Slotted openings shall be distributed uniformly around the circumference of the screen. Open area shall approach the formation's natural porosity.



1. Stainless Steel Screens: ASTM A 312/A 312M, Type 304, Schedule 40S, continuous slot construction, wire wound, with flush threaded joint ends.
 2. PVC Screens: ASTM D 1785, PVC 1120, NSF wc or NSF pw, Schedule 40 **OR** 80, **as directed**, screen, Schedule 80, machine-slotted construction, flush threaded joint ends. Slots shall be even in width, length, and separation.
- C. Primary Filter Pack: Provide clean, durable, well-rounded, and washed quartz or granite, with less than 5 percent non-siliceous material. The filter pack shall not contain organic matter or friable materials. The filter pack shall allow free flow of water in the well, and shall prevent the infiltration of aquifer materials. Filter pack shall have a 30 percent finer than (d-30) grain size size as required to meet project requirements, and a uniformity coefficient less than 2.5, in accordance with ASTM C 117 and ASTM C 136.
- D. Secondary Filter Pack: Gradation in accordance with ASTM D 5092. Provide clean, durable, well-rounded, and washed quartz or granite. Pack shall not contain organic matter or friable materials.
- E. Annular Sealants
1. Bentonite Seal: Provide powdered, granular, pelletized, or chipped sodium **OR** calcium, **as directed**, montmorillonite in sealed containers from a commercial source, free of impurities. Diameter of pellets shall be less than one fifth the diameter of the borehole annular space to prevent bridging. Bentonite base grout shall be in accordance with ASTM D 5092.
 2. Neat Cement Grout: Provide neat cement grout in accordance with ASTM D 5092. Cement shall be in accordance with ASTM C 150. Quick setting admixtures shall not be allowed. Drilling mud or cuttings shall not be used as a sealing material.
- F. Bottom Plugs: Provide flush threaded solid plug at the bottom of the well. Plug shall be the same material as the well casing **OR** screen to which it is attached, **as directed**. Joints shall be wrapped with fluoropolymer tape and provided with nitrile O-ring gaskets.
- G. Locking Well Cap: Provide flush threaded, weatherproof, and non-removable locking well cap on the top of the well. Well cap shall be of the same material as the well casing to which it is attached. Well cap shall accommodate padlock. Provide a long shackled padlock in accordance with ASTM F 883. Provide two keys for the padlock, and turn them over to the Owner. Locks at the well site shall be keyed alike.
- H. Well Head Completions: Clearly mark and secure the well to avoid unauthorized access and tampering. Cast the words "MONITORING WELL" on the well head cover. Provide a sign reading, "WELL IS FOR MONITORING AND IS NOT SAFE FOR DRINKING." Provide stamped metal identification tag as follows:
- DO NOT DISTURB
 - ID #: _____ Date: _____
 - Installed By: _____
 - Total Depth: _____
 - Screened Interval: _____
 - TOC Elevation: _____
 - Other: _____
 - For Information, Call: _____
1. Aboveground Completions: Provide protective outer casing around the well casing extending above grade. The diameter of the protective outer casing shall be a minimum of 4 in. (100 mm) larger than the well casing diameter. The top of the protective outer casing shall extend a minimum of 6 in. (150 mm) above the top of the well casing cap. The protective outer casing shall be set in cement grout and the bottom of the protective well casing shall extend below the depth of the frost line **OR** to the depth indicated, **as directed**. A 1/4 in. (6 mm) diameter weep hole shall be drilled in the protective outer casing 3 in. (75 mm) above the ground surface. The annular space between the protective outer casing and the well casing shall be filled with pea gravel or coarse sand to just below the level of the cap on the well casing. The locking well cap



shall be provided on top of the protective outer casing. Provide 6 in. (150 mm) diameter steel pipe bollards, filled with concrete as indicated to protect the exposed well head.

- a. Protective Outer Casing and Bollards: ASTM A 53, Type E or S, Grade B.
 - b. Well Casing Cap: Provide cap on top of the protective outer casing. Cap shall be flush threaded and of the same material as the protective outer casing. Threaded joints shall be wrapped with fluoropolymer tape and provided with nitrile O-ring gaskets.
2. At-Grade Completions: Provide cast iron **OR** aluminum, **as directed**, vault box, 30 by 30 in. (750 by 750 mm) **OR** 12 in. (300 mm) diameter, **as directed**, with watertight frame and cover. Vault shall support H-20 loading for traffic areas **OR** a 100,000 lb. (45,360 kg) loading for airfield locations, **as directed**. The frame shall be 6 in. (150 mm) deep, and shall be set in a concrete collar a minimum of 8 in. (200 mm) thick, and extending 4 in. (100 mm) beyond the edge of the frame in all directions. Frame and concrete collar shall be set flush with the level of the existing pavement **OR** set 3 in. (75 mm) above the existing grade, **as directed**. Locking well cap shall be provided on top of the well casing, which will terminate inside the vault as indicated.
- I. Polyethylene Sheeting: ASTM D 4397.

1.3 EXECUTION

- A. General: Notify the Owner at least 15 days prior to commencement of work. Locations of wells shall be as indicated. Drilling, installation, and development of the monitoring wells shall be supervised, directed, and monitored by the CPC. Drilling, sampling, and well development equipment introduced to the well shall be decontaminated before and after each use in accordance with ASTM D 5088.
- B. Drilling: Borehole shall be advanced using conventional 10 in. (250 mm) hollow-stem auger **OR** solid auger **OR** rotary wash, **as directed**, drilling methods. If it is the opinion of the CPC that an alternate drilling method is required, justification for a boring method change shall be submitted to the Owner, and approval for the change granted prior to drilling. Drill crew shall be experienced and trained in drilling and safety requirements for contaminated sites.
 1. Sampling: Obtain samples in accordance with ASTM D 1586 or ASTM D 1587. Perform standard penetration tests at the following depths 0.0 to 1.5 ft (0 to 450 mm); 1.5 to 3.0 ft (450 to 900 mm); 3.0 to 4.5 ft (900 to 1350 mm); and 5 ft (1500 mm) centers or at changes in soil formation thereafter. Each soil sample shall be screened in the field with an organic vapor analyzer/flame ionization device (OVA/FID) capable of detecting vapors to a minimum of one ppm. Log boring in accordance with ASTM D 2487 and ASTM D 2488. Groundwater elevation shall be indicated.
 2. Analysis: The CPC shall review the log data from each borehole and compare the data with the well design requirements. The CPC shall verify the adequacy of the well design, or shall offer a proposed modification to the design based on the geologic and hydrogeologic data obtained from the borehole. This review and analysis shall be conducted for each borehole **OR** for one borehole considered representative of the entire project, **as directed**. The CPC shall submit the borehole boring logs, the analysis of the well design, and any proposed design modifications to the Owner in a Borehole Analysis Report. Any modifications to the well design approved by the Owner shall be considered a change to the contract documents and shall be negotiated in accordance with the "CHANGES" clause.
 3. Alignment: Verify that the well is straight by lowering a 10 ft (3 m) section of steel pipe 1/4 in. (6 mm) smaller in diameter than the inside diameter of the casing in to the well. For wells deeper than 200 ft (60 m), Contractor shall verify that the well is plumb.
- C. Soil Removed From The Borehole
 1. Temporary Containment of Soil Removed from the Borehole: Soil removed from the borehole shall be placed in a temporary containment area. Provide a temporary containment area near the well site. Cover containment area with 10 mil (0.25 mm) reinforced polyethylene sheeting. Place soil removed from the borehole[s] on the impervious barrier and cover with 6 mil (0.15 mm) reinforced polyethylene sheeting. Provide a straw bale berm around the outer limits of the



containment area and cover with polyethylene sheets. Secure edges of sheets with weights to keep the polyethylene sheeting in place. Water runoff shall be diverted from the stockpiled material. As an option, soil may be stockpiled in trucks suitable for transporting contaminated soils as specified herein.

2. Testing Requirements for Stockpiled Soils

a. Sampling: A minimum of one composite sample shall be developed and analyzed for each required test for every 100 cu. yds. (76.4 cu. m) or fraction thereof from a composite stockpile of soil removed from all well sites. To develop a composite sample of the size necessary to run the required tests, the Contractor shall take several samples from different areas along the surface and in the center of the stockpile. These samples shall be combined and thoroughly mixed to develop the composite sample.

b. Testing

- 1) The soil shall contain no free liquid as demonstrated by EPA SW-846, Method 9095, paint filter liquids test.
- 2) The sum of benzene, toluene, ethyl benzene, and xylene (BTEX) concentrations shall be determined by using EPA SW-846, Method 5030/8020.
- 3) TPH (total petroleum hydrocarbons) concentrations shall be determined by using EPA SW-846, Method 8015, which has been modified for use with soil.
- 4) Material shall be tested for TOX (total organic halogens) in accordance with EPA SW-846, Method 9020.
- 5) Material shall be analyzed for full TCLP in accordance with EPA SW-846, Method 1311 and for ignitability, corrosivity, and reactivity.
- 6) Material shall be tested for polychlorinated biphenyls (PCB's) in accordance with EPA SW-846, Method 8080.
- 7) Moisture content of the sample shall be determined in accordance with EPA Method 160.3.

c. Disposal of Stockpiled Soils

- 1) Soils exhibiting TPH less than 100 ppm, BTEX less than 10 ppm, TOX less than 100 ppm, passing TCLP tests, and testing negative for PCB's shall be considered clean as shall be disposed of on-site, as directed by the Owner.
- 2) Soils failing the TCLP test or exhibiting TOX greater than 100 ppm shall be managed in accordance with applicable State and local regulations. Payment for disposal of materials failing the TCLP metals test or TOX test shall be made in accordance with the "CHANGES" clause of the General Conditions.
- 3) If the concentration of total BTEX is greater than 10 ppm or TPH greater than 100 ppm, the soil shall be treated and disposed of at a permitted soil recycling facility.

D. Well Installation: Well installation shall be in accordance with ASTM D 5092 and EPA 600-4-89-034, and as indicated on the well construction drawings submitted by the CPC and approved by the Owner. Borehole shall be stable and shall be verified straight before beginning installation.

1. Casings and Screens: Well casings, screens, plugs, and caps shall be decontaminated prior to delivery by the manufacturer and shall be certified clean. Materials shall be delivered, stored, and handled in such manner as to ensure that grease, oil, or other contaminants do not contact any portion of the well screen and casing assembly prior to installation. If directed by the Owner, the well screen and casing assembly shall be cleaned with high pressure water prior to installation. Personnel shall wear clean cotton or surgical gloves while handling the assembly. Centralizers shall be used to ensure that the well screen and casing assembly is installed concentrically in the borehole. When the assembly has been installed at the appropriate elevation, it shall be adequately secured to preclude movement during placement of the filter packs and annular seals. The top of the well casing shall be capped during filter pack placement.
2. Primary and Secondary Filter Packs: Primary and secondary filter packs shall be placed as indicated on the approved well construction drawings to fill the entire annular space between the screen and casing assembly and the outside wall of the borehole. Place both the primary and secondary filters with a tremie pipe in accordance with EPA 600-4-89-034 and ASTM D 5092. Placement of the primary and secondary filters by gravity or free fall methods is not allowed. Control speed of filter placement to prevent bridging and to allow for settlement. Prior to



- commencement of work, equipment and methods required to place filters shall be approved by the Owner.
3. **Bentonite Seal:** Bentonite shall be placed as a slurry through a tremie pipe. Control speed of bentonite placement to prevent bridging or segregation of slurry. Additional water shall be added to the annular space as directed by the CPC to ensure complete hydration of the bentonite. Bentonite shall cure a minimum of 48 hours before the placement of cement grout to ensure complete hydration and expansion of the bentonite.
 4. **Neat Cement Grout:** Cement grout shall be placed in the annular space above the bentonite seal as indicated on the well construction drawings. Cement grout shall be placed as a slurry through a tremie pipe, and injected under pressure to reduce chance of voids. Grout shall be injected in one continuous operation until full strength grout flows out at the ground surface without evidence of drilling cuttings or fluid. Cement grout shall cure a minimum of 48 hours before beginning well development operations.
 5. **Well Head Completions:** Well head completions shall be as indicated and as specified herein.
- E. **Well Development:** Well development shall be in accordance with EPA 600-4-89-034 and ASTM D 5092 except as modified herein. Bailing, surging, and pumping/overpumping/backwashing are acceptable development methods. Air surging and jetting are prohibited. Method of development shall be chosen by the CPC and approved by the Owner. Well development shall not begin until the well installation is complete and accepted by the Owner. Well development operations shall be conducted continuously until development water flows clear and free of drilling fluids, cuttings, or other materials. At such time representative water samples shall be tested for pH, temperature, and specific conductivity in accordance with EPA 600-4-79-20. Samples shall be taken every 3 hours. When stabilized readings of these parameters, as accepted by the Owner, have been achieved for 12 consecutive hours, well development operations shall cease.
- F. **Water From Well Development Operations:** Water from the well development operations shall be containerized in accordance with State and local regulations. One sample shall be taken and analyzed for each required test for every 1000 gallons (3780 liters) of stored water from well development operations.
1. **Testing**
 - a. The sum of benzene, toluene, ethyl benzene, and xylene (BTEX) concentrations shall be determined by using EPA SW-846, Method 8020.
 - b. TPH (total petroleum hydrocarbons) concentrations shall be determined by using EPA SW-846, Method 8015.
 2. **Disposal of Containerized Water**
 - a. Water exhibiting TPH less than 0.5 ppm and BTEX less than 1 ppb shall be considered clean and shall be disposed of on-site as directed by the Owner.
 - b. If the concentration of total BTEX is greater than 1 ppb or TPH greater than 0.5 ppm, the water shall be treated and disposed of at a permitted facility.
- G. **Transportation Of Contaminated Soil And Water:** The Contractor shall be solely responsible for complying with Federal, State, and local requirements for transporting contaminated materials through the applicable jurisdictions and shall bear responsibility and cost for any noncompliance. In addition to those requirements, the Contractor shall do the following:
1. Inspect and document vehicles and containers for proper operation and covering.
 2. Inspect vehicles and containers for proper markings, manifest documents, and other requirements for waste shipment.
 3. Perform and document decontamination procedures prior to leaving the worksite and again before leaving the disposal site.
- H. **Disposal Of Contaminated Soil And Water:** Contaminated materials removed from the site shall be disposed of in a treatment/disposal facility permitted to accept such materials.



- I. Installation Survey: Upon completion of well installation and development and acceptance by the Owner therefor, the Contractor vertical and horizontal position of each well shall be determined by a registered land surveyor licensed in the State where the work is located . The survey shall document the vertical elevations of the top of the casing pipe and the ground surface elevation adjacent to each well. Survey shall be accurate to the nearest 0.01 ft (3 mm). This data shall be submitted with a well location map as the Installation Survey Report.

- J. Cleanup: Upon completion of the well construction, remove debris and surplus materials from the jobsite.

END OF SECTION 23 11 23 00a



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SECTION 23 11 23 00b - FACILITY NATURAL-GAS PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for facility natural gas piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pipes, tubes, and fittings.
 - b. Piping specialties.
 - c. Piping and tubing joining materials.
 - d. Valves.
 - e. Pressure regulators.
 - f. Service meters.
 - g. Mechanical sleeve seals.
 - h. Grout.
 - i. Concrete bases.

C. Definitions

1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Performance Requirements

1. Minimum Operating-Pressure Ratings:
 - a. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
 - b. Service Regulators: 65 psig (450 kPa) **OR** 100 psig (690 kPa), **as directed**, minimum unless otherwise indicated.
 - c. Minimum Operating Pressure of Service Meter: 5 psig (34.5 kPa) **OR** 10 psig (69 kPa) **OR** 20 psig (138 kPa) **OR** 65 psig (450 kPa), **as directed**.
2. Natural-Gas System Pressure within Buildings: 0.5 psig (3.45 kPa) or less **OR** More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) **OR** More than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa), **as directed**.

OR

Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.

OR

Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa), and is reduced to secondary pressure of more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa).

OR

Natural-Gas System Pressures within Buildings: Three pressure ranges. Primary pressure is more than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa), and is reduced to secondary pressures of more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa), and is reduced again to pressures of 0.5 psig (3.45 kPa) or less.



3. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
3. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of seismic restraints.
 - b. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Welding certificates.
5. Field quality-control reports.
6. Operation and maintenance data.

F. Quality Assurance

1. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Delivery, Storage, And Handling

1. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
2. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
3. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
4. Protect stored PE pipes and valves from direct sunlight.

H. Project Conditions

1. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - a. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
 - b. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - a. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - b. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - c. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.



- d. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1) Material Group: 1.1.
 - 2) End Connections: Threaded or butt welding to match pipe.
 - 3) Lapped Face: Not permitted underground.
 - 4) Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - 5) Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
- e. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - 1) Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
- f. Mechanical Couplings:
 - 1) Stainless-steel **OR** Steel, **as directed**, flanges and tube with epoxy finish.
 - 2) Buna-nitrile seals.
 - 3) Stainless-steel **OR** Steel, **as directed**, bolts, washers, and nuts.
 - 4) Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - 5) Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.
- 2. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
 - a. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
 - b. Coating: PE with flame retardant.
 - 1) Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a) Flame-Spread Index: 25 or less.
 - b) Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
 - c. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
 - d. Striker Plates: Steel, designed to protect tubing from penetrations.
 - e. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
 - f. Operating-Pressure Rating: 5 psig (34.5 kPa).
- 3. Aluminum Tubing: Comply with ASTM B 210 and ASTM B 241/B 241M.
 - a. Aluminum Alloy: Alloy 5456 is prohibited.
 - b. Protective Coating: Factory-applied coating capable of resisting corrosion on tubing in contact with masonry, plaster, insulation, water, detergents, and sewerage.
 - c. Flare Fittings: Comply with ASME B16.26 and SAE J513.
 - 1) Copper-alloy fittings.
 - 2) Metal-to-metal compression seal without gasket.
 - 3) Dryseal threads shall comply with ASME B1.20.3.
- 4. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 837, Type G, **as directed**.
 - a. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
 - b. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - 1) Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - 2) Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
 - c. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch (0.56 mm) thick.
- 5. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 837, Type G, **as directed**.
 - a. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
 - b. Flare Fittings: Comply with ASME B16.26 and SAE J513.



- 1) Copper fittings with long nuts.
- 2) Metal-to-metal compression seal without gasket.
- 3) Dryseal threads complying with ASME B1.20.3.
- c. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch (0.56 mm) thick.
6. Tin-Lined Copper Tube: ASTM B 280, seamless, annealed, with interior tin-plated lining.
 - a. Flare Fittings: Comply with ASME B16.26 and SAE J513.
 - 1) Copper fittings with long nuts.
 - 2) Metal-to-metal compression seal without gasket.
 - 3) Dryseal threads complying with ASME B1.20.3.
7. PE Pipe: ASTM D 2513, SDR 11.
 - a. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
 - b. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - c. Anodeless Service-Line Risers: Factory fabricated and leak tested.
 - 1) Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
 - 2) Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground, **as directed**.
 - 3) Aboveground Portion: PE transition fitting.
 - 4) Outlet shall be threaded or flanged or suitable for welded connection.
 - 5) Tracer wire connection.
 - 6) Ultraviolet shield.
 - 7) Stake supports with factory finish to match steel pipe casing or carrier pipe.
 - d. Transition Service-Line Risers: Factory fabricated and leak tested.
 - 1) Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
 - 2) Outlet shall be threaded or flanged or suitable for welded connection.
 - 3) Bridging sleeve over mechanical coupling.
 - 4) Factory-connected anode.
 - 5) Tracer wire connection.
 - 6) Ultraviolet shield.
 - 7) Stake supports with factory finish to match steel pipe casing or carrier pipe.
 - e. Plastic Mechanical Couplings, NPS 1-1/2 (DN 40) and Smaller: Capable of joining PE pipe to PE pipe.
 - 1) PE body with molded-in, stainless-steel support ring.
 - 2) Buna-nitrile seals.
 - 3) Acetal collets.
 - 4) Electro-zinc-plated steel stiffener.
 - f. Plastic Mechanical Couplings, NPS 2 (DN 50) and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - 1) Fiber-reinforced plastic body.
 - 2) PE body tube.
 - 3) Buna-nitrile seals.
 - 4) Acetal collets.
 - 5) Stainless-steel bolts, nuts, and washers.
 - g. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - 1) Stainless-steel **OR** Steel, **as directed**, flanges and tube with epoxy finish.
 - 2) Buna-nitrile seals.
 - 3) Stainless-steel **OR** Steel, **as directed**, bolts, washers, and nuts.
 - 4) Factory-installed anode for steel-body couplings installed underground.

**B. Piping Specialties**

1. Appliance Flexible Connectors:
 - a. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
 - b. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
 - c. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
 - d. Corrugated stainless-steel tubing with polymer coating.
 - e. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
 - f. End Fittings: Zinc-coated steel.
 - g. Threaded Ends: Comply with ASME B1.20.1.
 - h. Maximum Length: 72 inches (1830 mm).
2. Quick-Disconnect Devices: Comply with ANSI Z21.41.
 - a. Copper-alloy convenience outlet and matching plug connector.
 - b. Nitrile seals.
 - c. Hand operated with automatic shutoff when disconnected.
 - d. For indoor or outdoor applications.
 - e. Adjustable, retractable restraining cable.
3. Y-Pattern Strainers:
 - a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 125 psig (862 kPa).
4. Basket Strainers:
 - a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 125 psig (862 kPa).
5. T-Pattern Strainers:
 - a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
 - b. End Connections: Grooved ends.
 - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
 - d. CWP Rating: 750 psig (5170 kPa).
6. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

C. Joining Materials

1. Joint Compound and Tape: Suitable for natural gas.
2. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
3. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

D. Manual Gas Shutoff Valves

1. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
2. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
 - a. CWP Rating: 125 psig (862 kPa).



- b. Threaded Ends: Comply with ASME B1.20.1.
 - c. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 - d. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - e. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
 - f. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.
3. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
 - a. CWP Rating: 125 psig (862 kPa).
 - b. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 - c. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - d. Service Mark: Initials "WOG" shall be permanently marked on valve body.
 4. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated brass.
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE; blowout proof.
 - e. Packing: Separate packnut with adjustable-stem packing threaded ends.
 - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - g. CWP Rating: 600 psig (4140 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
 5. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated bronze.
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE; blowout proof.
 - e. Packing: Threaded-body packnut design with adjustable-stem packing.
 - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - g. CWP Rating: 600 psig (4140 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
 6. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated bronze.
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE.
 - e. Packing: Threaded-body packnut design with adjustable-stem packing.
 - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - g. CWP Rating: 600 psig (4140 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
 7. Bronze Plug Valves: MSS SP-78.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Plug: Bronze.



- c. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
- d. Operator: Square head or lug type with tamperproof feature where indicated.
- e. Pressure Class: 125 psig (862 kPa).
- f. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
- g. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- 8. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
 - a. Body: Cast iron, complying with ASTM A 126, Class B.
 - b. Plug: Bronze or nickel-plated cast iron.
 - c. Seat: Coated with thermoplastic.
 - d. Stem Seal: Compatible with natural gas.
 - e. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - f. Operator: Square head or lug type with tamperproof feature where indicated.
 - g. Pressure Class: 125 psig (862 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- 9. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
 - a. Body: Cast iron, complying with ASTM A 126, Class B.
 - b. Plug: Bronze or nickel-plated cast iron.
 - c. Seat: Coated with thermoplastic.
 - d. Stem Seal: Compatible with natural gas.
 - e. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - f. Operator: Square head or lug type with tamperproof feature where indicated.
 - g. Pressure Class: 125 psig (862 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- 10. PE Ball Valves: Comply with ASME B16.40.
 - a. Body: PE.
 - b. Ball: PE.
 - c. Stem: Acetal.
 - d. Seats and Seals: Nitrile.
 - e. Ends: Plain or fusible to match piping.
 - f. CWP Rating: 80 psig (552 kPa).
 - g. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C).
 - h. Operator: Nut or flat head for key operation.
 - i. Include plastic valve extension.
 - j. Include tamperproof locking feature for valves where indicated on Drawings.
- 11. Valve Boxes:
 - a. Cast-iron, two-section box.
 - b. Top section with cover with "GAS" lettering.
 - c. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
 - d. Adjustable cast-iron extensions of length required for depth of bury.
 - e. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.
- E. Motorized Gas Valves
 - 1. Automatic Gas Valves: Comply with ANSI Z21.21.
 - a. Body: Brass or aluminum.
 - b. Seats and Disc: Nitrile rubber.
 - c. Springs and Valve Trim: Stainless steel.



- d. Normally closed.
 - e. Visual position indicator.
 - f. Electrical **OR** Mechanical, **as directed**, operator for actuation by appliance automatic shutoff device.
2. Electrically Operated Valves: Comply with UL 429.
- a. Pilot operated.
 - b. Body: Brass or aluminum.
 - c. Seats and Disc: Nitrile rubber.
 - d. Springs and Valve Trim: Stainless steel.
 - e. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
 - f. NEMA ICS 6, Type 4, coil enclosure.
 - g. Normally closed.
 - h. Visual position indicator.
- F. Earthquake Valves
1. Earthquake Valves: Comply with ASCE 25.
- a. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - b. Maximum Operating Pressure: 5 psig (34.5 kPa).
 - c. Cast-aluminum body with nickel-plated chrome steel internal parts.
 - d. Nitrile-rubber valve washer.
 - e. Sight windows for visual indication of valve position.
 - f. Threaded end connections complying with ASME B1.20.1.
 - g. Wall mounting bracket with bubble level indicator.
2. Earthquake Valves: Comply with ASCE 25.
- a. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - b. Maximum Operating Pressure: 0.5 psig (3.45 kPa) **OR** 7 psig (48 kPa) **OR** 60 psig (414 kPa), **as directed**.
 - c. Cast-aluminum body with stainless-steel internal parts.
 - d. Nitrile-rubber, reset-stem o-ring seal.
 - e. Valve position, open or closed, indicator.
 - f. Composition valve seat with clapper held by spring or magnet locking mechanism.
 - g. Level indicator.
 - h. End Connections: Threaded for valves NPS 2 (DN 50) and smaller; flanged for valves NPS 2-1/2 (DN 65) and larger.
- G. Pressure Regulators
1. General Requirements:
- a. Single stage and suitable for natural gas.
 - b. Steel jacket and corrosion-resistant components.
 - c. Elevation compensator.
 - d. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.
2. Service Pressure Regulators: Comply with ANSI Z21.80.
- a. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - b. Springs: Zinc-plated steel; interchangeable.
 - c. Diaphragm Plate: Zinc-plated steel.
 - d. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - e. Orifice: Aluminum; interchangeable.
 - f. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - g. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 - h. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 - i. Overpressure Protection Device: Factory mounted on pressure regulator.



- j. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - k. Maximum Inlet Pressure: 100 psig (690 kPa).
 - 3. Line Pressure Regulators: Comply with ANSI Z21.80.
 - a. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - b. Springs: Zinc-plated steel; interchangeable.
 - c. Diaphragm Plate: Zinc-plated steel.
 - d. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - e. Orifice: Aluminum; interchangeable.
 - f. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - g. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 - h. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 - i. Overpressure Protection Device: Factory mounted on pressure regulator.
 - j. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - k. Maximum Inlet Pressure: 2 psig (13.8 kPa) **OR** 5 psig (34.5 kPa) **OR** 10 psig (69 kPa), **as directed**.
 - 4. Appliance Pressure Regulators: Comply with ANSI Z21.18.
 - a. Body and Diaphragm Case: Die-cast aluminum.
 - b. Springs: Zinc-plated steel; interchangeable.
 - c. Diaphragm Plate: Zinc-plated steel.
 - d. Seat Disc: Nitrile rubber.
 - e. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - f. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
 - g. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
 - h. Maximum Inlet Pressure: 1 psig (6.9 kPa) **OR** 2 psig (13.8 kPa) **OR** 5 psig (34.5 kPa), **as directed**.
- H. Service Meters
 - 1. Diaphragm-Type Service Meters: Comply with ANSI B109.1 **OR** ANSI B109.2, **as directed**.
 - a. Case: Die-cast aluminum.
 - b. Connections: Steel threads.
 - c. Diaphragm: Synthetic fabric.
 - d. Diaphragm Support Bearings: Self-lubricating.
 - e. Compensation: Continuous temperature and pressure, **as directed**.
 - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed**.
 - g. Meter Case and Index: Tamper resistant.
 - h. Remote meter reader compatible.
 - i. Maximum Inlet Pressure: 100 psig (690 kPa).
 - j. Pressure Loss: Maximum 0.5-inch wg (124 Pa) **OR** 2.0-inch wg (498 Pa), **as directed**.
 - k. Accuracy: Maximum plus or minus 1.0 percent.
 - 2. Rotary-Type Service Meters: Comply with ANSI B109.3.
 - a. Case: Extruded aluminum.
 - b. Connection: Flange.
 - c. Impellers: Polished aluminum.
 - d. Rotor Bearings: Self-lubricating.
 - e. Compensation: Continuous temperature and pressure, **as directed**.
 - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed**.
 - g. Tamper resistant.
 - h. Remote meter reader compatible.
 - i. Maximum Inlet Pressure: 100 psig (690 kPa).
 - j. Accuracy: Maximum plus or minus 2.0 percent.



3. Turbine Meters: Comply with ASME MFC-4M.
 - a. Housing: Cast iron or welded steel.
 - b. Connection Threads or Flanges: Steel.
 - c. Turbine: Aluminum or plastic.
 - d. Turbine Bearings: Self-lubricating.
 - e. Compensation: Continuous temperature and pressure, **as directed**.
 - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed**.
 - g. Tamper resistant.
 - h. Remote meter reader compatible.
 - i. Maximum Inlet Pressure: 100 psig (690 kPa).
 - j. Accuracy: Maximum plus or minus 2.0 percent.
 4. Service-Meter Bars:
 - a. Malleable- or cast-iron frame for supporting service meter.
 - b. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
 - c. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.
 5. Service-Meter Bypass Fittings:
 - a. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
 - b. Integral ball-check bypass valve.
- I. Dielectric Fittings
1. Dielectric Unions:
 - a. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
 - b. Combination fitting of copper alloy and ferrous materials.
 - c. Insulating materials suitable for natural gas.
 - d. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
 2. Dielectric Flanges:
 - a. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
 - b. Combination fitting of copper alloy and ferrous materials.
 - c. Insulating materials suitable for natural gas.
 - d. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
 3. Dielectric-Flange Kits:
 - a. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
 - b. Companion-flange assembly for field assembly.
 - c. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
 - d. Insulating materials suitable for natural gas.
 - e. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
- J. Sleeves
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- K. Mechanical Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**.



- c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

L. Escutcheons

1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.
2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Escutcheons: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

M. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.

N. Labeling And Identifying

1. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

1.3 EXECUTION

A. Preparation

1. Close equipment shutoff valves before turning off natural gas to premises or piping section.
2. Inspect natural-gas piping according to NFPA 54 **OR** the International Fuel Gas Code, **as directed**, to determine that natural-gas utilization devices are turned off in piping section affected.
3. Comply with NFPA 54 **OR** the International Fuel Gas Code, **as directed**, requirements for prevention of accidental ignition.

B. Outdoor Piping Installation

1. Comply with NFPA 54 **OR** the International Fuel Gas Code, **as directed**, for installation and purging of natural-gas piping.
2. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 - a. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.
3. Install underground, PE, natural-gas piping according to ASTM D 2774.
4. Steel Piping with Protective Coating:
 - a. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.



- b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

OR

Replace pipe having damaged PE coating with new pipe.

- 5. Copper Tubing with Protective Coating:
 - a. Apply joint cover kits over tubing to cover, seal, and protect joints.
 - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
- 6. Install fittings for changes in direction and branch connections.
- 7. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - a. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - b. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
- 8. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- 9. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- 10. Install pressure gage downstream **OR** upstream and downstream, **as directed**, from each service regulator. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".

C. Indoor Piping Installation

- 1. Comply with NFPA 54 **OR** the International Fuel Gas Code, **as directed**, for installation and purging of natural-gas piping.
- 2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- 3. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- 4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- 5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- 6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- 7. Locate valves for easy access.
- 8. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- 9. Install piping free of sags and bends.
- 10. Install fittings for changes in direction and branch connections.
- 11. Install escutcheons at penetrations of interior walls, ceilings, and floors.
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 2) Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - OR**
 - Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - 3) Piping at Ceiling Penetrations in Finished Spaces: One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.



- Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
- 4) Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
- 5) Piping in Equipment Rooms: One-piece, cast-brass type.
- Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
- 6) Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- b. Existing Piping:
- 1) Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
OR
Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
- 2) Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
OR
Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
- 3) Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
- 4) Piping in Equipment Rooms: Split-casting, cast-brass type.
OR
Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
- 5) Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
13. Verify final equipment locations for roughing-in.
14. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
15. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
- a. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
16. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
17. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
18. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.



- a. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
- b. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
- c. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
- d. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - 1) Exception: Tubing passing through partitions or walls does not require striker barriers.
- e. Prohibited Locations:
 - 1) Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - 2) Do not install natural-gas piping in solid walls or partitions.
19. Use concentric reducer fittings to make reductions in pipe sizes.
20. Connect branch piping from top or side of horizontal piping.
21. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
22. Do not use natural-gas piping as grounding electrode.
23. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
24. Install pressure gage downstream **OR** upstream and downstream, **as directed**, from each line regulator. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".

D. Service-Meter Assembly Installation

1. Install service-meter assemblies aboveground, on concrete bases.
2. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.
3. Install strainer on inlet of service-pressure regulator and meter set.
4. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
5. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
6. Install service meters downstream from pressure regulators.
7. Install metal bollards to protect meter assemblies. Comply with requirements in Division 05 Section "Metal Fabrications" for pipe bollards.

E. Valve Installation

1. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
2. Install underground valves with valve boxes.
3. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
4. Install earthquake valves aboveground outside buildings according to listing.
5. Install anode for metallic valves in underground PE piping.

F. Piping Joint Construction

1. Ream ends of pipes and tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints:



- a. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - b. Cut threads full and clean using sharp dies.
 - c. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - d. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - e. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
4. Welded Joints:
- a. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - b. Bevel plain ends of steel pipe.
 - c. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
6. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
7. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
8. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
- a. Plain-End Pipe and Fittings: Use butt fusion.
 - b. Plain-End Pipe and Socket Fittings: Use socket fusion.
- G. Hanger And Support Installation
1. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 2. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
 3. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - a. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
 - b. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
 - e. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (15.8 mm).
 4. Install hangers for horizontal drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
 - a. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
 - b. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches (2134 mm); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 1 (DN 25): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).
 5. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
 - a. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).



- b. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
- c. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

H. Connections

1. Connect to utility's gas main according to utility's procedures and requirements.
2. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
3. Install piping adjacent to appliances to allow service and maintenance of appliances.
4. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
5. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

I. Labeling And Identifying

1. Comply with requirements in Division 23 Section "Identification For Hvac Piping And Equipment" for piping and valve identification.
OR
Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

J. Painting

1. Comply with requirements in Division 07 for painting interior and exterior natural-gas piping.
2. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - a. Alkyd System: MPI EXT 5.1D.
 - 1) Prime Coat: Alkyd anticorrosive metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Exterior alkyd enamel matching topcoat.
 - 3) Topcoat: Exterior alkyd enamel (flat) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **unless directed otherwise**.
3. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - a. Latex Over Alkyd Primer System: MPI INT 5.1Q.
 - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Interior latex matching topcoat.
 - 3) Topcoat: Interior latex (flat) **OR** (low sheen) **OR** (eggshell) **OR** (satin) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **unless directed otherwise**.
 - b. Alkyd System: MPI INT 5.1E.
 - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Interior alkyd matching topcoat.
 - 3) Topcoat: Interior alkyd (flat) **OR** (eggshell) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **unless directed otherwise**.
4. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

K. Concrete Bases

1. Concrete Bases: Anchor equipment to concrete base according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.



- b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Use 3000-psig (20.7-MPa), **unless directed otherwise**, 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
- L. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Test, inspect, and purge natural gas according to NFPA 54 **OR** the International Fuel Gas Code, **as directed**, and authorities having jurisdiction.
 3. Natural-gas piping will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.
- M. Outdoor Piping Schedule
1. Underground natural-gas piping shall be one of the following:
 - a. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
 - b. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
 - c. Annealed **OR** Drawn, **as directed**,-temper copper tube with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
 2. Aboveground natural-gas piping shall be one of the following:
 - a. Steel pipe with malleable-iron fittings and threaded joints.
 - b. Steel pipe with wrought-steel fittings and welded joints.
 - c. Annealed **OR** Drawn, **as directed**,-temper copper tube with wrought-copper fittings and brazed joints.
 3. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and brazed **OR** flared, **as directed**, joints. Install piping embedded in concrete with no joints in concrete.
 4. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- N. Indoor Piping Schedule For System Pressures Less Than 0.5 psig (3.45 kPa)
1. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:
 - a. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
 - b. Annealed-temper, tin-lined copper tube with flared joints and fittings.
 - c. Annealed-temper, copper tube with wrought-copper fittings and brazed **OR** flared, **as directed**, joints.
 - d. Aluminum tube with flared fittings and joints.
 - e. Steel pipe with malleable-iron fittings and threaded joints.
 2. Aboveground, distribution piping shall be one of the following:
 - a. Steel pipe with malleable-iron fittings and threaded joints.
 - b. Steel pipe with wrought-steel fittings and welded joints.
 - c. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
 3. Underground, below building, piping shall be one of the following:
 - a. Steel pipe with malleable-iron fittings and threaded joints.
 - b. Steel pipe with wrought-steel fittings and welded joints.
 4. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.



5. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- O. Indoor Piping Schedule For System Pressures More Than 0.5 psig (3.45 kPa) And Less Than 5 psig (34.5 kPa)
1. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:
 - a. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
 - b. Annealed-temper, tin-lined copper tube with flared joints and fittings.
 - c. Annealed-temper, copper tube with wrought-copper fittings and brazed **OR** flared, **as directed**, joints.
 - d. Aluminum tube with flared fittings and joints.
 - e. Steel pipe with malleable-iron fittings and threaded joints.
 2. Aboveground, distribution piping shall be one of the following:
 - a. Steel pipe with malleable-iron fittings and threaded joints.
 - b. Steel pipe with steel welding fittings and welded joints.
 - c. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
 3. Underground, below building, piping shall be one of the following:
 - a. Steel pipe with malleable-iron fittings and threaded joints.
 - b. Steel pipe with wrought-steel fittings and welded joints.
 4. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.
 5. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- P. Indoor Piping Schedule For System Pressures More Than 5 psig (34.5 kPa)
1. Aboveground Piping: Maximum operating pressure more than 5 psig (34.5 kPa).
 2. Aboveground, Branch Piping: Steel pipe with steel welding fittings and welded joints.
 3. Aboveground, distribution piping shall be one of the following:
 - a. Steel pipe with steel welding fittings and welded joints.
 - b. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
 4. Underground, below building, piping shall be one of the following:
 - a. Steel pipe with malleable-iron fittings and threaded joints.
 - b. Steel pipe with wrought-steel fittings and welded joints.
 5. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
 6. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- Q. Underground Manual Gas Shutoff Valve Schedule
1. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
 2. Underground:
 - a. PE valves.
 - b. NPS 2 (DN 50) and Smaller: Bronze plug valves.
 - c. NPS 2-1/2 (DN 65) and Larger: Cast-iron, lubricated **OR** nonlubricated, **as directed**, plug valves.
- R. Aboveground Manual Gas Shutoff Valve Schedule
1. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be one of the following:
 - a. One-piece, bronze ball valve with bronze trim.
 - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.



- c. Bronze plug valve.
2. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:
 - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - b. Bronze plug valve.
 - c. Cast-iron, nonlubricated plug valve.
3. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be one of the following:
 - a. One-piece, bronze ball valve with bronze trim.
 - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - c. Bronze plug valve.
4. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be one of the following:
 - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - b. Bronze plug valve.
 - c. Cast-iron, nonlubricated **OR** lubricated, **as directed**, plug valve.
5. Valves in branch piping for single appliance shall be one of the following:
 - a. One-piece, bronze ball valve with bronze trim.
 - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - c. Bronze plug valve.

END OF SECTION 23 11 23 00b



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**SECTION 23 11 23 00c - FACILITY LIQUEFIED-PETROLEUM GAS PIPING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for facility liquid-petroleum gas piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pipes, tubes, and fittings.
 - b. Piping specialties.
 - c. Piping and tubing joining materials.
 - d. Valves.
 - e. Pressure regulators.
 - f. Service meters.
 - g. Storage containers.
 - h. Transport truck unloading facility specialties.
 - i. Pumps.
 - j. Vaporizers.
 - k. Air mixers.
 - l. Mechanical sleeve seals.
 - m. Grout.
 - n. Concrete bases.

C. Definitions

1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. LPG: Liquefied-petroleum gas.

D. Performance Requirements

1. Minimum Operating-Pressure Ratings:
 - a. For Piping Containing Only Vapor:
 - 1) Piping and Valves: 125 psig (862 kPa) unless otherwise indicated.
 - b. For Piping Containing Liquid:
 - 1) Piping between Shutoff Valves: 350 psig (2413 kPa) unless otherwise indicated.
 - 2) Piping Other Than Above: 250 psig (1723 kPa) unless otherwise indicated.
 - 3) Valves and Fittings: 250 psig (1723 kPa) unless otherwise indicated.
 - c. Minimum Operating Pressure of Service Meter: 5 psig (34.5 kPa) **OR** 10 psig (69 kPa) **OR** 20 psig (138 kPa) **OR** 65 psig (450 kPa), **as directed**.
2. LPG System Pressure within Buildings: One pressure range. 0.5 psig (3.45 kPa) or less **OR** More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) **OR** More than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa), **as directed**.
OR
LPG System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.

**OR**

LPG System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa) and is reduced to secondary pressure of more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa).

OR

LPG System Pressures within Buildings: Three pressure ranges. Primary pressure is more than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa) and is reduced to secondary pressures of more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) and is reduced again to pressures of 0.5 psig (3.45 kPa) or less.

3. Delegated Design: Design restraints and anchors for LPG piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
4. Seismic Performance: Vaporizers and storage container supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For facility LPG piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
3. Delegated-Design Submittal: For LPG piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of seismic restraints.
 - b. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Seismic Qualification Certificates: Submit certification that vaporizer, air mixer, storage container supports, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Welding certificates.
6. Field quality-control reports.
7. Operation and maintenance data.

F. Quality Assurance

1. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Delivery, Storage, And Handling

1. Handling Flammable Liquids: Remove and dispose of liquids from existing LPG piping according to requirements of authorities having jurisdiction.
2. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.



3. Store pipes and tubes with protective PE coating to avoid damaging coating and protect from direct sunlight.
4. Protect stored PE pipes and valves from direct sunlight.

H. Project Conditions

1. Interruption of Existing LPG Service: Do not interrupt LPG service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of LPG supply according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of LPG service.
 - b. Do not proceed with interruption of LPG service without the Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. Steel Pipe: ASTM A 53/A 53M, black steel, Schedules 40 and 80, Type E or S, Grade B.
 - a. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - b. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - c. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - d. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1) Material Group: 1.1.
 - 2) End Connections: Threaded or butt welding to match pipe.
 - 3) Lapped Face: Not permitted underground.
 - 4) Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - 5) Bolts and Nuts: ASME B18.2.1, carbon steel aboveground, and stainless steel underground.
 - e. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - 1) Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
 - f. Mechanical Couplings:
 - 1) Stainless-steel **OR** Steel, **as directed**, flanges and tube with epoxy finish.
 - 2) Buna-nitrile seals.
 - 3) Stainless-steel **OR** Steel, **as directed**, bolts, washers, and nuts.
 - 4) Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - 5) Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.
2. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
 - a. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
 - b. Coating: PE with flame retardant.
 - 1) Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a) Flame-Spread Index: 25 or less.
 - b) Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
 - c. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
 - d. Striker Plates: Steel, designed to protect tubing from penetrations.
 - e. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
 - f. Operating-Pressure Rating: 5 psig (34.5 kPa).



3. Aluminum Tubing: Comply with ASTM B 210 and ASTM B 241/B 241M.
 - a. Aluminum Alloy: Alloy 5456 is prohibited.
 - b. Protective Coating: Factory-applied coating capable of resisting corrosion on tubing in contact with masonry, plaster, insulation, water, detergents, and sewerage.
 - c. Flare Fittings: Comply with ASME B16.26 and SAE J513.
 - 1) Copper-alloy fittings.
 - 2) Metal-to-metal compression seal without gasket.
 - 3) Dryseal threads shall comply with ASME B1.20.3.
4. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 837, Type G, **as directed**.
 - a. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
 - b. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - 1) Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - 2) Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
 - c. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch (0.56 mm) thick.
5. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 837, Type G, **as directed**.
 - a. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
 - b. Flare Fittings: Comply with ASME B16.26 and SAE J513.
 - 1) Copper fittings with long nuts.
 - 2) Metal-to-metal compression seal without gasket.
 - 3) Dryseal threads complying with ASME B1.20.3.
 - c. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch (0.56 mm) thick.
6. Tin-Lined Copper Tube: ASTM B 280, seamless, annealed, with interior tin-plated lining.
 - a. Flare Fittings: Comply with ASME B16.26 and SAE J513.
 - 1) Copper fittings with long nuts.
 - 2) Metal-to-metal compression seal without gasket.
 - 3) Dryseal threads complying with ASME B1.20.3.
7. PE Pipe: ASTM D 2513, SDR 11.
 - a. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
 - b. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - c. Anodeless Service-Line Risers: Factory fabricated and leak tested.
 - 1) Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
 - 2) Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B with corrosion-protective coating covering. Vent casing aboveground, **as directed**.
 - 3) Aboveground Portion: PE transition fitting.
 - 4) Outlet shall be threaded or flanged or suitable for welded connection.
 - 5) Tracer wire connection.
 - 6) Ultraviolet shield.
 - 7) Stake supports with factory finish to match steel pipe casing or carrier pipe.
 - d. Transition Service-Line Risers: Factory fabricated and leak tested.
 - 1) Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
 - 2) Outlet shall be threaded or flanged or suitable for welded connection.
 - 3) Bridging sleeve over mechanical coupling.
 - 4) Factory-connected anode.
 - 5) Tracer wire connection.



- 6) Ultraviolet shield.
- 7) Stake supports with factory finish to match steel pipe casing or carrier pipe.
- e. Plastic Mechanical Couplings, NPS 1-1/2 (DN 40) and Smaller: Capable of joining PE pipe to PE pipe.
 - 1) PE body with molded-in, stainless-steel support ring.
 - 2) Buna-nitrile seals.
 - 3) Acetal collets.
 - 4) Electro-zinc-plated steel stiffener.
- f. Plastic Mechanical Couplings, NPS 2 (DN 50) and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - 1) Fiber-reinforced plastic body.
 - 2) PE body tube.
 - 3) Buna-nitrile seals.
 - 4) Acetal collets.
 - 5) Stainless-steel bolts, nuts, and washers.
8. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - 1) Stainless-steel **OR** Steel, **as directed**, flanges and tube with epoxy finish.
 - 2) Buna-nitrile seals.
 - 3) Stainless-steel **OR** Steel, **as directed**, bolts, washers, and nuts.
 - 4) Factory-installed anode for steel-body couplings installed underground.

B. Piping Specialties

1. Flexible Piping Joints:
 - a. Approved for LPG service.
 - b. Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
 - c. Minimum working pressure of 250 psig (1723 kPa) and 250 deg F (121 deg C) operating temperature.
 - d. Flanged- or threaded-end connections to match equipment connected and shall be capable of minimum 3/4-inch (20-mm) misalignment.
 - e. Maximum 36-inch (914-mm) length for liquid LPG lines.
2. Appliance Flexible Connectors:
 - a. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
 - b. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
 - c. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
 - d. Corrugated stainless-steel tubing with polymer coating.
 - e. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
 - f. End Fittings: Zinc-coated steel.
 - g. Threaded Ends: Comply with ASME B1.20.1.
 - h. Maximum Length: 72 inches (1830 mm).
3. Quick-Disconnect Devices: Comply with ANSI Z21.41.
 - a. Copper-alloy convenience outlet and matching plug connector.
 - b. Nitrile seals.
 - c. Hand operated with automatic shutoff when disconnected.
 - d. For indoor or outdoor applications.
 - e. Adjustable, retractable restraining cable.
4. Y-Pattern Strainers:
 - a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: 40 **OR** 60, **as directed**,-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 125 psig (862 kPa).
5. Basket Strainers:



- a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 - b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
 - d. CWP Rating: 125 psig (862 kPa).
6. T-Pattern Strainers:
- a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
 - b. End Connections: Grooved ends.
 - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
 - d. CWP Rating: 750 psig (5170 kPa).
7. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

C. Joining Materials

1. Joint Compound and Tape: Suitable for LPG.
2. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
3. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M.

D. Manual Gas Shutoff Valves

1. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
2. Metallic Valves, NPS 2 (DN 50) and Smaller for Liquid Service: Comply with ASME B16.33 and UL 842.
 - a. CWP Rating: 250 psig (1723 kPa).
 - b. Threaded Ends: Comply with ASME B1.20.1.
 - c. Socket ends for brazed joints.
 - d. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - e. Listing by CSA or agency acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
 - f. Valves 1-1/4 inch (32 mm) and larger shall be suitable for LPG service, with "WOG" indicated on valve body.
3. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller for Vapor Service: Comply with ASME B16.33.
 - a. CWP Rating: 125 psig (862 kPa).
 - b. Threaded Ends: Comply with ASME B1.20.1.
 - c. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 - d. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - e. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
 - f. Service Mark: Valves 1-1/4 inch (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.
4. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
 - a. CWP Rating: 125 psig (862 kPa).
 - b. Flanged Ends: Comply with ASME B16.5 for steel flanges.



- c. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
- d. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- 5. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated brass.
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE; blowout proof.
 - e. Packing: Separate packnut with adjustable-stem packing threaded ends.
 - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - g. CWP Rating: 600 psig (4143 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
- 6. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated bronze.
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE; blowout proof.
 - e. Packing: Threaded-body packnut design with adjustable-stem packing.
 - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - g. CWP Rating: 600 psig (4143 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
- 7. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Ball: Chrome-plated bronze
 - c. Stem: Bronze; blowout proof.
 - d. Seats: Reinforced TFE.
 - e. Packing: Threaded-body packnut design with adjustable-stem packing.
 - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - g. CWP Rating: 600 psig (4140 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
- 8. Bronze Plug Valves: MSS SP-78.
 - a. Body: Bronze, complying with ASTM B 584.
 - b. Plug: Bronze.
 - c. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - d. Operator: Square head or lug type with tamperproof feature where indicated.
 - e. Pressure Class: 125 psig (862 kPa).
 - f. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - g. Service: Suitable for LPG service with "WOG" indicated on valve body.
- 9. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
 - a. Body: Cast iron, complying with ASTM A 126, Class B.
 - b. Plug: Bronze or nickel-plated cast iron.
 - c. Seat: Coated with thermoplastic.
 - d. Stem Seal: Compatible with LPG.
 - e. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.



- f. Operator: Square head or lug type with tamperproof feature where indicated.
 - g. Pressure Class: 125 psig (862 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
10. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
- a. Body: Cast iron, complying with ASTM A 126 Class B.
 - b. Plug: Bronze or nickel-plated cast iron.
 - c. Seat: Coated with thermoplastic.
 - d. Stem Seal: Compatible with LPG.
 - e. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - f. Operator: Square head or lug type with tamperproof feature where indicated.
 - g. Pressure Class: 125 psig (862 kPa).
 - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
11. PE Ball Valves: Comply with ASME B16.40.
- a. Body: PE.
 - b. Ball: PE.
 - c. Stem: Acetal.
 - d. Seats and Seals: Nitrile.
 - e. Ends: Plain or fusible to match piping.
 - f. CWP Rating: 80 psig (552 kPa).
 - g. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C).
 - h. Operator: Nut or flat head for key operation.
 - i. Include plastic valve extension.
 - j. Include tamperproof locking feature for valves where indicated on Drawings.
12. Valve Boxes:
- a. Cast-iron, two-section box.
 - b. Top section with cover with "GAS" lettering.
 - c. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
 - d. Adjustable cast-iron extensions of length required for depth of bury.
 - e. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head and with stem of length required to operate valve.
- E. Motorized Gas Valves
1. Hydrostatic Relief Valves: Comply with NFPA 58.
- a. Operating Pressure: 350 psig (2413 kPa).
 - b. Body: Brass.
 - c. Spring: Stainless steel.
 - d. Disc and Seat: Nitrile.
 - e. Brass body and stainless-steel, spring-operated valve with resilient rubber disc seat and protective cap.
 - f. Factory set and tested.
 - g. Listing: Valves listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - h. Valve shall reseal after relieving pressure.
2. Automatic Gas Valves: Comply with ANSI Z21.21.
- a. Body: Brass or aluminum.
 - b. Seats and Disc: Nitrile rubber.
 - c. Springs and Valve Trim: Stainless steel.
 - d. Normally closed.
 - e. Visual position indicator.



- f. Electrical **OR** Mechanical, **as directed**, operator for actuation by appliance automatic shutoff device.
 3. Electrically Operated Valves: Comply with UL 429.
 - a. Pilot operated.
 - b. Body: Brass or aluminum.
 - c. Seats and Disc: Nitrile rubber.
 - d. Springs and Valve Trim: Stainless steel.
 - e. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, replaceable.
 - f. NEMA ICS 6, Type 4, coil enclosure.
 - g. Normally closed.
 - h. Visual position indicator.
- F. Earthquake Valves
 1. Earthquake Valves: Comply with ASCE 25.
 - a. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - b. Maximum Operating Pressure: 5 psig (34.5 kPa).
 - c. Cast-aluminum body with nickel-plated chrome steel internal parts.
 - d. Nitrile-rubber valve washer.
 - e. Sight windows for visual indication of valve position.
 - f. Threaded-end connections complying with ASME B1.20.1.
 2. Earthquake Valves: Comply with ASCE 25.
 - a. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - b. Maximum Operating Pressure: 0.5 psig (3.45 kPa) **OR** 7 psig (48 kPa) **OR** 60 psig (414 kPa), **as directed**.
 - c. Cast-aluminum body with stainless-steel internal parts.
 - d. Nitrile-rubber, reset-stem o-ring seal.
 - e. Valve position, open or closed, indicator.
 - f. Composition valve seat with clapper held by spring or magnet locking mechanism.
 - g. Level indicator.
 - h. End Connections: Threaded for valves NPS 2 (DN 50) and smaller; flanged for valves NPS 2-1/2 (DN 65) and larger.
- G. Pressure Regulators
 1. General Requirements:
 - a. Single stage and suitable for LPG.
 - b. Steel jacket and corrosion-resistant components.
 - c. Elevation compensator.
 - d. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.
 2. Service Pressure Regulators: Comply with ANSI Z21.80.
 - a. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - b. Springs: Zinc-plated steel; interchangeable.
 - c. Diaphragm Plate: Zinc-plated steel.
 - d. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - e. Orifice: Aluminum; interchangeable.
 - f. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - g. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure sensing piping external to the regulator.
 - h. Pressure regulator shall maintain discharge pressure setting downstream and not exceed 150 percent of design discharge pressure at shutoff.
 - i. Overpressure Protection Device: Factory mounted on pressure regulator.
 - j. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - k. Maximum Inlet Pressure: 100 psig (690 kPa).
 3. Line Pressure Regulators: Comply with ANSI Z21.80.



- a. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - b. Springs: Zinc-plated steel; interchangeable.
 - c. Diaphragm Plate: Zinc-plated steel.
 - d. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - e. Orifice: Aluminum; interchangeable.
 - f. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - g. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure sensing piping external to the regulator.
 - h. Pressure regulator shall maintain discharge pressure setting downstream and not exceed 150 percent of design discharge pressure at shutoff.
 - i. Overpressure Protection Device: Factory mounted on pressure regulator.
 - j. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - k. Maximum Inlet Pressure: 2 psig (13.8 kPa) **OR** 5 psig (34.5 kPa) **OR** 10 psig (69 kPa), **as directed**.
4. Appliance Pressure Regulators: Comply with ANSI Z21.18.
- a. Body and Diaphragm Case: Die-cast aluminum.
 - b. Springs: Zinc-plated steel; interchangeable.
 - c. Diaphragm Plate: Zinc-plated steel.
 - d. Seat Disc: Nitrile rubber.
 - e. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - f. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
 - g. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
 - h. Maximum Inlet Pressure: 1 psig (6.9 kPa) **OR** 2 psig (13.8 kPa) **OR** 5 psig (34.5 kPa-), **as directed**.

H. Service Meters

1. Diaphragm-Type Service Meters: Comply with ANSI B109.1 **OR** ANSI B109.2, **as directed**.
 - a. Case: Die-cast aluminum.
 - b. Connections: Steel threads.
 - c. Diaphragm: Synthetic fabric.
 - d. Diaphragm Support Bearings: Self-lubricating.
 - e. Compensation: Continuous temperature and pressure, **as directed**.
 - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed**.
 - g. Meter Case and Index: Tamper resistant.
 - h. Remote meter reader compatible.
 - i. Maximum Inlet Pressure: 100 psig (690 kPa).
 - j. Pressure Loss: Maximum 0.5-inch wg (124 Pa) **OR** 2.0-inch wg (498 Pa), **as directed**.
 - k. Accuracy: Maximum plus or minus 1.0 percent.
2. Rotary-Type Service Meters: Comply with ANSI B109.3.
 - a. Case: Extruded aluminum.
 - b. Connection: Flange.
 - c. Impellers: Polished aluminum.
 - d. Rotor Bearings: Self-lubricating.
 - e. Compensation: Continuous temperature and pressure, **as directed**.
 - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed**.
 - g. Tamper resistant.
 - h. Remote meter reader compatible.
 - i. Maximum Inlet Pressure: 100 psig (690 kPa).
 - j. Accuracy: Maximum plus or minus 2.0 percent.
3. Turbine Meters: Comply with ASME MFC-4M.
 - a. Housing: Cast iron or welded steel.
 - b. Connection Threads or Flanges: Steel.



- c. Turbine: Aluminum or plastic.
 - d. Turbine Bearings: Self-lubricating.
 - e. Compensation: Continuous temperature and pressure, **as directed**.
 - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed**.
 - g. Tamper resistant.
 - h. Remote meter reader compatible.
 - i. Maximum Inlet Pressure: 100 psig (690 kPa).
 - j. Accuracy: Maximum plus or minus 2.0 percent.
4. Service-Meter Bars:
- a. Malleable- or cast-iron frame for supporting service meter.
 - b. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
 - c. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.
5. Service-Meter Bypass Fittings:
- a. Ferrous, tee, pipe fitting with capped side inlet for temporary LPG supply.
 - b. Integral ball-check bypass valve.
- I. Dielectric Fittings
1. Dielectric Unions:
- a. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
 - b. Combination fitting of copper alloy and ferrous materials.
 - c. Insulating materials suitable for LPG.
 - d. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
2. Dielectric Flanges:
- a. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
 - b. Combination fitting of copper alloy and ferrous materials.
 - c. Insulating materials suitable for LPG.
 - d. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
3. Dielectric-Flange Kits:
- a. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
 - b. Companion-flange assembly for field assembly.
 - c. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
 - d. Insulating materials suitable for LPG.
 - e. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
- J. Storage Containers
1. Description: Factory fabricated, complying with requirements in NFPA 58 and ASME Boiler and Pressure Vessel Code and bearing the ASME label. Tanks shall be rated for 250-psig (1723-kPa) minimum working pressure.
- a. Liquid outlet and vapor inlet and outlet connections shall have shutoff valves with excess-flow safety shutoff valves and bypass and back-pressure check valves with smaller than 0.039-inch (1-mm) drill-size hole to equalize pressure. Liquid-fill connection shall have backflow check valve.
 - 1) Connections: Color-code and tag valves to indicate type.
 - a) Liquid fill and outlet, red.
 - b) Vapor inlet and outlet, yellow.
 - b. Level gage shall indicate current level of liquid in the container. Gages shall also indicate storage container contents; e.g., "Butane," "50-50 LPG Mix," or "Propane."
 - c. Pressure relief valves, type and number as required by NFPA 58, connected to vapor space and having discharge piping same size as relief-valve outlet and long enough to extend at least 84 inches (2130 mm) directly overhead. Identify relief valves as follows:



- 1) Discharge pressure in psig (kPa).
 - 2) Rate of discharge for standard air in cfm (L/s).
 - 3) Manufacturer's name.
 - 4) Catalog or model number.
 - d. Container pressure gage.
 - e. For outdoor installation, exposed metal surfaces mechanically cleaned, primed, and painted for resistance to corrosion.
 - f. Ladders for access to valves more than 72 inches (1830 mm) aboveground.
 - g. Stainless-Steel Nameplate: Attach to aboveground storage container or to adjacent structure for underground storage container.
 - 1) Name and address of supplier or trade name of container.
 - 2) Water capacity in gallons and liters.
 - 3) Design pressure in psig (kPa).
 - 4) Statement, "This container shall not contain a product having a vapor pressure in excess of **<Insert maximum pressure in psig (kPa) at 100 deg F (37.8 deg C)>**."
 - 5) Outside surface area in sq. ft. (sq. m).
 - 6) Year of manufacture.
 - 7) Shell thickness in inches (mm).
 - 8) Overall length in feet (m).
 - 9) OD in feet (m).
 - 10) Manufacturer's serial number.
 - 11) ASME Code label.
 - h. Felt support pads and two concrete or painted-steel saddles per storage container. Corrosion protection required at container-to-felt contact.
 - i. Tie straps for each saddle.
 - j. Straps and anchors for tie-down slab.
 - k. Asphalt-based coating for corrosion protection.
 - l. Container connections and valves protected in manway at top of storage container.
 - m. Manway equipped with ventilation louvers.
- K. Transport Truck Unloading Facility
1. Description: Comply with requirements in NFPA 58.
 - a. Support structure consisting of a minimum 6-inch (150-mm) steel channel or 6-by-4-inch (150-by-100-mm) rectangular steel tubing, a minimum of 36 inches (914 mm) above and below grade.
 - b. Liquid-fill and vapor-return, quick-disconnect fittings.
 - c. Liquid and vapor shutoff valves with hydrostatic relief valves mounted between the quick-disconnect fittings and shutoff valves.
 - d. Excess-flow safety shutoff valve in vapor-return line.
 - e. Backflow check valve in liquid-fill line.
 - f. Remote emergency shutoff valve station with underground cable to the vapor emergency shutoff valve.
- L. Pumps
1. Description: Factory-assembled and -tested, duplex, positive-displacement, belt drive.
 2. Pump Construction:
 - a. Casing: Ductile-iron casing with threaded gage tappings at inlet and outlet.
 - b. Internal Pressure Relief Valve: For pump protection in addition to the external pressure relief valves.
 - c. Impeller: Carbon or composite vane in cast-iron rotor.
 - d. Pump Shaft: Carbon steel.
 - e. Seal: Mechanical with Buna-N o-ring.
 - f. Pump Bearings: Ball bearings with grease fittings.
 - g. Baseplate: Bent carbon-steel channel or structural channel.



3. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
 - c. Motor Speeds: Single.
 - d. Bearings: Permanently lubricated **OR** Grease-lubricated, **as directed**, ball bearings.
 - e. Class I, Division 1, Group D requirements per NFPA 70.
4. Factory-Installed Piping and Specialties:
 - a. Pipe: ASTM A 53/A 53M, Type E or S, Grade B; Schedule 40 black steel with welded fittings and joints or Schedule 80 for threaded malleable-iron fittings and joints.
 - b. Piping Specialties for Each Pump:
 - 1) Bypass valve.
 - 2) Isolation valves.
 - 3) Unions for each connection.
 - 4) Check valve.
 - 5) Basket strainer.
 - 6) Pressure gages for suction and discharge connections.
 - 7) Hydrostatic relief valve.
 - 8) Pilot-operated, pressure-regulating valve.
5. Braided-jacket flexible connectors for suction and discharge connections.
6. Pump and Piping Finish: For outdoor installation, exposed metal surfaces mechanically cleaned, primed, and painted for resistance to corrosion.
7. Controls:
 - a. Explosion-proof controls enclosure.
 - b. Magnetic starter package with automatic alternator.
 - c. Pressure-activated start and stop.
 - d. Lag pump starts if lead pump fails.
 - e. Audible and visual indication of pump failure.

M. Vaporizers

1. Description: Factory-fabricated, -assembled, and -tested vaporizer with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket, flue-gas vent, liquid fuel supply and vapor connections, and controls. Assembly shall be FMG labeled and comply with NFPA 58 and NFPA 70.
2. Fabricate base and attachment to vaporizers with reinforcement strong enough to resist vaporizer movement during a seismic event when steel base is anchored to a concrete base.
3. Casing:
 - a. Mineral-fiber insulation, a minimum of 2 inches (50 mm) thick, surrounding the heat exchanger.
 - b. Integral one-piece skid with forklift access holes.
 - c. Lifting lugs on top of vaporizer.
 - d. Flue rain cap and bird screen.
 - e. Sheet metal jacket with screw-fastened closures and baked-enamel **OR** powder-coat, **as directed**, protective finish.
 - f. Mounting base to secure boiler to concrete base.
 - g. Control Compartment Enclosure: NEMA 250, Type 4, enclosure housing control panels for LPG-fired vaporizers. Explosion-proof control compartment construction required for electric vaporizers.
4. LPG Liquid and Vapor Circuit Specialties:
 - a. Y-type strainer with drain valve at inlet.
 - b. Vaporizer coil safety pressure relief valve.
 - c. Vaporizer coil blowdown valve.
 - d. Vapor outlet isolation valve.



- e. Pressure gages, a minimum of 2-1/2 inches (63 mm) in diameter, at liquid inlet and vapor discharge. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
 - f. Inlet safety solenoid valve to close with off-normal operation alarm.
 - g. Backflow check valve in bypass around inlet safety solenoid valve.
 - h. Liquid carryover or float-type safety shutoff switch.
 - i. LPG Vapor Filter: Steel shell designed and manufactured per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; factory mounted on vaporizer discharge. Shells larger than 5 inches (125 mm) shall be ASME "U" stamped. Fill with stainless-steel, woven-mesh coalescing element to remove 99 percent of particles larger than 10 microns. 250-psig (1723-kPa) minimum working pressure. Finish with corrosion-resistant coating for an exterior application. Include factory-mounted and -piped, differential pressure gage with gage cocks in and out, and minimum NPS 3/4 (DN 20) full-port, ball-type drain valve.
5. Direct-Type, Direct-Fired Heat Exchanger:
- a. Description: ASME-rated and -stamped, LPG, vaporizer coil contained in an enclosure insulated with at least 2-inch- (50-mm-) thick, mineral-fiber board enclosure with a burner.
 - b. Burner Tubes and Orifices: Stainless steel.
 - 1) Gas Train: Control devices and burner control sequence shall be FMG labeled. Include shutoff valve, high- and low-pressure safety switches, pressure regulator, and main- and pilot-control valves.
 - 2) Pilot: Standing pilot with 100 percent main-valve and pilot safety shutoff.
 - c. Burner Operating Controls:
 - 1) Controls shall maintain safe operating conditions. Mechanical burner safety controls limit operation of the burner.
 - 2) High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design pressure.
 - 3) Operating Vapor-Pressure Control: Factory piped and mounted to control burner.
6. Indirect-Type, Direct-Fired Heat Exchanger:
- a. Description: ASME-rated and -stamped, LPG, vaporizer vessel with a replaceable, immersion-type, electric heating element.
 - b. Heating Element Operating Controls:
 - 1) Operating controls shall maintain safe operating conditions. Safety controls limit operation of the element. Microprocessor-based control system integrates safety and operating controls, **as directed**.
 - 2) Operating Vapor-Pressure Control: Factory wired and mounted to control heating element.
 - 3) High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design pressure.
 - 4) Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
 - 5) Control Transformer: 115-V maximum control voltage.
7. Direct-Type, Water-Bath Heat Exchanger:
- a. Description: Straight, steel fire tubes welded into steel headers with ASME-rated and -stamped, helical, LPG, vaporizer coil submerged in water bath. Include the following:
 - 1) Water bath filled with water/glycol solution designed to prevent freezing at minus 30 deg F (minus 34 deg C).
 - 2) Water-bath, high- and low-level sight glasses.
 - 3) Low-water cutoff to stop burner and annunciate alarm.
 - 4) Water/glycol fill and vent fitting.
 - 5) Minimum NPS 3/4 (DN 20) hose-end drain valves.
 - 6) Operating high- and low-limit aquastat controllers.
 - 7) Water-bath temperature gage; a minimum of 2-1/2 inches (63 mm) in diameter. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
 - b. Burner Tubes and Orifices: Stainless steel.



- 1) Gas Train: Control devices and burner modulation control sequence shall be FMG labeled. Include shutoff valve, high- and low-pressure safety switches, pressure regulator, and main- and pilot-control valves.
 - 2) Pilot: Intermittent-electric-spark **OR** Hot-surface, **as directed**, pilot ignition with 100 percent main-valve and pilot safety shutoff with electronic supervision of burner flame.
 - c. Burner Operating Controls:
 - 1) Operating controls shall maintain safe operating conditions. Safety controls limit operation of the burner. Microprocessor-based control system integrates safety and operating controls, **as directed**.
 - 2) Operating Water-Bath Temperature Control: Factory wired and mounted to control burner.
 - 3) High-Temperature and High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design temperature or vapor pressure.
 - 4) Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
 - 5) Control Transformer: 115-V maximum control voltage.
 8. Indirect-Type, Water-Bath Heat Exchanger:
 - a. Description: Immersion-type, electric heating element with ASME-rated and -stamped, helical, LPG, vaporizer coil submerged in water bath. Include the following:
 - 1) Water bath filled with water/glycol solution designed to prevent freezing at minus 30 deg F (minus 34 deg C).
 - 2) Water-bath, high- and low-level sight glasses.
 - 3) Low-water cutoff to stop electric heater and annunciate alarm.
 - 4) Water/glycol fill and vent fitting.
 - 5) Minimum NPS 3/4 (DN 20) hose-end drain valves.
 - 6) Operating high- and low-limit aquastat controllers.
 - 7) Water-bath temperature gage; a minimum of 2-1/2 inches (63 mm) in diameter. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
 - b. Electric Heater Operating Controls:
 - 1) Controls shall maintain safe operating conditions. Safety controls limit operation of the electric element. Microprocessor-based control system integrates safety and operating controls, **as directed**.
 - 2) Operating Water-Bath Temperature Control: Factory wired and mounted to control burner.
 - 3) High-Temperature and High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design temperature or pressure.
 - 4) Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
 - 5) Control Transformer: 115-V maximum control voltage.
 9. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control set points and display vaporizer status and alarms.
- N. Air Mixers
1. Description: Factory-fabricated, -assembled, -calibrated, and -tested, blower-assisted, **as directed**, air mixer with surge tank, built on a steel base; including vapor supply and discharge connections, and controls. Assembly shall be FMG labeled and comply with NFPA 58 and NFPA 70.
 2. Fabricate base and attachment to mixers with reinforcement strong enough to resist air mixer movement during a seismic event when steel base is anchored to a concrete base.
 3. Mounting Skid, Panels, and Surge Tank:
 - a. Integral one-piece skid with forklift access holes.
 - b. Lifting lugs on top of air mixer.
 - c. Baked-enamel **OR** Powder-coat, **as directed**, protective finish.



- d. Mounting base to secure boiler to concrete base.
 - e. Control Compartment Enclosure: NEMA 250, Type 4, enclosure housing control panels.
 - f. ASME-stamped surge tank with venturi, isolation valves, excess-flow safeties, and safety relief valves.
4. Blower: Positive-displacement, rotary-lobe type.
 - a. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 5. LPG Circuit Specialties:
 - a. Venturi solenoid valves.
 - b. Venturi nozzles, minimum of 3, for minimum of 10:1 turndown capacity.
 - c. Venturi silencers.
 - d. Mist filter and strainer with pressure differential gage, and blowdown ball valve.
 - e. Inlet and outlet isolation valves.
 - f. Pressure gages, a minimum of 2-1/2 inches (63 mm) in diameter, at inlet and discharge. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
 6. Air-Mixer Controls:
 - a. Controls shall maintain safe operating conditions. The following safety controls limit the operation of the air mixer. All safety controls are manual reset.
 - 1) Low-inlet-vapor pressure.
 - 2) High- or low-discharge pressure.
 - b. Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
 - c. Control Transformer: 115-V maximum control voltage.
 7. Mount on common skid with vaporizer.
- O. Sleeves
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- P. Mechanical Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.
- Q. Escutcheons
1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.
 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn brass with polished chrome-plated finish.
 3. One-Piece, Cast-Brass Escutcheons: With set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
 6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.



7. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

R. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - c. Packaging: Premixed and factory packaged.

S. Labeling And Identifying

1. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

1.3 EXECUTION

A. Earthwork

1. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Preparation

1. Close equipment shutoff valves before turning off LPG to premises or piping section.
2. Inspect LPG piping according to NFPA 58 and NFPA 54 **OR** the International Fuel Gas Code, **as directed**, to determine that LPG utilization devices are turned off in piping section affected.
3. Comply with NFPA 58 and NFPA 54 **OR** the International Fuel Gas Code, **as directed**, requirements for prevention of accidental ignition.

C. Outdoor Piping Installation

1. Comply with NFPA 58 and NFPA 54 **OR** the International Fuel Gas Code, **as directed**, requirements for installation and purging of LPG piping.
2. Install underground, LPG piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 - a. If LPG piping is installed less than 36 inches (914 mm) below finished grade, install it in containment conduit.
3. Install underground, PE, LPG piping according to ASTM D 2774.
4. Steel Piping with Protective Coating:
 - a. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

OR

Replace pipe having damaged PE coating with new pipe.
5. Copper Tubing with Protective Coating:
 - a. Apply joint cover kits over tubing to cover, seal, and protect joints.
 - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
6. Install fittings for changes in direction and branch connections.
7. Joints for connection to inlets and outlets on vaporizers, air mixers, regulators, and valves may be flanged or threaded to match the equipment.
8. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.



- a. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - b. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
9. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 10. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
 11. Install pressure gage downstream **OR** upstream and downstream, **as directed**, from each service regulator. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".
- D. Indoor Piping Installation
1. Comply with NFPA 54 **OR** the International Fuel Gas Code, **as directed**, for installation and purging of LPG piping.
 2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
 3. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
 4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
 5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
 6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 7. Locate valves for easy access.
 8. Install LPG piping at uniform grade of 2 percent down toward drip and sediment traps.
 9. Install piping free of sags and bends.
 10. Install fittings for changes in direction and branch connections.
 11. Install escutcheons for penetrations of interior walls, ceilings, and floors.
 - a. New Piping:
 - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 2) Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
OR
Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - 3) Piping at Ceiling Penetrations in Finished Spaces: One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
OR
Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
 - 4) Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
 - 5) Piping in Equipment Rooms: One-piece, cast-brass type.
OR
Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.



- 6) Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- b. Existing Piping:
 - 1) Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
OR
Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
 - 2) Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
OR
Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
 - 3) Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
OR
Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
 - 4) Piping in Equipment Rooms: Split-casting, cast-brass type.
OR
Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
 - 5) Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
- 12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping" for materials.
- 13. Verify final equipment locations for roughing-in.
- 14. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- 15. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - a. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- 16. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- 17. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- 18. Concealed Location Installations: Except as specified below, install concealed LPG piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - a. Above Accessible Ceilings: LPG piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - b. In Floors: Install LPG piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 - c. In Floor Channels: Install LPG piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
 - d. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - 1) Exception: Tubing passing through partitions or walls does not require striker barriers.



- e. Prohibited Locations:
 - 1) Do not install LPG piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - 2) Do not install LPG piping in solid walls or partitions.
 - 19. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
 - 20. Connect branch piping from top or side of horizontal piping.
 - 21. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
 - 22. Do not use LPG piping as grounding electrode.
 - 23. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
 - 24. Install pressure gage downstream **OR** upstream and downstream, **as directed**, from each line regulator. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".
- E. Service-Meter Assembly Installation
- 1. Install service-meter assemblies aboveground, on concrete bases, **as directed**.
 - 2. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.
 - 3. Install strainer on inlet of service-pressure regulator and meter set.
 - 4. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
 - 5. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
 - 6. Install service meters downstream from pressure regulators.
 - 7. Install metal bollards to protect meter assemblies. Comply with requirements in Division 05 Section "Metal Fabrications" for pipe bollards.
- F. Valve Installation
- 1. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
 - 2. Install underground valves with valve boxes.
 - 3. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
 - 4. Install earthquake valves aboveground outside buildings according to listing.
 - 5. Install anode for metallic valves in underground PE piping.
- G. Piping Joint Construction
- 1. Ream ends of pipes and tubes and remove burrs.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 - 3. Threaded Joints:
 - a. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - b. Cut threads full and clean using sharp dies.
 - c. Ream threaded pipe ends to remove burrs and restore full ID of pipe.
 - d. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - e. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
 - 4. Welded Joints:
 - a. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - b. Bevel plain ends of steel pipe.
 - c. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.



5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Ch. 22, "Pipe and Tube."
 6. Flanged Joints: Install gasket material, size, type, and thickness appropriate for LPG service. Install gasket concentrically positioned.
 7. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
 8. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - a. Plain-End Pipe and Fittings: Use butt fusion.
 - b. Plain-End Pipe and Socket Fittings: Use socket fusion.
- H. Hanger And Support Installation
1. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 2. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
 3. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - a. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
 - b. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
 - e. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (16 mm).
 4. Install hangers for horizontal, drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
 - a. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
 - b. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches (2134 mm); minimum rod size, 3/8 inch (10 mm).
 - d. NPS 1 (DN 25): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).
 5. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
 - a. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
 - b. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
 - c. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod, 3/8 inch (10 mm).
- I. Connections
1. Connect to utility's gas main according to utility's procedures and requirements.
 2. Install LPG piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
 3. Install piping adjacent to appliances to allow service and maintenance of appliances.
 4. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1830 mm) of each gas-fired appliances and equipment. Install union between valve and appliances or equipment.



5. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.
- J. Transport Truck Unloading Facility
1. Install transport truck unloading in a cast-in-place concrete base, 48 inches (1220 mm) square by 36 inches (914 mm) deep. Set top of concrete base at least 6 inches (150 mm) above finished grade.
 2. Install remote emergency shutoff station with cable release in an accessible location, a minimum of 25 feet (7.6 m) and a maximum of 100 feet (30 m) away from transport truck unloading.
 3. Install at least two 6-inch- (150-mm-) diameter metal bollards set in and filled with concrete on both sides of transport truck unloading. Bollard length shall be at least 48 inches (1220 mm) above and below grade, with concrete encasement a minimum of 12 inches (305 mm) in diameter.
- K. Storage Container Installation
1. Fill storage container to at least 80 percent capacity with butane **OR** propane, **as directed**.
 2. Install piping connections with swing joints or flexible connectors to allow for storage container settlement and for thermal expansion and contraction.
 3. Ground containers according to NFPA 780. Grounding is specified in Division 26 Section "Lightning Protection For Structures".
 4. Set storage containers in felt pads on concrete or steel saddles. Install corrosion protection at container-to-felt contact.
 5. Install tie-downs over storage containers on saddles with proper tension.
 6. Set concrete saddles on dowels set in concrete base. Anchor steel saddles to concrete base.
 7. Set storage container on concrete ballast base large enough to offset buoyancy of empty storage container immersed in water.
 8. Install tie-down straps over container anchored in ballast base and repair damaged coating.
 9. Backfill with a minimum coverage for underground or mounded storage containers according to NFPA 58.
 10. Backfill with pea gravel as required in Division 31 Section "Earth Moving".
 11. Install cathodic protection for storage container. Cathodic protection is specified in Division 26 Section "Cathodic Protection".
- L. Pump Installation
1. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
 2. Set pumps on and anchored to concrete base.
 3. Install suction piping with minimum fittings and change of direction.
 4. Connect liquid suction to container, supply to vaporizer, and return line to container.
- M. Vaporizer Installation
1. Install vaporizer with access space for periodic maintenance.
 2. Set vaporizers on and anchor to concrete base.
 3. Connect liquid line from pump set, and vapor supply to distribution piping.
 4. Install backup connection from vapor space of container to inlet of pressure-regulating valve at vaporizer discharge to bypass the vaporizer during maintenance. Install shutoff valves to change source from vaporizer to storage container.
- N. Air Mixer With Vaporizer Installation
1. Install air mixer with vaporizer with access space for periodic maintenance.
 2. Set air mixer with vaporizer on and anchor to concrete base.
 3. Connect liquid line from pump set, and mixed gas supply to distribution piping.
 4. Install backup connection from vapor space of container to inlet of pressure-regulating valve at vaporizer discharge to bypass vaporizer during maintenance. Install shutoff valves to change source from vaporizer to storage container.



5. Replace filters at Final Completion if air mixer was operated during construction.
- O. Labeling And Identifying
1. Comply with requirements in Division 23 Section "Identification For Hvac Piping And Equipment" for piping and valve identification.
OR
Install detectable warning tape directly above gas piping, 12 inches (305 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.
- P. Painting
1. Comply with requirements in Division 07 for painting interior and exterior LPG piping.
 2. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components with factory-applied paint or protective coating.
 - a. Alkyd System: MPI EXT 5.1D.
 - 1) Prime Coat: Alkyd anticorrosive metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Exterior alkyd enamel matching topcoat.
 - 3) Topcoat: Exterior alkyd enamel (flat) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **unless directed otherwise**.
 3. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components with factory-applied paint or protective coating.
 - a. Latex Over Alkyd Primer System: MPI INT 5.1Q.
 - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Interior latex matching topcoat.
 - 3) Topcoat: Interior latex (flat) **OR** (low sheen) **OR** (eggshell) **OR** (satin) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **unless directed otherwise**.
 - b. Alkyd System: MPI INT 5.1E.
 - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
 - 2) Intermediate Coat (for a Premium Grade system): Interior alkyd matching topcoat.
 - 3) Topcoat: Interior alkyd (flat) **OR** (eggshell) **OR** (semigloss) **OR** (gloss), **as directed**.
 - 4) Color: Gray, **unless directed otherwise**.
 4. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

Q. Concrete Bases

 1. Concrete Bases: Anchor equipment to concrete base according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (451-mm) centers around the full perimeter of the base.
 - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Use 3000-psig (20.7-MPa), **unless directed otherwise**, 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

R. Field Quality Control

 1. Perform tests and inspections.
 2. Tests and Inspections:



- a. Test, inspect, and purge LPG according to NFPA 58 and NFPA 54 **OR** the International Fuel Gas Code, **as directed**, and requirements of authorities having jurisdiction.
3. LPG piping will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

S. Outdoor Piping Schedule

1. Underground LPG liquid piping shall be one of the following:
 - a. Schedule 40 steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
 - b. Annealed **OR** Drawn, **as directed**,-temper copper tube, Type K (Type A) **OR** Type L (Type B), **as directed**, with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
2. Aboveground LPG liquid piping shall be one of the following:
 - a. NPS 2 (DN 50) and Smaller: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe, malleable-iron threaded fittings and threaded and seal welded, **as directed**, joints. Coat pipe and fittings with protective coating for steel piping.
 - b. NPS 2-1/2 (DN 65) and Larger: Schedule 40, steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
 - c. Annealed **OR** Drawn, **as directed**,-temper copper tube, Type L (Type B), with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
3. Underground LPG vapor piping shall be one of the following:
 - a. PE pipe and fittings joined by heat-fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
 - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
 - c. Annealed **OR** Drawn, **as directed**,-temper copper tube, Type L (Type B) with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
4. Aboveground LPG vapor piping shall be one of the following:
 - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
 - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints, or mechanical couplings.
 - c. Annealed **OR** Drawn, **as directed**,-temper copper tube, Type L (Type B), with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
5. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper, with wrought-copper fittings and brazed **OR** flared, **as directed**, joints. Install piping embedded in concrete with no joints in concrete.
6. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

T. Indoor Piping Schedule For System Pressures Less Than 0.5 psig (3.45 kPa)

1. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:
 - a. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
 - b. Annealed-temper, tin-lined copper tube with flared joints and fittings.
 - c. Annealed-temper copper tube with wrought-copper fittings and brazed **OR** flared, **as directed**, joints.
 - d. Aluminum tube with flared fittings and joints.
 - e. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
2. Aboveground, distribution piping shall be one of the following:
 - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
 - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints.



- c. Drawn-temper copper tube, Type L (Type B) with wrought-copper fittings and brazed joints.
 3. Underground, below building, piping shall be one of the following:
 - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
 - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints.
 4. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
 5. Containment Conduit Vent Piping: Schedule 40, steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- U. Indoor Piping Schedule For System Pressures More Than 0.5 psig (3.45 kPa) And Less Than 5 psig (34.5 kPa)
 1. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:
 - a. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
 - b. Annealed-temper, tin-lined copper tube with flared joints and fittings.
 - c. Annealed-temper copper tube, Type L (Type B) with wrought-copper fittings and brazed **OR** flared, **as directed**, joints.
 - d. Aluminum tube with flared fittings and joints.
 - e. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
 2. Aboveground, distribution piping shall be one of the following:
 - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
 - b. Schedule 40, steel pipe with steel welding fittings and welded joints.
 - c. Drawn-temper copper tube, Type L (Type B) **OR** Type G, **as directed**, with wrought-copper fittings and brazed joints.
 3. Underground, below building, piping shall be one of the following:
 - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
 - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints.
 4. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.
 5. Containment Conduit Vent Piping: Schedule 40, steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- V. Indoor Piping Schedule For System Pressures More Than 5 psig (34.5 kPa)
 1. Aboveground Piping: Maximum operating pressure more than 5 psig (34.5 kPa).
 2. Aboveground, Branch Piping: Schedule 40, steel pipe with steel welding fittings and welded joints.
 3. Aboveground, distribution piping shall be one of the following:
 - a. Schedule 40, steel pipe with steel welding fittings and welded joints.
 - b. Drawn-temper copper tube, Type L (Type B) **OR** Type G, **as directed**, with wrought-copper fittings and brazed joints.
 4. Underground, below building, piping shall be one of the following:
 - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
 - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints.
 5. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
 6. Containment Conduit Vent Piping: Schedule 40, steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- W. Underground Manual Gas Shutoff Valve Schedule
 1. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
 2. Underground Vapor Piping:
 - a. PE valves.



- b. NPS 2 (DN 50) and Smaller: Bronze, lubricated **OR** nonlubricated, **as directed**, plug valves.
- c. NPS 2-1/2 (DN 65) and Larger: Cast-iron, lubricated **OR** nonlubricated, **as directed**, plug valves.

X. Aboveground Manual Gas Shutoff Valve Schedule

- 1. Aboveground Liquid Piping:
 - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
- 2. Valves for pipe NPS 2 (DN 50) and smaller at service meter shall be one of the following:
 - a. One-piece, bronze ball valve with bronze trim.
 - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - c. Bronze plug valve.
- 3. Valves for pipe NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:
 - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - b. Bronze plug valve.
 - c. Cast-iron, nonlubricated plug valve.
- 4. Distribution piping valves for pipe NPS 2 (DN 50) and smaller shall be one of the following:
 - a. One-piece, bronze ball valve with bronze trim.
 - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - c. Bronze plug valve.
- 5. Distribution piping valves for pipe NPS 2-1/2 (DN 65) and larger shall be one of the following:
 - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - b. Bronze plug valve.
 - c. Cast-iron, nonlubricated **OR** lubricated, **as directed**, plug valve.
- 6. Valves in branch piping for single appliance shall be one of the following:
 - a. One-piece, bronze ball valve with bronze trim.
 - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
 - c. Bronze plug valve.

END OF SECTION 23 11 23 00c



Task	Specification	Specification Description
23 11 23 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 11 23 00	22 11 23 23	Water Supply Wells
23 11 23 00	22 05 76 00	Sanitary Sewerage
23 11 23 00	07 63 00 00	Common Work Results for Fire Suppression
23 11 23 00	07 63 00 00a	Common Work Results for Plumbing
23 11 23 00	07 63 00 00b	Common Work Results for HVAC
23 11 33 00	23 11 23 00	Relief Wells
23 11 33 00	22 05 76 00	Sanitary Sewerage
23 11 33 00	22 12 23 26	Underground Storage Tanks
23 11 33 00	07 63 00 00	Common Work Results for Fire Suppression
23 11 33 00	07 63 00 00a	Common Work Results for Plumbing
23 11 33 00	07 63 00 00b	Common Work Results for HVAC
23 11 33 00	22 11 16 00a	Sanitary Waste And Vent Piping
23 12 13 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 12 23 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 13 13 13	22 05 23 00	Piped Utilities Basic Materials And Methods
23 13 13 13	22 12 23 26	Underground Storage Tanks
23 13 13 13	22 12 23 26a	Facility Fuel-Oil Piping
23 13 13 13	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
23 13 13 23	22 05 23 00	Piped Utilities Basic Materials And Methods
23 13 13 23	22 12 23 26	Underground Storage Tanks
23 13 13 23	22 12 23 26a	Facility Fuel-Oil Piping
23 13 23 16	22 05 23 00	Piped Utilities Basic Materials And Methods
23 13 23 16	22 12 23 26a	Facility Fuel-Oil Piping
23 13 23 16	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
23 13 23 19	22 05 23 00	Piped Utilities Basic Materials And Methods
23 13 23 19	22 12 23 26a	Facility Fuel-Oil Piping
23 13 23 19	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
23 13 23 26	22 05 23 00	Piped Utilities Basic Materials And Methods
23 13 23 26	22 12 23 26a	Facility Fuel-Oil Piping
23 13 33 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 13 33 00	22 12 23 26	Underground Storage Tanks



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**SECTION 23 21 13 23 - RADIANT HEATING PIPING****1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for radiant heating piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes radiant heating piping, including pipes, fittings, and piping specialties.

C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. PEX: Crosslinked polyethylene.
3. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.

D. Submittals

1. Product Data: For each type of radiant heating pipe, fitting, manifold, specialty, and control.
 - a. For radiant heating piping and manifolds, include pressure and temperature rating, oxygen-barrier performance, fire-performance characteristics, and water flow and pressure drop characteristics.
2. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
3. Operation and Maintenance Data.

1.2 PRODUCTS**A. PEX Pipe And Fittings**

1. Pipe Material: PEX plastic according to ASTM F 876.
2. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.
3. Fittings: ASTM F 1807, metal insert and copper crimp rings.
4. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 180 deg F (82 deg C).

B. PEX/AL/PEX Pipe And Fittings

1. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F 1281.
2. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.
3. Fittings: ASTM F 1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).
4. Flame-Spread and Smoke-Developed Indexes: 25 and 50 or less, respectively, tested according to ASTM E 84.
5. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

C. EPDM Pipe And Fittings

1. Pipe Material: Crosslinked EPDM inner and outer tubes.
2. Wall Thickness: Minimum 0.125 inch (3.2 mm).
3. Oxygen Barrier: Ductile aluminum foil layer applied to the inner tube to limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.



4. Reinforcing Braid: Braided-aluminum wire between the inner and outer tube.
5. Fittings: ASTM F 1807, copper with stainless-steel crimps or clamps.
6. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

D. Distribution Manifolds

1. Manifold: Minimum NPS 1 (DN 25), brass **OR** copper **OR** modular plastic **OR** stainless steel, **as directed**.
2. Main Shutoff Valves:
 - a. Factory installed on supply and return connections.
 - b. Two **OR** Three, **as directed**, -piece body.
 - c. Body: Brass or bronze.
 - d. Ball: Chrome-plated bronze.
 - e. Seals: PTFE.
 - f. CWP Rating: 150 psig (1035 kPa).
 - g. Maximum Operating Temperature: 225 deg F (107 deg C).
3. Manual Air Vents:
 - a. Body: Bronze.
 - b. Internal Parts: Nonferrous.
 - c. Operator: Key furnished with valve, or screwdriver bit.
 - d. Inlet Connection: NPS 1/2 (DN 15).
 - e. Discharge Connection: NPS 1/8 (DN 6).
 - f. CWP Rating: 150 psig (1035 kPa).
 - g. Maximum Operating Temperature: 225 deg F (107 deg C).
4. Balancing Valves:
 - a. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 - b. Ball or Plug: Brass or stainless steel.
 - c. Globe Cartridge and Washer: Brass with EPDM composition washer.
 - d. Seat: PTFE.
 - e. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.
OR
Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.
 - f. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
 - g. CWP Rating: Minimum 125 psig (860 kPa).
 - h. Maximum Operating Temperature: 250 deg F (121 deg C).
5. Zone Control Valves:
 - a. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 - b. Ball or Plug: Brass or stainless steel.
 - c. Globe Cartridge and Washer: Brass with EPDM composition washer.
 - d. Seat: PTFE.
 - e. Actuator: Replaceable electric motor.
 - f. CWP Rating: Minimum 125 psig (860 kPa).
 - g. Maximum Operating Temperature: 250 deg F (121 deg C).
6. Thermometers:
 - a. Mount on supply and return connections.
 - b. Case: Dry type, metal or plastic, 2-inch (50-mm) diameter.
 - c. Element: Bourdon tube or other type of pressure element.
 - d. Movement: Mechanical, connecting element and pointer.
 - e. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - f. Pointer: Black metal.
 - g. Window: Plastic.
 - h. Connector: Rigid, back type.
 - i. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.



- j. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.
 - 7. Mounting Brackets: Copper, or plastic or copper-clad steel, where in contact with manifold.
- E. Piping Specialties
- 1. Cable Ties:
 - a. Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
 - b. Minimum Width: 1/8 inch (3 mm).
 - c. Tensile Strength: 20 lb (9 kg), minimum.
 - d. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 2. Floor-Mounting Staples:
 - a. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
 - b. Minimum Thickness: 3/32 inch (2.4 mm).
 - c. Width: Minimum, wider than tubing.
 - 3. Floor-Mounting Clamps:
 - a. Two bolt, steel, with corrosion-resistant coating and smooth finish without sharp edges.
 - b. Minimum Thickness: 3/32 inch (2.4 mm).
 - c. Width: Minimum, wider than tubing.
 - 4. Floor Mounting Tracks:
 - a. Aluminum or plastic channel track with smooth finish, no sharp edges.
 - b. Minimum Thickness: 1/16 inch (1.6 mm).
 - c. Slot Width: Snap fit to hold tubing.
 - d. Slot Spacing: 2-inch (50-mm) **OR** 3-inch (75-mm), **as directed**, intervals.
 - 5. Channeled Subfloor:
 - a. Plywood, APA-rated subfloor panel, composed of premium, tongue-and-groove, 7-layer, Douglas fir structural subfloor panels.
 - b. Particleboard manufactured to meet Federal Housing Authority standards of less than 0.3-ppm formaldehyde.
 - c. Clad panel with minimum 0.025-inch- (0.635-mm-) thick aluminum recessed in the grooves sized to maintain contact with radiant piping.
 - 6. Modular Interlocking Blocks:
 - a. Polypropylene snap-together blocks with grooves to support piping.
 - b. Galvanized sheet metal or aluminum emission plates.
 - c. Natural mineralboard cover panel.
 - 7. Heat-Emission Plates:
 - a. Formed aluminum suitable for radiant heating piping.
 - b. Minimum Thickness: 1/16 inch (1.6 mm).
 - c. Slot Width: Snap fit to maintain pressure fit on tubing.
- F. Controls
- 1. Temperature-control devices and sequence of operations are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
 - 2. Wall-Mounting Thermostat:
 - a. Minimum temperature range from 50 to 90 deg F (10 to 32 deg C).
 - b. Manually operated with on-off switch.
 - c. Day and night setback and clock program with minimum four periods per day.
 - d. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting.
 - 3. Heated-Panel Thermostat:
 - a. Remote bulb unit with adjustable temperature range from 50 to 90 deg F (10 to 32 deg C).
 - b. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
 - c. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
 - d. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.



- e. Corrosion-resistant, waterproof control enclosure.
- 4. Heated-Panel Thermostat with Outdoor Temperature Reset:
 - a. Remote bulb unit with adjustable temperature range from 50 to 90 deg F (10 to 32 deg C).
 - b. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump and zone control valve.
 - c. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
 - d. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing outdoor-air temperature.
 - e. Operate zone control valves to reset supply-water temperature inversely with outdoor-air temperature as follows:
 - 1) Low outdoor-air temperature, zero deg F (minus 18 deg C) with high supply-water temperature 110 deg F (43 deg C).
 - 2) High outdoor-air temperature, 60 deg F (16 deg C) with low supply-water temperature 70 deg F (21 deg C).
 - f. Corrosion-resistant, waterproof control enclosure.
- 5. Precipitation and Temperature Sensor:
 - a. Microprocessor-based **OR** Automatic, **as directed**, control with manual on, automatic, and standby/reset switch.
 - b. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to operate pump and zone control valves as follows:
 - 1) Temperature Span: 34 to 44 deg F (1 to 7 deg C).
 - 2) Adjustable Delay Off Span: 30 to 90 minutes.
 - 3) Start Pump or Open Zone Control Valves: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
 - 4) Stop Pump or Close Zone Control Valves: On detection of a dry surface plus time delay.
 - c. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
 - d. Minimum 30-A contactor to start pump and open valves.
 - e. Precipitation sensor shall be mounted in pavement.
 - f. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.

1.3 EXECUTION

A. Applications

- 1. Install the following types of radiant heating piping for the applications described:
 - a. Piping in Exterior Pavement: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
 - b. Piping in Interior Reinforced-Concrete Floors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
 - c. Piping in Level Fill Concrete Floors (Not Reinforced): EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
 - d. Piping in Ceilings: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
 - e. Piping in Subfloors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
 - f. Piping below Wood Floors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.

B. Installation

- 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop or Coordination Drawings.
- 2. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.



3. Connect radiant piping to manifold in a reverse-return arrangement.
4. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
5. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Division 08 Section "Access Doors And Frames".
6. Refer to Division 23 Section "Hydronic Piping" for pipes and connections to hydronic systems and for glycol-solution fill requirements.
7. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Division 07 Section "Penetration Firestopping".
8. Piping in Exterior Pavement:
 - a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - b. Space cable ties a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
 - c. Maintain 3-inch (75-mm) minimum cover.
 - d. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - e. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.
9. Piping in Interior Reinforced-Concrete Floors:
 - a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - b. Space cable ties a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
 - c. Maintain 2-inch (50-mm) minimum cover.
 - d. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - e. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.
10. Piping in Level Fill Concrete Floors (Not Reinforced):
 - a. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
 - b. Space tracks, clamps, or staples a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
 - c. Maintain 3/4-inch (19-mm) minimum cover.
 - d. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - e. Maintain minimum 40-psig (275-kPa) pressure in piping during the concrete pour and continue for 24 hours during curing.
11. Piping in Ceiling:
 - a. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
 - b. Space clamps or staples a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
 - c. Maintain 1-1/2-inch (38-mm) minimum plaster cover.
 - d. Maintain minimum 40-psig (275-kPa) pressure in piping during the plaster application and continue for 24 hours during curing.
12. Piping in Subfloor:
 - a. Secure piping by laying piping in subfloor channels or modular interlocking blocks.
 - b. Use straight channel panels or blocks in the center, and curved channel panels or blocks at the ends.
 - c. Finish floor with mineralboard panel cover or finished floor surface.
13. Piping below Wood Floor:
 - a. Secure piping by attaching pipes to subfloor using heat-emission plates, clamps, or staples.



- b. Space heat-emission plates, clamps, or staples a maximum of 4 inches (100 mm) o.c., and at center of turns or bends.
 - c. Install heat-emission plates on underside of wood subfloor with maximum space between plates, as noted above, to maintain pipe contact with floor.
 14. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved.
 15. After system balancing has been completed, mark balancing valves to permanently indicate final position.
 16. Perform the following adjustments before operating the system:
 - a. Open valves to fully open position.
 - b. Check operation of automatic valves.
 - c. Set temperature controls so all zones call for full flow.
 - d. Purge air from piping.
 17. After the concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant heating system as follows:
 - a. Start system heating at a maximum of 10 deg F (6 deg C) above the ambient radiant panel temperature, and increase 10 deg F (6 deg C) each following day until design temperature is achieved.
 - b. For freeze protection, operate at a maximum of 60 deg F (16 deg C) supply-water temperature.
- C. Field Quality Control
1. Prepare radiant heating piping for testing as follows:
 - a. Open all isolation valves and close bypass valves.
 - b. Open and verify operation of zone control valves.
 - c. Flush with clean water, and clean strainers.
 2. Tests and Inspections:
 - a. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig (690 kPa). Repair leaks and retest until no leaks exist.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Remove and replace malfunctioning radiant heating piping components that do not pass tests, and retest as specified above.
 4. Prepare a written report of testing.

END OF SECTION 23 21 13 23



Task	Specification	Specification Description
23 21 13 23	22 05 23 00	Piped Utilities Basic Materials And Methods
23 21 13 23	23 11 23 00	Relief Wells
23 21 13 23	21 05 19 00	Water Distribution
23 21 13 23	23 11 23 00a	Monitoring Wells
23 21 13 23	22 11 23 23	Water Supply Wells
23 21 13 23	22 05 76 00	Sanitary Sewerage
23 21 13 23	23 05 29 00	Steam Distribution
23 21 13 23	07 63 00 00	Common Work Results for Fire Suppression
23 21 13 23	07 63 00 00a	Common Work Results for Plumbing
23 21 13 23	07 63 00 00b	Common Work Results for HVAC
23 21 13 23	22 11 16 00	Domestic Water Piping
23 21 13 23	22 11 16 00a	Sanitary Waste And Vent Piping
23 21 13 23	22 11 16 00b	Storm Drainage Piping
23 21 13 23	22 11 16 00c	Hydronic Piping
23 21 13 23	22 11 16 00d	Steam And Condensate Piping
23 21 13 23	22 11 16 00e	Refrigerant Piping
23 21 13 23	22 12 23 26a	Facility Fuel-Oil Piping
23 21 13 23	23 11 23 00b	Facility Natural-Gas Piping
23 21 13 23	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
23 21 13 23	22 11 16 00f	General-Service Compressed-Air Piping
23 21 13 23	22 11 16 00g	Compressed-Air Piping For Laboratory And Healthcare Facilities
23 21 13 23	22 11 16 00h	Vacuum Piping For Laboratory And Healthcare Facilities
23 21 13 23	22 11 16 00i	Gas Piping For Laboratory And Healthcare Facilities
23 21 16 00	01 22 16 00	No Specification Required
23 21 16 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 21 16 00	21 05 19 00	Water Distribution
23 21 16 00	23 05 29 00	Steam Distribution
23 21 16 00	22 12 23 26	Underground Storage Tanks
23 21 16 00	07 63 00 00	Common Work Results for Fire Suppression
23 21 16 00	07 63 00 00a	Common Work Results for Plumbing
23 21 16 00	07 63 00 00b	Common Work Results for HVAC
23 21 16 00	22 11 16 00c	Hydronic Piping
23 21 16 00	22 11 16 00d	Steam And Condensate Piping
23 21 16 00	22 11 16 00e	Refrigerant Piping
23 21 16 00	22 11 23 23a	Hydronic Pumps
23 21 16 00	22 12 23 26a	Facility Fuel-Oil Piping
23 21 16 00	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
23 21 16 00	22 11 16 00f	General-Service Compressed-Air Piping
23 21 23 13	22 05 23 00	Piped Utilities Basic Materials And Methods
23 21 23 13	22 11 23 23	Water Supply Wells
23 21 23 13	22 11 23 23a	Hydronic Pumps
23 21 23 16	22 05 23 00	Piped Utilities Basic Materials And Methods
23 21 23 16	22 11 23 23	Water Supply Wells
23 21 23 16	22 11 23 23a	Hydronic Pumps



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SECTION 23 21 23 23 - ELECTRIC-DRIVE, VERTICAL-TURBINE FIRE PUMPS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for electric-drive, vertical-turbine fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Vertical-turbine fire pumps.
 - b. Fire-pump accessories and specialties.
 - c. Flowmeter systems.

C. Performance Requirements

1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.2 PRODUCTS



- A. General Requirements For Vertical-Turbine Fire Pumps
1. Description: Factory-assembled and -tested fire-pump and driver unit.
 2. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
 3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.
- B. Vertical-Turbine Fire Pumps
1. Pump Head: Cast iron, for surface discharge.
 - a. Discharge Outlet: With flange according to ASME B16.1 except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
 - b. Pump Head Seal: Stuffing box and packing.
 - c. Base: Cast iron or steel with hole for electrical cable.
 2. Pump:
 - a. Standard: UL 448, for vertical-turbine pumps for fire service.
 - b. Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
 - c. Line Shaft Bearings: Rubber sleeve, water lubricated.
 - d. Line Shaft: Steel.
 - e. Line Shaft Bearings: Corrosion resistant, oil lubricated.
 - f. Impeller Shaft: Monel metal or stainless steel.
 - g. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
 - h. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less.
 - i. Suction Strainer: Cast or fabricated, bronze or stainless steel, and sized to restrict passage of 0.5-inch (12.7-mm) spheres.
 3. Driver:
 - a. Standard: UL 1004A.
 - b. Type: Electric motor; NEMA MG 1, polyphase Design B.
 - c. Mounting: On pump head above pump.
- C. Fire-Pump Accessories And Specialties
1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.
 2. Relief Valves:
 - a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
 3. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.
 4. Discharge Cone: Closed **OR** Open, **as directed**, type.
 5. Hose Valve Manifold Assembly:
 - a. Standard: Comply with requirements in NFPA 20.
 - b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
 - c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
 - d. Automatic Drain Valve: UL 1726.
 - e. Manifold:
 - 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - 2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
 - 3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
 - 4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - 5) Escutcheon Plate: Brass or bronze; rectangular.
 - 6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.



7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.

8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

OR

Manifold:

1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.

2) Body: Exposed type, brass, with number of outlets required by NFPA 20.

3) Escutcheon Plate: Brass or bronze; round.

4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.

5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.

6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

D. Flowmeter Systems

1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.

2. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.

3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.

4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.

a. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.

OR

Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

E. Grout

1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

2. Characteristics: Nonshrink and recommended for interior and exterior applications.

3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.

4. Packaging: Premixed and factory packaged.

F. Source Quality Control

1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Protection Tests."

a. Verification of Performance: Rate fire pumps according to UL 448.

2. Fire pumps will be considered defective if they do not pass tests and inspections.

3. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation

1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".

a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.



- c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.
 4. Support piping and pumps separately so weight of piping does not rest on pumps.
 5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
 6. Install pressure gage on pump head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
 7. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
 8. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
 9. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Alignment
1. Align pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
 2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
 3. Align piping connection.
 4. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.
- C. Connections
1. Comply with requirements for piping and valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to pumps and equipment to allow service and maintenance.
 3. Connect relief-valve discharge to drainage piping or point of discharge.
 4. Connect flowmeter-system meters, sensors, and valves to tubing.
 5. Connect fire pumps to their controllers.
- D. Identification
1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.
- E. Field Quality Control
1. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Division 21 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps"
 2. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 3. Tests and Inspections:
 - a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
 - b. Test according to NFPA 20 for acceptance and performance testing.



- c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 4. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
 - 5. Prepare test and inspection reports.
 - 6. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to the Owner.
- F. Startup Service
- 1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
- G. Demonstration
- 1. Train the Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 23 21 23 23



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SECTION 23 21 23 23a - DIESEL-DRIVE, VERTICAL-TURBINE FIRE PUMPS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for diesel-drive, vertical-turbine fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Vertical-turbine fire pumps.
 - b. Fire-pump accessories and specialties.
 - c. Flowmeter systems.

C. Performance Requirements

1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For fire pumps, right-angle gear drives, engine drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."



1.2 PRODUCTS

- A. General Requirements For Vertical-Turbine Fire Pumps
1. Description: Factory-assembled and -tested fire pump, right-angle gear drive, and driver.
 2. Base: Fabricated and attached to fire pump, right-angle gear drive, and driver with reinforcement to resist movement of pump, gear drive, and driver during seismic events when base is anchored to building substrate.
 3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.
- B. Vertical-Turbine Fire Pumps
1. Pump Head: Cast iron, for surface discharge.
 - a. Discharge Outlet: With flange according to ASME B16.1 except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
 - b. Pump Head Seal: Stuffing box and packing.
 - c. Base: Cast iron or steel with hole for electrical cable.
 2. Pump:
 - a. Standard: UL 448, for vertical-turbine pumps for fire service.
 - b. For static water levels of 50 feet (15 m) or less and for water-lubricated bearings.
 - 1) Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
 - 2) Line Shaft Bearings: Rubber sleeve, water lubricated.
 - c. For static water levels between 50 and 200 feet (15 and 61 m) and for oil-lubricated bearings.
 - 1) Line Shaft: Steel.
 - 2) Line Shaft Bearings: Corrosion resistant, oil lubricated.
 - d. Impeller Shaft: Monel metal or stainless steel.
 - e. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
 - f. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less.
 - g. Suction Strainer: Cast or fabricated, bronze or stainless steel, and sized to restrict passage of 0.5-inch (12.7-mm) spheres.
 3. Right-Angle Gear Drive:
 - a. Description: FM-Approved, speed-reduction gear drive for pump speed control. Provide ratio for outlet speed of approximately 1760 rpm.
 4. Engine-to-Gear Drive Shaft: FM-Approved, telescoping, steel drive shaft with universal joint and grease fitting at each end. Include metal shaft guard.
 5. Driver:
 - a. Standard: UL 1247.
 - b. Type: Diesel engine.
 - c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
 - d. Engine Cooling System: Factory-installed radiator.
 - 1) Coolant: Type recommended by driver manufacturer.

OR

Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.

 - 1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
 - e. Engine-Jacket Water Heater: Factory-installed electric elements.
 - f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.
 - g. Fuel System: According to NFPA 20.
 - 1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.



- h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
 - 1) Exhaust Connector: Flexible type.
 - 2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.

 - C. Fire-Pump Accessories And Specialties
 - 1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.
 - 2. Relief Valves:
 - a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
 - 3. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.
 - 4. Discharge Cone: Closed **OR** Open, **as directed**, type.
 - 5. Hose Valve Manifold Assembly:
 - a. Standard: Comply with requirements in NFPA 20.
 - b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
 - c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
 - d. Automatic Drain Valve: UL 1726.
 - e. Manifold:
 - 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - 2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
 - 3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
 - 4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - 5) Escutcheon Plate: Brass or bronze; rectangular.
 - 6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - 7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
 - 8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

 - OR**
 - Manifold:
 - 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - 2) Body: Exposed type, brass, with number of outlets required by NFPA 20.
 - 3) Escutcheon Plate: Brass or bronze; round.
 - 4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
 - 5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
 - 6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."
-
- D. Flowmeter Systems
 - 1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.
 - 2. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
 - 3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
 - 4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.
 - a. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.

**OR**

Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

E. Grout

1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

F. Source Quality Control

1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
 - a. Verification of Performance: Rate fire pumps according to UL 448.
2. Fire pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

1.3 EXECUTION**A. Installation**

1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.
4. Support piping and pumps separately so weight of piping does not rest on pumps.
5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
6. Install pressure gage on pump head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
7. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
8. Install fuel system according to NFPA 20.
9. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.
10. Install exhaust system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.
11. Install condensate drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.
12. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
13. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.



14. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Alignment
1. Align fire-pump-driver, right-angle gear-drive, and fire-pump shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
 2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
 3. Align piping connections.
 4. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.
- C. Connections
1. Comply with requirements for piping and valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to pumps and equipment to allow service and maintenance.
 3. Connect relief-valve discharge to drainage piping or point of discharge.
 4. Connect flowmeter-system meters, sensors, and valves to tubing.
 5. Connect fire pumps to their controllers.
- D. Identification
1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.
- E. Field Quality Control
1. Test each fire pump with its right-angle gear drive and controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Division 21 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps".
 2. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 3. Tests and Inspections:
 - a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
 - b. Test according to NFPA 20 for acceptance and performance testing.
 - c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 4. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
 5. Prepare test and inspection reports.
 6. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to the Owner.
- F. Startup Service
1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.



G. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain fire pumps, right-angle gear drives, and fire-pump controllers.

END OF SECTION 23 21 23 23a



Task	Specification	Specification Description
23 21 23 23	22 05 23 00	Piped Utilities Basic Materials And Methods
23 21 23 23	22 11 23 23	Water Supply Wells
23 21 29 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 21 29 00	22 11 23 23a	Hydronic Pumps
23 22 13 00	22 11 16 00d	Steam And Condensate Piping
23 22 16 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 22 16 00	21 05 19 00	Water Distribution
23 22 16 00	23 05 29 00	Steam Distribution
23 22 16 00	21 05 19 00a	Meters and Gages for Plumbing Piping
23 22 16 00	21 05 19 00b	Meters and Gages for HVAC Piping
23 22 16 00	22 11 16 00d	Steam And Condensate Piping
23 22 16 00	22 11 16 00e	Refrigerant Piping
23 22 16 00	22 11 16 00f	General-Service Compressed-Air Piping



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**SECTION 23 22 23 13 - STEAM CONDENSATE PUMPS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for steam condensate pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes electric-driven and pressure-powered steam condensate pumps.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include details of installation.
 - a. Include wiring diagrams.
3. Operation and maintenance data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label steam condensate pumps to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Delivery, Storage, and Handling

1. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
2. Store steam condensate pumps in dry location.
3. Retain protective covers for flanges and protective coatings during storage.
4. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
5. Comply with pump manufacturer's written rigging instructions.

1.2 PRODUCTS

A. Electric-Driven Steam Condensate Pumps

1. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pump(s), controls, and accessories suitable for operation with steam condensate.
2. Configuration: Simplex **OR** Duplex, **as directed**, floor-mounting pump with receiver and float switch(es); rated to pump 200 deg F (93 deg C) steam condensate.
 - a. Receiver: Floor-mounting, close-grained cast iron **OR** welded steel, **as directed**; with externally adjustable float switch(es), and flange(s) for pump mounting.
 - b. Pump(s): Centrifugal, close coupled, vertical design, permanently aligned, and bronze fitted; with replaceable bronze case ring and mechanical seal; mounted on receiver flange.
 - c. Factory Wiring: Between pump(s) and float switch(es), for single external electrical connection. Fused control power transformer if voltage exceeds 230 V.
 - d. Electrical **OR** Mechanical, **as directed**, pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate if the normal start level for a single pump is exceeded.
3. Configuration: Duplex floor-mounting pump with receiver and float switches; rated to pump 210 deg F (99 deg C) steam condensate.



- a. Receiver: Floor-mounting, close-grained cast iron **OR** welded steel, **as directed**; with externally adjustable float switches and flanges for pump mounting.
 - b. Pumps: Regenerative turbine, close coupled, permanently aligned, and bronze fitted; with mechanical seals and an independent pump control circuit for each pump; mounted on base or receiver flange; rated to operate with a minimum of 2 feet (6 kPa) of NPSH.
 - c. Factory Wiring: Between pumps and float switches, for single external electrical connection. Fused control power transformer if voltage exceeds 230 V.
 - d. Electrical **OR** Mechanical, **as directed**, pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate if the normal start level for a single pump is exceeded.
4. Configuration: Duplex floor-mounting pumps with receiver and float switches; rated to pump minimum 200 deg F (93 deg C) **OR** 210 deg F (99 deg C), **as directed**, steam condensate.
- a. Receiver: Floor-mounting, close-grained cast iron **OR** welded steel, **as directed**; externally adjustable float switches; with water-level gage, steam condensate thermometer, discharge-pressure gage for each pump, bronze gate valves between receiver and pumps, flanges for pump mounting, and lifting eyebolts.
 - b. Inlet Strainer: Cast iron with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.
 - c. Pumps: Centrifugal, close coupled, vertical design, permanently aligned, and bronze fitted; with replaceable bronze case rings, stainless-steel shafts, and mechanical seals; mounted on receiver flanges; rated to operate with a minimum of 2 feet (6 kPa) of NPSH.
 - d. Control Panel: NEMA 250, Type 1 **OR** 2 **OR** 12, **as directed**, enclosure with hinged door and grounding lug, mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
 - 1) Motor controller for each pump.
 - 2) Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
 - 3) Manual lead-lag control to override electrical pump alternator to manually select the lead pump.
 - 4) Momentary contact "TEST" push button on cover for each pump.
 - 5) Numbered terminal strip.
 - 6) Disconnect switch.
 - 7) Fused transformer for control circuit.
5. Configuration: Duplex floor-mounting pump with elevated receiver, float switches, and connecting piping; rated to pump 212 deg F (100 deg C) steam condensate.
- a. Receiver: Close-grained cast iron **OR** Welded steel, **as directed**, mounted on fabricated-steel supports; externally adjustable float switches; with water-level gage, steam condensate thermometer, pump discharge pressure gages, bronze isolation valves between receiver and pumps, and lifting eyebolts.
 - b. Inlet Strainer: Cast iron with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.
 - c. Pumps: Centrifugal, close coupled, permanently aligned, and bronze fitted; with replaceable bronze case rings, stainless-steel shafts, and mechanical seals; mounted on base below receiver; rated to operate with a minimum of 2 feet (6 kPa) of NPSH.
 - d. Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106; Schedule 80; seamless steel.
 - e. Fittings NPS 2 (DN 50) and Smaller: ASME B16.1, Class 125 cast iron, threaded.
 - f. Fittings NPS 2-1/2 (DN 65) and Larger: ASTM A 234/A 234M, steel, for welded connections.
 - g. Control Panel: NEMA 250, Type 1 **OR** 2 **OR** 12, **as directed**, enclosure with hinged door and grounding lug; mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
 - 1) Motor controller for each pump.
 - 2) Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.



- 3) Manual lead-lag control to override electrical alternator to manually select the lead pump.
 - 4) Momentary contact "TEST" push button on cover for each pump.
 - 5) Numbered terminal strip.
 - 6) Disconnect switch.
 - 7) Fused transformer for control circuit.
6. Configuration: Underground duplex pump with basin and float switches; rated to pump 200 deg F (93 deg C) steam condensate.
- a. Basin: Cast iron, with hub-type inlets.
 - b. Basin Cover: Cast iron or steel with gasketed openings for access, pumps, pump shafts, control rods, discharge piping, and vent connections.
 - 1) Anchor Flange: Cast iron, attached to basin, in location and of size required to anchor basin to concrete slab.
 - c. Pumps: Wet-pit mounted, vertical, flexible coupled, and suspended.
 - 1) Casing: Cast iron with open inlet.
 - 2) Shaft and Bearings: Stainless-steel shaft with oil-lubricated, bronze, intermediate sleeve bearings; 48-inch (1200-mm) maximum intervals where basin depth is more than 48 inches (1200 mm); and grease-lubricated, ball-type, thrust bearings.
 - 3) Shaft Couplings: Flexible, capable of absorbing vibration.
 - 4) Seals: Mechanical; with carbon rotating ring, bearing on a ceramic seat held by a stainless-steel spring, and enclosed by a flexible bellows and gasket.
 - 5) Motors: Vertically mounted on cast-iron pedestal.
 - 6) Pump Discharge Piping: Manufacturer's standard steel or bronze pipe, unless otherwise indicated.
 - d. Control Panel: NEMA 250, Type 1 **OR** 2 **OR** 12, **as directed**, enclosure with hinged door and grounding lug; mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
 - 1) Motor controller for each pump.
 - 2) Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
 - 3) Manual lead-lag control to override electrical alternator to manually select the lead pump.
 - 4) Momentary contact "TEST" push button on cover for each pump.
 - 5) Numbered terminal strip.
 - 6) Disconnect switch.
 - 7) Fused transformer for control circuit.
- B. Pressure-Powered Steam Condensate Pumps
1. Description: Factory-fabricated, pressure-powered pumps with mechanical controls, valves, piping connections, and accessories suitable for pumping steam condensate using steam **OR** compressed air, **as directed**.
 2. Configuration: Simplex **OR** Duplex, **as directed**, pump with float-operated valve control.
 - a. Pump Body: Cast iron **OR** Welded steel, **as directed**.
 - b. Piping Connections: Threaded; for steam condensate, operating medium, vent, and indicated accessories.
 - c. Level Gage: Glass site gage with shutoff cocks.
 - d. Valves: Manufacturer's standard check valves on inlet and outlet.
 - e. Internal Parts: Stainless-steel float, springs, and actuating mechanism.
 - f. Valve Seals: Replaceable from exterior.
 - g. Receiver: Cast iron **OR** Welded steel, **as directed**, factory mounted on steel supports; with water-level site glass and threaded piping connections.
 - h. Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106; Schedule 80; seamless steel.
 - i. Fittings: ASME B16.1, Class 125 cast iron, threaded.
- C. Motors



1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

1.3 EXECUTION

A. Installation

1. Install pumps according to HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."
2. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
3. Support pumps and piping separately so piping is not supported by pumps.
4. Install pumps on concrete bases. Anchor pumps to bases using inserts or anchor bolts.
5. Install thermometers and pressure gages.

B. Connections

1. Install piping adjacent to machine to allow service and maintenance.
2. Install steam supply for pressure-powered pumps as required by Division 23 Section "Steam And Condensate Heating Piping".
3. Install compressed-air supply for pressure-powered pumps as required by Division 22 Section "General-service Compressed-air Piping".
4. Install gate and check valves on inlet and outlet of pressure-powered pumps.
5. Install check valve, gate valve, and globe valve at pump discharge connections for each electric-driven pump.
6. Pipe drain to nearest floor drain for overflow and drain piping connections.
7. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.
8. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

END OF SECTION 23 22 23 13



Task	Specification	Specification Description
23 23 13 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 23 13 00	22 11 16 00e	Refrigerant Piping
23 23 16 00	07 63 00 00	Common Work Results for Fire Suppression
23 23 16 00	07 63 00 00a	Common Work Results for Plumbing
23 23 16 00	07 63 00 00b	Common Work Results for HVAC
23 23 16 00	22 11 16 00a	Sanitary Waste And Vent Piping
23 23 16 00	22 11 16 00b	Storm Drainage Piping
23 23 16 00	22 11 16 00c	Hydronic Piping
23 23 16 00	22 11 16 00e	Refrigerant Piping
23 23 16 00	23 01 60 71	Condensing Units
23 23 23 00	23 01 60 71	Condensing Units



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SECTION 23 25 13 00 - HVAC WATER TREATMENT

- A. Description Of Work
 - 1. This specification covers the furnishing and installation of materials for HVAC water treatment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work

- B. Summary
 - 1. This Section includes the following HVAC water-treatment systems:
 - a. Bypass chemical-feed equipment and controls.
 - b. Biocide chemical-feed equipment and controls.
 - c. Ozone-generator biocide equipment and controls.
 - d. UV-irradiation unit, biocide equipment, and controls.
 - e. Chemical treatment test equipment.
 - f. HVAC water-treatment chemicals.
 - g. Makeup water softeners.
 - h. RO equipment for HVAC makeup water.
 - i. Water filtration units for HVAC makeup water.

- C. Definitions
 - 1. EEPROM: Electrically erasable, programmable read-only memory.
 - 2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
 - 3. RO: Reverse osmosis.
 - 4. TDS: Total dissolved solids.
 - 5. UV: Ultraviolet.

- D. Performance Requirements
 - 1. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
 - 2. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
 - 3. Closed hydronic systems, including hot-water heating, chilled water, dual-temperature water, and glycol cooling, shall have the following water qualities:
 - a. pH: Maintain a value within 9.0 to 10.5.
 - b. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
 - c. Boron: Maintain a value within 100 to 200 ppm.
 - d. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
 - e. Soluble Copper: Maintain a maximum value of 0.20 ppm.
 - f. TDS: Maintain a maximum value of 10 ppm.
 - g. Ammonia: Maintain a maximum value of 20 ppm.
 - h. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
 - i. Microbiological Limits:
 - 1) Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
 - 2) Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
 - 3) Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
 - 4) Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
 - 5) Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
 - 4. Steam Boiler and Steam Condensate:
 - a. Steam Condensate:
 - 1) pH: Maintain a value within 7.8 to 8.4.
 - 2) Total Alkalinity: Maintain a value within 5 to 50 ppm.



- 3) Chemical Oxygen Demand: Maintain a maximum value of 15 ppm.
- 4) Soluble Copper: Maintain a maximum value of 0.20 ppm.
- 5) TDS: Maintain a maximum value of 10 ppm.
- 6) Ammonia: Maintain a maximum value of 20 ppm.
- 7) Total Hardness: Maintain a maximum value of 2 ppm.
- b. Steam boiler operating at 15 psig (104 kPa) and less shall have the following water qualities:
 - 1) "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
 - 2) TDS: Maintain a value within 600 to 3000 ppm.
- c. Steam boiler operating at more than 15 psig (104 kPa) shall have the following water qualities:
 - 1) "OH" Alkalinity: 200 to 400 ppm.
 - 2) TDS: Maintain a value within 600 to 1200 ppm to maximum 30 times RO water TDS.
5. Open hydronic systems, including condenser **OR** fluid-cooler spray, **as directed**, water, shall have the following water qualities:
 - a. pH: Maintain a value within 8.0 to 9.1.
 - b. "P" Alkalinity: Maintain a maximum value of 100 ppm.
 - c. Chemical Oxygen Demand: Maintain a maximum value of 100ppm.
 - d. Soluble Copper: Maintain a maximum value of 0.20 ppm.
 - e. TDS: Maintain a maximum value of 10 ppm.
 - f. Ammonia: Maintain a maximum value of 20 ppm.
 - g. Free "OH" Alkalinity: Maintain a maximum value of 0 ppm.
 - h. Microbiological Limits:
 - 1) Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/ml.
 - 2) Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
 - 3) Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
 - 4) Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
 - 5) Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
 - i. Polymer Testable: Maintain a minimum value within 10 to 40.
6. Passivation for Galvanized Steel: For the first 60 days of operation.
 - a. pH: Maintain a value within 7 to 8.
 - b. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.
 - c. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm.

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
 - a. Wiring Diagrams: Power and control wiring.
3. Field quality-control test reports.
4. Manufacturer Seismic Qualification Certification
5. Other Informational Submittals:
 - a. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
 - b. Water Analysis: Illustrate water quality available at Project site.
 - c. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to the Owner.

F. Quality Assurance

1. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.



2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Manual Chemical-Feed Equipment

1. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
 - a. Capacity: 2 gal. (7.6 L) **OR** 5 gal. (19 L), **as directed**.
 - b. Minimum Working Pressure: 125 psig (860 kPa) **OR** 175 psig (1210 kPa), **as directed**.

B. Automatic Chemical-Feed Equipment

1. Water Meter:
 - a. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
 - b. Body: Bronze.
 - c. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
 - d. Registration: Gallons (Liters) or cubic feet (cubic meters).
 - e. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
2. Water Meter:
 - a. AWWA C701, turbine-type, totalization meter.
 - b. Body: Bronze.
 - c. Minimum Working-Pressure Rating: 100 psig (690 kPa).
 - d. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
 - e. Registration: Gallons (Liters) or cubic feet (cubic meters).
 - f. End Connections: Threaded.
 - g. Control: Low-voltage signal capable of transmitting 1000 feet (305 m).
3. Water Meter:
4. AWWA C701, turbine-type, totalization meter.
 - a. Body: Bronze **OR** Epoxy-coated cast iron, **as directed**.
 - b. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
 - c. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
 - d. Registration: Gallons (Liters) or cubic feet (cubic meters).
 - e. End Connections: Flanged.
 - f. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
5. Inhibitor Injection Timers:
 - a. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
 - b. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
 - c. Test switch.
 - d. Hand-off-auto switch for chemical pump.
 - e. Illuminated legend to indicate feed when pump is activated.
 - f. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
 - g. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
6. pH Controller:



- a. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
 - b. Digital display and touch pad for input.
 - c. Sensor probe adaptable to sample stream manifold.
 - d. High, low, and normal pH indication.
 - e. High or low pH alarm light, trip points field adjustable; with silence switch.
 - f. Hand-off-auto switch for acid pump.
 - g. Internal adjustable hysteresis or deadband.
7. TDS Controller:
- a. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
 - b. Digital display and touch pad for input.
 - c. Sensor probe adaptable to sample stream manifold.
 - d. High, low, and normal conductance indication.
 - e. High or low conductance alarm light, trip points field adjustable; with silence switch.
 - f. Hand-off-auto switch for solenoid bleed-off valve.
 - g. Bleed-off valve activated indication.
 - h. Internal adjustable hysteresis or deadband.
 - i. Bleed Valves:
 - 1) Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
 - 2) Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.
8. Biocide Feeder Timer:
- a. Microprocessor-based controller with digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
 - b. 24-hour timer with 14-day skip feature to permit activation any hour of day.
 - c. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
 - d. Solid-state alternator to enable use of two different formulations.
 - e. 24-hour display of time of day.
 - f. 14-day display of day of week.
 - g. Battery backup so clock is not disturbed by power outages.
 - h. Hand-off-auto switches for biocide pumps.
 - i. Biocide A and Biocide B pump running indication.
9. Chemical Solution Tanks:
- a. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
 - b. Molded cover with recess for mounting pump.
 - c. Capacity: 30 gal. (114 L) **OR** 50 gal. (189 L) **OR** 120 gal. (454 L), **as directed**.
10. Chemical Solution Injection Pumps:
- a. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
 - b. Adjustable flow rate.
 - c. Metal and thermoplastic construction.
 - d. Built-in relief valve.
 - e. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".



11. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.
 12. Injection Assembly:
 - a. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
 - b. Ball Valve: Three **OR** Two, **as directed**, -piece, stainless steel; selected to fit quill.
 - c. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
 - d. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).
- C. Ozone-Generator Biocide Equipment
1. Corona discharge generator with stainless-steel generating cells, and transformer housed in a NEMA 250, Type 4 enclosure. Assembly shall be suitable for continuous duty. Provide site glasses to verify proper operation of generator.
 2. Water-cooled generators shall be provided with cooling water at maximum 70 deg F (21 deg C) and 35 psig (241 kPa).
 3. Generator vessels exposed to system pressure shall be constructed according to ASME Boiler and Pressure Vessel Code and be equipped with pressure relief valve.
 4. External air compressor or induced airflow through a cleanable prefilter supplies concentrated oxygen through a molecular sieve with minus 62 deg F (minus 52 deg C) dew point to avoid the formation of nitric acid.
 5. Microprocessor-based control with software in EEPROM, surge protection, high-temperature cutout, and operational status lights. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
 6. Ozone Contactors:
 - a. Bubble diffusers.
 - b. Induction injection nozzle.
 - c. Injectors with static mixers.
 7. Ozone Detector and Alarm Devices:
 - a. Detector:
 - 1) Sensor: Metal dioxide semiconductor.
 - 2) Concentration Range: 0.01 to 0.14 ppm.
 - 3) Accuracy: Plus or minus 20 percent of range.
 - 4) Sensitivity: 0.01 ppm.
 - 5) Response Time: Maximum 10 seconds.
 - 6) Operating Temperature: 50 to 100 deg F (10 to 38 deg C).
 - 7) Relatively Humidity: 20 to 95 percent, noncondensing over the operating temperature range.
 - b. Horns:
 - 1) Electric-vibrating-polarized type.
 - 2) 24-V dc; with provision for housing the operating mechanism behind a grille.
 - 3) Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn.
 - c. Visible Alarm Devices:
 - 1) Xenon strobe lights listed in UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate.
 - 2) Rated Light Output: 75 **OR** 110, **as directed**, candela.
 - 3) Strobe Leads: Factory connected to screw terminals.
 8. Self-Contained Breathing Apparatus: Open-circuit, pressure-demand, compressed air includes completely assembled, portable, self-contained devices designed for hazardous breathing environment application.
 - a. Face Piece: EPDM or silicone rubber construction material, one-size-fits-all with double-sealing edge, stainless-steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in



mask, close-fitting nose piece to ensure no CO₂ buildup, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.

- b. Backplate: Orthopedically designed of chemical and impact-resistant, glass-fiber composite **OR** aluminum, **as directed**.
- c. Harness and Carrier Assembly: Large triangular back pad, backplate, and adjustable waist and shoulder straps. Modular in design, detachable components, and easy to clean and maintain. Shoulder straps padded with flame-resistant material, reinforced with stainless-steel cable, and attached with T-nuts, washers, and screws.
- d. Air Cylinder: 30 **OR** 45 **OR** 60, **as directed**, -minute, low-pressure, air-supply-loaded fiberglass **OR** aluminum **OR** steel, **as directed**, cylinders fitted with quick-fill assembly for refilling and air transfer.
- e. Wall-Mounting Cabinet: Leakproof, corrosion-resistant, clear, plastic case.
- f. Tested and Certified: By the National Institute for Occupational Safety and Health and by the Mine Safety and Health Administration, according to 42 CFR 84, Subpart H.

D. Stainless-Steel Pipes And Fittings

1. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.
2. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.
3. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig (1725-kPa) SWP and 600-psig (4140-kPa) CWP ratings.
4. Three-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, threaded body design with adjustable stem packing, threaded ends, and 150-psig (1035-kPa) SWP and 600-psig (4140-kPa) CWP rating.

E. UV Biocide Equipment

1. Target Irradiation: Minimum 30,000 microwatts x s/sq. cm.
2. Light Source Vessels:
 - a. ASTM A 666, Type 304 stainless steel.
 - b. Construct for minimum 150 psig (1035 kPa) at 150 deg F (65 deg C) according to ASME Boiler and Pressure Vessel Code, and equipped with pressure relief valve.
 - c. Light Source Sleeve: Quartz, with EPDM O-ring seals.
 - d. Light Source: Replaceable UV lamp producing minimum target irradiation of 254-nm wavelength light.
3. Controls: Interlock with pumps to operate when water is circulating.

F. Chemical Treatment Test Equipment

1. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.
2. Sample Cooler:
 - a. Tube: Sample.
 - 1) Size: NPS 1/4 (DN 8) tubing.
 - 2) Material: ASTM A 666, Type 316 stainless steel.
 - 3) Pressure Rating: Minimum 2000 psig (13 790 kPa).
 - 4) Temperature Rating: Minimum 850 deg F (454 deg C).
 - b. Shell: Cooling water.
 - 1) Material: ASTM A 666, Type 304 stainless steel.
 - 2) Pressure Rating: Minimum 250 psig (1725 kPa).
 - 3) Temperature Rating: Minimum 450 deg F (232 deg C).
 - c. Capacities and Characteristics:
 - 1) Tube: Sample.
 - a) Flow Rate: 0.25 gpm (0.016 L/s).



- b) Entering Temperature: 400 deg F (204 deg C).
- c) Leaving Temperature: 88 deg F (31 deg C).
- d) Pressure Loss: 6.5 psig (44.8 kPa).
- 2) Shell: Cooling water.
 - a) Flow Rate: 3 gpm (0.19 L/s).
 - b) Entering Temperature: 70 deg F (21 deg C).
 - c) Pressure Loss: 1.0 psig (6.89 kPa).
- 3. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 - a. Two-station rack for closed-loop systems.
 - b. Four-station rack for open systems.

G. Chemicals

- 1. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1.1 "Performance Requirements" Article.
- 2. Water Softener Chemicals:
 - a. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.
 - b. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

H. HVAC Makeup Water Softener

- 1. Description: Twin mineral tanks and one brine tank, factory mounted on skid.
- 2. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.
- 3. Mineral Tanks:
 - a. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
 - c. Pressure Rating: 100 psig (690 kPa) **OR** 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, minimum.
 - d. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C).
 - e. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
 - f. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
 - g. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
 - h. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
 - i. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even-flow distribution through resin bed.
- 4. Controls: Automatic; factory mounted on mineral tanks and factory wired.
 - a. Adjustable duration of regeneration steps.
 - b. Push-button start and complete manual operation override.
 - c. Pointer on pilot-control valve shall indicate cycle of operation.
 - d. Means of manual operation of pilot-control valve if power fails.
 - e. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:



- 1) Slow opening and closing, nonslam operation.
 - 2) Diaphragm guiding on full perimeter from fully open to fully closed.
 - 3) Isolated dissimilar metals within valve.
 - 4) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
 - 5) Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
 - 6) Sampling cocks for soft water.
 - f. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons (liters), and automatically resets after regeneration to preset total in gallons (liters) for next service run. Include alternator to regenerate one mineral tank with the other in service.
 5. Brine Tank: Combination measuring and wet-salt storing system.
 - a. Tank and Cover Material: Fiberglass a minimum of 3/16 inch (4.8 mm) thick; or molded PE a minimum of 3/8 inch (9.5 mm) thick.
 - b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
 - c. Size: Large enough for at least four regenerations at full salting.
 6. Factory-Installed Accessories:
 - a. Piping, valves, tubing, and drains.
 - b. Sampling cocks.
 - c. Main-operating-valve position indicators.
 - d. Water meters.
 7. Water Test Kit: Include water test kit in wall-mounting enclosure for water softener.
- I. RO Equipment For HVAC Makeup Water
1. Description: Factory fabricated and tested with RO membrane elements in housings, high-pressure pumps and motors, controls, valves, and prefilter; mounted on skid.
 2. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.
 3. Skid Assembly: Welded-steel frame coated with epoxy protective finish.
 4. RO Membrane and Housing:
 - a. Element: Thin-film composite with U-cup brine seal with minimum 98 percent salt rejection based on 2000-ppm water supplied at 225 psig (1551 kPa) and 77 deg F (25 deg C).
 - b. Housing: ASTM A 666, Type 304 stainless steel with PVC end caps held in place with stainless-steel straps.
 5. High-Pressure Pumps and Motors:
 - a. Pump:
 - 1) Vertical, multistage centrifugal operating at 3500 rpm with ASTM A 666, Type 304 stainless-steel casing, shaft, impellers, and inlet and discharge casting.
 - 2) Bearings shall be tungsten carbide and ceramic.
 - 3) Cast-iron frame and flanged suction and discharge connections.
 - b. Motor: NEMA-standard, C-faced TEFC motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 6. Controls:
 - a. Microprocessor-based controller with LCD display.
 - b. Interlock for remote start/stop control.
 - c. Membrane flush sequence when pumps shut down.
 - d. Run time indicator.
 - e. Low-pressure safety cutoff.
 - f. Panel-mounted gages as follows:



- 1) Product and concentrate.
 - 2) Inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product pressures.
 - 3) Product conductivity monitor.
7. Valves:
- a. Stainless-steel pump, concentrate, and recycle throttling valves rated for minimum 300 psig (2068 kPa).
 - b. Automatic inlet shutoff valve, diaphragm type; solenoid actuated, normally closed, and constructed of glass-reinforced noryl thermoplastic.
 - c. PVC valves with EPDM seats and seals for isolation at inlet, and check and sample valves at product and concentrate. Sample valves at cartridge filter outlet, concentrate, and product outlet.
8. Prefilter:
- a. Housing: Polypropylene with built-in relief or vent valve.
 - b. Element: Spun-wound polypropylene.
9. Inlet Water Tempering Valve: Thermostatic water-tempering valve to maintain 77 deg F (25 deg C), **as directed**, inlet water temperature to RO unit.
10. Activated Carbon Filter:
- a. Media Tank: Fiberglass-reinforced polyester rated for minimum 150 psig (1035 kPa) with internal backwash distributor and filtered water collector.
 - b. Media: 12 x 40-mesh, bituminous coal-based activated carbon.
 - c. Backwash Valve: Piston-operated control valve with drain-line, flow-control orifice.
 - d. Backwash Control: Seven-day time clock.
11. Atmospheric Storage Tank:
- a. Tank: Polyethylene single piece with closed top and flat bottom with manway in top, 0.2-micron filter vent, inlet, discharge, and drain piping connections, and bulkhead fittings for level controls.
 - b. Control: Level switches start and stop RO unit. Low-level limit shall stop repressurization pumps, and signal an alarm.
12. Repressurization Pumps:
- a. Pumps: Two close-coupled, single-stage centrifugal pumps, with mechanical seals. Wetted components ASTM A 666, Type 316 stainless steel.
 - b. Controls: NEMA-4X pump control panel constructed of fiberglass to control pumps, one operating, one standby, with automatic alternator and fail-over control.
 - c. Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
13. Water Test Kit: Include water test kit in wall-mounting cabinet for RO unit.
- J. Filtration Equipment
1. Multimedia Filters:
- a. Description: Factory-fabricated and -tested, simplex, multimedia filter system of filter tank, media, strainer, circulating pump, piping, and controls for removing particles from water.
 - 1) Filter Tank: Corrosion resistant with distribution system and media.
 - a) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
 - c) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
 - d) Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
 - e) FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; Designation E, 125-psig (0.862-MPa) or F, 150-psig (1.034-MPa) pressure category flanges of grade same as tank material according to ASTM D 5421.



- 2) Motorized Valves: Flanged or grooved-end, ductile-iron butterfly type with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
 - 3) Strainer: Basket type mounted on pump suction.
 - 4) Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
 - 5) Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
 - 6) Safety Valves: Automatic pressure relief.
 - 7) Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
 - a) Casing: Radially split, cast iron.
 - b) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, minimum.
 - c) Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - d) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 - e) Seal: Mechanical.
 - f) Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 8) Controls: Automatic control of circulating pump and tank backwash; factory wired for single electrical connection.
 - a) Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.
 - b) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
 - c) Backwash: Automatic; with time clock and differential pressure switch.
 - d) Backwash Valve: Tank mounted with valves interlocked to single actuator.
 - 9) Support: Skid mounting. Fabricate supports and base and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
2. Self-Cleaning Strainers:
- a. Description: Factory-fabricated and -tested, ASTM A 126, Class B, cast-iron or steel, self-cleaning strainer system of tank, strainer, backwash arm or cleaning spiral, drive and motor, piping, and controls for removing particles from water.
 - 1) Fabricate and label ASTM A 126, Class B, cast-iron or steel strainer tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2) Pipe Connections:
 - a) NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
 - b) NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
 - b. Motorized Valves: Flanged or grooved-end, ductile-iron angle type with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
 - c. Strainer: ASTM A 666, Type 316 stainless steel.
 - d. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
 - e. Safety Valves: Automatic pressure relief.
 - f. Backwash Arm Drive:
 - 1) Drive Casing: Cast iron.
 - 2) Worm Gears: Immersed in oil.
 - 3) Motor: ODP motor supported on the strainer-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - g. Controls: Automatic control of backwash; factory wired for single electrical connection.
 - 1) Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.



- 2) Backwash Arm Drive: Automatic and manual switching; manual switch position bypasses safeties and controls.
 - 3) Backwash: Automatic; with time clock and differential pressure switch.
 - 4) Backwash Valve: Electric actuator.
 - h. Support: Skid mounting. Fabricate supports and base and attachment to tank with reinforcement strong enough to resist strainer movement during a seismic event when strainer base is anchored to building structure.
3. Bag **OR** Cartridge, **as directed**, -Type Filters:
- a. Description: Floor-mounting housing with filter bags **OR** cartridges, **as directed**, for removing particles from water.
 - 1) Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through bag **OR** cartridge, **as directed**, -type water filter; with bag support and base, feet, or skirt.
 - a) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
 - b) Steel Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
 - c) Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: 150-psig (1035-kPa) plastic flanges.
 - 2) Bag **OR** Cartridge, **as directed**: Replaceable; of shape to fit housing.
4. Centrifugal Separators:
- a. Description: Simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity.
 - b. Housing: With manufacturer's proprietary system of baffles and chambers.
 - 1) Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2) Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
 - 3) Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
 - 4) Collection Chamber: Designed to hold separated particles.
 - 5) Outlet: Near top of unit.
 - 6) Purge: At bottom of collection chamber.
 - 7) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
 - 8) Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if tank is stainless steel.
 - c. Motorized Purge Valve: Gate or plug pattern valve.
 - 1) Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
 - d. Strainer: Stainless-steel basket type mounted on pump suction.
 - e. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
 - f. Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
 - g. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
 - 1) Casing: Radially split, cast iron.
 - 2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, minimum.
 - 3) Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - 4) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 - 5) Seal: Mechanical.



- 6) Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- h. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.
 - 1) Panel: NEMA 250, Type 4 enclosure.
 - 2) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
 - 3) Separator Purge: Automatic and manual.
 - 4) TDS Controller Interlock: Open separator purge valve with bleed-off control.
- i. Support: Skid mounting. Fabricate supports and base and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event when separator base is anchored to building structure.

1.3 EXECUTION

A. Water Analysis

1. Perform an analysis of supply water to determine quality of water available at Project site.

B. Installation

1. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
2. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
3. Install water testing equipment on wall near water chemical application equipment.
4. Install interconnecting control wiring for chemical treatment controls and sensors.
5. Mount sensors and injectors in piping circuits.
6. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, chilled water, dual-temperature water, and glycol cooling, and equipped with the following:
 - a. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
 - b. Install water meter in makeup water supply.
 - c. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
 - d. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
 - e. Install a swing check on inlet after the isolation valve.
7. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:
 - a. Install makeup water softener.
 - b. Install water meter in makeup water supply.
 - c. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
 - 1) Pumps shall operate for timed interval when contacts close at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
 - d. Install test equipment and furnish test-kit to the Owner.
 - e. Install RO unit for makeup water.
 - f. Install TDS controller with sensor and bleed valves.
 - 1) Bleed valves shall cycle to maintain maximum TDS concentration.
 - g. Install inhibitor injection timer with injection pumps and solution tanks.



- 1) Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into main steam supply header.
8. Install automatic chemical-feed equipment for condenser **OR** fluid-cooler spray, **as directed**, water and include the following:
 - a. Install makeup water softener.
 - b. Install water meter in makeup water supply.
 - c. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
 - 1) Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
 - d. Install test equipment and provide test-kit to the Owner. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
 - e. Install TDS controller with sensor and bleed valves.
 - 1) Bleed valves shall cycle to maintain maximum TDS concentration.
 - f. Install pH sensor and controller with injection pumps and solution tanks.
 - 1) Injector pumps shall operate to maintain required pH.
 - g. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
 - 1) Injection pumps shall operate to feed biocide on an alternating basis.
 - h. Install ozone generator with diffusers in condenser-water piping.
 - i. Ozone generator shall operate continuously with condenser-water flow.
 - j. Install UV-irradiation lamps in condenser-water piping.
 - 1) UV lights shall operate continuously with condenser-water flow.
- C. Ozone-Generator Installation
 1. Install ozone generator and equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
 2. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
 3. Pipe ozone from ozone generator to condenser water with stainless-steel pipe and fittings with welded joints.
 4. Install two **OR** three, **as directed**,-piece, stainless-steel ball valve in ozone supply to condenser water.
 5. Pipe cooling water to ozone generator, and to air-gap drain fitting with stainless-steel pipe and fittings with welded joints where enclosed in ozone-generator room.
 6. Install two **OR** three, **as directed**,-piece, stainless-steel ball valve in cooling water supply to ozone generator.
 7. Mounting supports for ozone generator shall be ASTM A 666, Type 316 stainless steel.
 8. Mount breathing apparatus outside ozone-generator room.
 9. Mount and install ozone detector, warning lights, and audible alarm inside ozone-generator room. Mount another set of warning lights and audible alarm just outside the main entrance to ozone-generator room.
- D. UV-Irradiation Unit Installation
 1. Install UV-irradiation units on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
 2. Install seismic restraints for UV-irradiation units and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
- E. Water Softener Installation



1. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
2. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
3. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.
4. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.
5. Install water-testing sets on wall adjacent to water softeners.

F. RO Unit Installation

1. Install RO unit and storage tank on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.
2. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
3. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.
4. Install water testing sets on wall adjacent to RO unit.

G. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment to allow service and maintenance.
3. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 23 Section "Common Work Results For Hvac".
4. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section "General-duty Valves For Hvac Piping".
5. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.
6. Confirm applicable electrical requirements in Division 22 for connecting electrical equipment.
7. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
8. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

H. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
 - a. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - b. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - c. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.



- d. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
- e. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
- f. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
- g. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
- h. Repair leaks and defects with new materials and retest piping until no leaks exist.
4. Remove and replace malfunctioning units and retest as specified above.
5. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising the Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at four **OR** six **OR** eight, **as directed**,-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.
6. At four **OR** six **OR** eight, **as directed**,-week intervals following Final Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising the Owner of changes necessary to adhere to Part 1.1 "Performance Requirements" Article.
7. Comply with ASTM D 3370 and with the following standards:
 - a. Silica: ASTM D 859.
 - b. Steam System: ASTM D 1066.
 - c. Acidity and Alkalinity: ASTM D 1067.
 - d. Iron: ASTM D 1068.
 - e. Water Hardness: ASTM D 1126.
- I. Demonstration
 1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 23 25 13 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 25 13 00	22 05 23 00	Piped Utilities Basic Materials And Methods
23 25 13 00	22 12 23 26	Underground Storage Tanks
23 25 13 00	22 11 16 00c	Hydronic Piping
23 25 13 00	22 12 23 26a	Facility Fuel-Oil Piping



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SECTION 23 31 13 13 - METAL DUCTS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for metal ducts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Single-wall rectangular ducts and fittings.
 - b. Double-wall rectangular ducts and fittings.
 - c. Single-wall round and flat-oval ducts and fittings.
 - d. Double-wall round and flat-oval ducts and fittings.
 - e. Sheet metal materials.
 - f. Duct liner.
 - g. Sealants and gaskets.
 - h. Hangers and supports.
 - i. Seismic-restraint devices.

C. Performance Requirements

1. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
2. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
 - a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
OR
Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
OR
Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Submittals

1. Product Data: For each type of the following products:
 - a. Liners and adhesives.
 - b. Sealants and gaskets.
 - c. Seismic-restraint devices.
2. LEED Submittals:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
 - c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
 - d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-Up."



- e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
 3. Shop Drawings:
 - a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - b. Factory- and shop-fabricated ducts and fittings.
 - c. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
 - d. Elevation of top of ducts.
 - e. Dimensions of main duct runs from building grid lines.
 - f. Fittings.
 - g. Reinforcement and spacing.
 - h. Seam and joint construction.
 - i. Penetrations through fire-rated and other partitions.
 - j. Equipment installation based on equipment being used on Project.
 - k. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 - l. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
 4. Delegated-Design Submittal:
 - a. Sheet metal thicknesses.
 - b. Joint and seam construction and sealing.
 - c. Reinforcement details and spacing.
 - d. Materials, fabrication, assembly, and spacing of hangers and supports.
 - e. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.
 5. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 - b. Suspended ceiling components.
 - c. Structural members to which duct will be attached.
 - d. Size and location of initial access modules for acoustical tile.
 - e. Penetrations of smoke barriers and fire-rated construction.
 - f. Items penetrating finished ceiling including the following:
 - 1) Lighting fixtures.
 - 2) Air outlets and inlets.
 - 3) Speakers.
 - 4) Sprinklers.
 - 5) Access panels.
 - 6) Perimeter moldings.
 6. Welding certificates.
 7. Field quality-control reports.
- E. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
 - c. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
 3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."



1.2 PRODUCTS

- A. Single-Wall Rectangular Ducts And Fittings
1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 2. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 3. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 4. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Double-Wall Rectangular Ducts And Fittings
1. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.
 2. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 3. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 4. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 5. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - c. Coat insulation with antimicrobial coating.
 - d. Cover insulation with polyester film complying with UL 181, Class 1.

OR
 6. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
 - a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
 7. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent **OR** solid sheet steel, **as directed**.
 8. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."



9. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Single-Wall Round And Flat-Oval Ducts And Fittings

1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
2. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
3. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
4. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
5. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Double-Wall Round And Flat-Oval Ducts And Fittings

1. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
2. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
 - a. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1) Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
 - b. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1) Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - 2) Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
 - c. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements,



- materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
3. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch-(2.4-mm-) diameter perforations, with overall open area of 23 percent **OR** solid sheet steel, **as directed**.
 4. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - c. Coat insulation with antimicrobial coating.
 - d. Cover insulation with polyester film complying with UL 181, Class 1.**OR**
 5. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
 - a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
- E. Sheet Metal Materials
1. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
 2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - a. Galvanized Coating Designation: G60 (Z180) **OR** G90 (Z275), **as directed**.
 - b. Finishes for Surfaces Exposed to View: Mill phosphatized.
 3. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - a. Galvanized Coating Designation: G60 (Z180) **OR** G90 (Z275), **as directed**.
 - b. Minimum Thickness for Factory-Applied PVC Coating: 4 mils (0.10 mm) thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil (0.025 mm) thick on opposite surface, **as directed**.
 - c. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.
 4. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
 5. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
 6. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
 7. Factory- or Shop-Applied Antimicrobial Coating:
 - a. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 - b. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - c. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 - d. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - e. Shop-Applied Coating Color: Black **OR** White, **as directed**.
 - f. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
 8. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.



- a. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
9. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

F. Duct Liner

1. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Maximum Thermal Conductivity:
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - b. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - c. Solvent-Based **OR** Water-Based, **as directed**, Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 - a. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - b. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - 1) For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.
 - a. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature when tested according to ASTM C 518.
 - b. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
 - c. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - 1) For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Insulation Pins and Washers:
 - a. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - b. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel **OR** aluminum **OR** stainless steel, **as directed**; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
5. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
 - a. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 - b. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.



- c. Butt transverse joints without gaps, and coat joint with adhesive.
- d. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- e. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
- f. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s).
- g. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
- h. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - 1) Fan discharges.
 - 2) Intervals of lined duct preceding unlined duct.
 - 3) Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.
- i. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - 1) Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
- j. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

G. Sealant And Gaskets

- 1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- 2. Two-Part Tape Sealing System:
 - a. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - b. Tape Width: 3 inches (76 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm), **as directed**.
 - c. Sealant: Modified styrene acrylic.
 - d. Water resistant.
 - e. Mold and mildew resistant.
 - f. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
 - g. Service: Indoor and outdoor.
 - h. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
 - i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 - j. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 3. Water-Based Joint and Seam Sealant:
 - a. Application Method: Brush on.
 - b. Solids Content: Minimum 65 percent.
 - c. Shore A Hardness: Minimum 20.
 - d. Water resistant.
 - e. Mold and mildew resistant.
 - f. VOC: Maximum 75 g/L (less water).
 - g. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
 - h. Service: Indoor or outdoor.



- i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
 - 4. Solvent-Based Joint and Seam Sealant:
 - a. Application Method: Brush on.
 - b. Base: Synthetic rubber resin.
 - c. Solvent: Toluene and heptane.
 - d. Solids Content: Minimum 60 percent.
 - e. Shore A Hardness: Minimum 60.
 - f. Water resistant.
 - g. Mold and mildew resistant.
 - h. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - i. VOC: Maximum 395 g/L.
 - j. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
 - k. Service: Indoor or outdoor.
 - l. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
 - 5. Flanged Joint Sealant: Comply with ASTM C 920.
 - a. General: Single-component, acid-curing, silicone, elastomeric.
 - b. Type: S.
 - c. Grade: NS.
 - d. Class: 25.
 - e. Use: O.
 - f. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 6. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
 - 7. Round Duct Joint O-Ring Seals:
 - a. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
 - b. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 - c. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.
- H. Hangers And Supports
 - 1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
 - 2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 - 3. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
 - 4. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
 - 5. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
 - 6. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
 - 7. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
 - 8. Trapeze and Riser Supports:
 - a. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - b. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - c. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.
- I. Seismic-Restraint Devices
 - 1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR**



the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.

- a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
3. Restraint Cables: ASTM A 603, galvanized-steel **OR** ASTM A 492, stainless-steel, **as directed**, cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.3 EXECUTION

A. Duct Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
2. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
3. Install round and flat-oval ducts in maximum practical lengths.
4. Install ducts with fewest possible joints.
5. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
6. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
7. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
8. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
9. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
10. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
11. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
12. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines", **as directed**.

B. Installation Of Exposed Ductwork

1. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
2. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.



3. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
 4. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
 5. Repair or replace damaged sections and finished work that does not comply with these requirements.
- C. Additional Installation Requirements For Commercial Kitchen Hood Exhaust Duct
1. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
 2. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet (6 m) **OR** 12 feet (3.7 m), **as directed**, in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches (38 mm) from bottom of duct.
 3. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.
- D. Duct Sealing
1. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
OR
Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - a. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - b. Outdoor, Supply-Air Ducts: Seal Class A.
 - c. Outdoor, Exhaust Ducts: Seal Class C.
 - d. Outdoor, Return-Air Ducts: Seal Class C.
 - e. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
 - f. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
 - g. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - h. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - i. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
 - j. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
 - k. Conditioned Space, Exhaust Ducts: Seal Class B.
 - l. Conditioned Space, Return-Air Ducts: Seal Class C.
- E. Hanger And Support Installation
1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
 2. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - a. Where practical, install concrete inserts before placing concrete.
 - b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 - e. Do not use powder-actuated concrete fasteners for seismic restraints.



3. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
 4. Hangers Exposed to View: Threaded rod and angle or channel supports.
 5. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
 6. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- F. Seismic-Restraint-Device Installation
1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR** ASCE/SEI 7, **as directed**.
 - a. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - b. Brace a change of direction longer than 12 feet (3.7 m).
 2. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
 3. Install cables so they do not bend across edges of adjacent equipment or building structure.
 4. Install cable restraints on ducts that are suspended with vibration isolators.
 5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
 6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
 7. Drilling for and Setting Anchors:
 - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - d. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - e. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.
- G. Connections
1. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories".
 2. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- H. Painting
1. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 07.
- I. Field Quality Control
1. Perform tests and inspections.



2. Leakage Tests:
 - a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - b. Test the following systems:
 - 1) Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - 2) Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
 - 3) Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
 - 4) Exhaust Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
 - 5) Outdoor Air Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
 - c. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - d. Test for leaks before applying external insulation.
 - e. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - f. Give seven days' advance notice for testing.
3. Duct System Cleanliness Tests:
 - a. Visually inspect duct system to ensure that no visible contaminants are present.
 - b. Test sections of metal duct system, chosen randomly by the Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - 1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
4. Duct system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

J. Duct Cleaning

1. Clean new **OR** existing **OR** new and existing, **as directed**, duct system(s) before testing, adjusting, and balancing.
2. Use service openings for entry and inspection.
 - a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 - b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - c. Remove and reinstall ceiling to gain access during the cleaning process.



3. Particulate Collection and Odor Control:
 - a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
4. Clean the following components by removing surface contaminants and deposits:
 - a. Air outlets and inlets (registers, grilles, and diffusers).
 - b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - d. Coils and related components.
 - e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - f. Supply-air ducts, dampers, actuators, and turning vanes.
 - g. Dedicated exhaust and ventilation components and makeup air systems.
5. Mechanical Cleaning Methodology:
 - a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - e. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - f. Provide drainage and cleanup for wash-down procedures.
 - g. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

K. Start Up

1. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, And Balancing For Hvac".

L. Duct Schedule

1. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
 - a. Underground Ducts: Concrete-encased, galvanized sheet steel **OR** PVC-coated, galvanized sheet steel with thicker coating on duct exterior **OR** stainless steel, **as directed**.
2. Supply Ducts:
 - a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - 1) Pressure Class: Positive 1-inch wg (250 Pa) **OR** 2-inch wg (500 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 12 **OR** 24, **as directed**.
 - b. Ducts Connected to Constant-Volume Air-Handling Units:
 - 1) Pressure Class: Positive 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.



- 4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed**.
- c. Ducts Connected to Variable-Air-Volume Air-Handling Units:
 - 1) Pressure Class: Positive 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 3 **OR** 6, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6, **as directed**.
- d. Ducts Connected to Equipment Not Listed Above:
 - 1) Pressure Class: Positive 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 3 **OR** 6 **OR** 12, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12, **as directed**.
3. Return Ducts:
 - a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - 1) Pressure Class: Positive or negative 1-inch wg (250 Pa) **OR** 2-inch wg (500 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 12 **OR** 24, **as directed**.
 - b. Ducts Connected to Air-Handling Units:
 - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed**.
 - c. Ducts Connected to Equipment Not Listed Above:
 - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 3 **OR** 6 **OR** 12, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12, **as directed**.
4. Exhaust Ducts:
 - a. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - 1) Pressure Class: Negative 1-inch wg (250 Pa) **OR** 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed**, if negative pressure, and A if positive pressure.
 - 3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed**.
 - b. Ducts Connected to Air-Handling Units:
 - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**, if negative pressure, and A if positive pressure.
 - 3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12 **OR** 24, **as directed**.
 - c. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
 - 1) Exposed to View: Type 304, stainless-steel sheet, No. 4 **OR** No. 3, **as directed**, finish.
 - 2) Concealed: Type 304, stainless-steel sheet, No. 2D finish **OR** Carbon-steel sheet, **as directed**.
 - 3) Welded seams and joints.
 - 4) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.



- 5) Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
- 6) SMACNA Leakage Class: 3.
- d. Ducts Connected to Dishwasher Hoods:
 - 1) Type 304, stainless-steel sheet.
 - 2) Exposed to View: No. 4 **OR** No. 3, **as directed**, finish.
 - 3) Concealed: No. 2D finish.
 - 4) Welded seams and flanged joints with watertight EPDM gaskets.
 - 5) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
 - 6) Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
 - 7) SMACNA Leakage Class: 3.
- e. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:
 - 1) Type 316 **OR** Type 304, **as directed**, stainless-steel sheet.
 - a) Exposed to View: No. 4 **OR** No. 3, **as directed**, finish.
 - b) Concealed: No. 2B **OR** No. 2D, **as directed**, finish.
 - OR**
PVC-coated, galvanized sheet steel with thicker coating on duct interior.
 - 2) Pressure Class: Positive or negative 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa) **OR** 6-inch wg (1500 Pa), **as directed**.
 - 3) Minimum SMACNA Seal Class: A **OR** Welded seams, joints, and penetrations, **as directed**.
 - 4) SMACNA Leakage Class: 3.
- f. Ducts Connected to Equipment Not Listed Above:
 - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**, if negative pressure, and A if positive pressure.
 - 3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12 **OR** 24, **as directed**.
5. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
 - a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - 1) Pressure Class: Positive or negative 1-inch wg (250 Pa) **OR** 2-inch wg (500 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed**.
 - b. Ducts Connected to Air-Handling Units:
 - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12 **OR** 24, **as directed**.
 - c. Ducts Connected to Equipment Not Listed Above:
 - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
 - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
 - 3) SMACNA Leakage Class for Rectangular: 3 **OR** 6 **OR** 12, **as directed**.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12, **as directed**.
6. Intermediate Reinforcement:
 - a. Galvanized-Steel Ducts: Galvanized steel **OR** Carbon steel coated with zinc-chromate primer **OR** Galvanized steel or carbon steel coated with zinc-chromate primer, **as directed**.
 - b. PVC-Coated Ducts:
 - 1) Exposed to Airstream: Match duct material.



- 2) Not Exposed to Airstream: Galvanized **OR** Match duct material, **as directed**.
- c. Stainless-Steel Ducts:
 - 1) Exposed to Airstream: Match duct material.
 - 2) Not Exposed to Airstream: Galvanized **OR** Match duct material, **as directed**.
- d. Aluminum Ducts: Aluminum **OR** galvanized sheet steel coated with zinc chromate, **as directed**.
- 7. Liner:
 - a. Supply Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
 - b. Return Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
 - c. Exhaust Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) thick.
 - d. Supply Fan Plenums: Fibrous glass, Type II **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
 - e. Return- and Exhaust-Fan Plenums: Fibrous glass, Type II **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 2 inches (51 mm) thick.
 - f. Transfer Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
- 8. Double-Wall Duct Interstitial Insulation:
 - a. Supply Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
 - b. Return Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
 - c. Exhaust Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
- 9. Elbow Configuration:
 - a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - 1) Velocity 1000 fpm (5 m/s) or Lower:
 - a) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - b) Mitered Type RE 4 without vanes.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
 - a) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - b) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - c) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher:
 - a) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - OR**
 - b. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.



- 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
- c. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - 1) Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - a) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - b) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - c) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - d) Radius-to Diameter Ratio: 1.5.
 - 2) Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
 - 3) Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam **OR** Welded, **as directed**.
10. Branch Configuration:
 - a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
 - 1) Rectangular Main to Rectangular Branch: 45-degree entry.
 - 2) Rectangular Main to Round Branch: Spin in.
 - b. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 23 31 13 13



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**SECTION 23 31 13 13a - HVAC CASINGS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC casings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Factory- and Shop-fabricated, field-assembled, single- and double-wall casings for HVAC equipment.

C. Performance Requirements

1. Static-Pressure Classes:
 - a. Upstream from Fan(s): 2-inch wg (500 Pa).
 - b. Downstream from Fan(s): 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa) **OR** 6-inch wg (1500 Pa) **OR** 10-inch wg (2500 Pa), **as directed**.
2. Acoustical Performance:
 - a. NRC: 1.09 **OR** 0.94, **as directed**, according to ASTM C 423.
 - b. STC: 40 **OR** 34, **as directed**, according to ASTM E 90.
3. Structural Performance:
 - a. Casings shall be fabricated to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 inch per foot (0.97 mm per meter) of width.
 - 1) Fabricate outdoor casings to withstand wind load of 15 lbf/sq. ft. (720 N/sq. m) and snow load of 30 lbf/sq. ft. (1440 N/sq. m).
4. Seismic Performance: HVAC casings shall withstand the effects of earthquake motions determined according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
 - c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
 - d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-Up."
 - e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For HVAC casings. Include plans, elevations, sections, components, and attachments to other work.
4. Welding certificates.
5. Field quality-control reports.



E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports **OR** AWS D9.1M/D9.1, "Sheet Metal Welding Code," for casing joint and seam welding, **as directed**.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

1.2 PRODUCTS

A. General Casing Fabrication Requirements

1. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 6, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
 - a. Fabricate casings with more than 3-inch wg (750-Pa) negative static pressure according to SMACNA's "Rectangular Industrial Duct Construction Standards."
 - b. Casings with more than 2-inch wg (500-Pa) positive static pressure may be fabricated according to SMACNA's "Rectangular Industrial Duct Construction Standards."
2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - a. Exterior Surface Galvanized Coating Designation: G60 (Z180) **OR** G90 (Z275), **as directed**.
 - b. Interior Surface Galvanized Coating Designation:
 - 1) Sections Not Exposed to Moisture: G60 (Z180) **OR** G90 (Z275), **as directed**.
 - 2) Sections Housing and Downstream from Cooling Coil and Humidifiers: G90 (Z275).
3. Stainless Steel: ASTM A 480/A 480M, Type 304 **OR** Type 316, **as directed**, and having a No. 2D, **as directed**, finish.
4. Factory- or Shop-Applied Antimicrobial Coating:
 - a. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
 - b. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - c. Coating containing the antimicrobial compound shall have a hardness of 2H minimum when tested according to ASTM D 3363.
 - d. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to UL 723; certified by an NRTL.
 - e. Applied Coating Color: Standard **OR** Black **OR** White, **as directed**.
5. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
6. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.
7. Penetrations: Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Provide shaft seals where fan shafts penetrate casing.
8. Access Doors: Fabricate access doors according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-11, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 6.12, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and according to pressure class of the plenum or casing section in which access doors are to be installed.
 - a. Size: 20 by 54 inches (500 by 1370 mm).
 - b. Vision Panel: Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
 - c. Hinges: Piano or butt hinges and latches, number and size according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."



- d. Latches: Minimum of two wedge-lever-type latches, operable from inside and outside.
 - e. Neoprene gaskets around entire perimeters of door frames.
 - f. Doors shall open against air pressure.
9. Condensate Drain Pans: Formed sections of Type 304, stainless-steel sheet **OR** G90 (Z275) coated, galvanized sheet steel, **as directed**, complying with requirements in ASHRAE 62.1. Pans shall extend a minimum of 12 inches (300 mm) past coil.
- a. Double-wall construction shall have space between walls filled with foam insulation and sealed moisture tight.
 - b. Intermediate drain pan or drain trough shall collect condensate from top coil for units with stacked coils or stacked eliminators.
 - c. Insulation: Polystyrene or polyurethane.
 - d. Slopes shall be in a minimum of two planes to collect condensate from cooling coils (including coil piping connections and return bends), eliminators, and humidifiers when units are operating at maximum catalogued face velocity across cooling coil.
 - e. Each drain pan connection shall have a trap. Drain traps with depth and height differential between inlet and outlet equal or greater to the design static pressure plus 2-inch wg (500 Pa), **as directed**. Include slab height in trap calculation.
- B. Shop-Fabricated Casings
1. Single- and Double-Wall Casings: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
 2. Double-Wall Casing Inner Panel: Perforated, galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
OR
Double-Wall Casing Inner Panel: Solid sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
 3. Interstitial Insulation: Polyurethane foam complying with NFPA 90A or NFPA 90B.
OR
Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - b. Coat insulation with antimicrobial coating.
 - c. Cover insulation with polyester film complying with UL 181, Class 1.**OR**
Interstitial Insulation: Flexible-elastomeric duct liner complying with ASTM C 534, Type II for sheet materials and with NFPA 90A or NFPA 90B.
 - a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
 4. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.
 5. Fabricate close-off sheets from casing to dampers, filter frames, and coils and between stacked coils. Use galvanized sheet steel of same thickness as casing and with a galvanized coating designation of G90 (Z275).
 6. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.
 7. Reinforce casings with galvanized-steel angles.
- C. Manufactured Casings
1. Description: Double-wall, insulated, pressurized equipment casing.
 2. Double-Wall Panel Fabrication: Solid, galvanized sheet steel exterior wall and solid **OR** perforated, **as directed**, galvanized sheet steel interior wall; with space between wall filled with insulation.



- a. Wall Thickness: 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
 - b. Fabricate with a minimum number of joints.
 - c. Weld exterior and interior walls to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
 - d. Sheet metal thickness shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for static-pressure class indicated for casing.
OR
Sheet Metal Thicknesses:
 - 1) Exterior Wall Thickness: 0.040 inch (1.0 mm) minimum.
 - 2) Interior Wall Thickness: 0.034 inch (0.85 mm) minimum.
 - e. Double-Wall Casing Inner Panel: Perforated, galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.
OR
Double-Wall Casing Inner Panel: Solid sheet steel.
 - f. Fill each panel assembly with insulating material that is noncombustible, inert, mildew resistant and vermin proof and that complies with NFPA 90A.
 - g. Fabricate panels with continuous tongue-and-groove **OR** self-locking, **as directed**, joints effective inside and outside each panel.
3. Trim Items: Fabricate from a minimum of 0.052-inch (1.3-mm) galvanized sheet steel, furnished in standard lengths for field cutting.

D. Casing Liner

1. Fibrous-Glass Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Maximum Thermal Conductivity:
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - b. Antimicrobial Erosion-Resistant Coating: Apply to surface of the liner that will form the interior surface of casing to act as a moisture repellent and an erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - c. Solvent **OR** Water, **as directed**,-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Flexible-Elastomeric Casing Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1, and with NFPA 90A or NFPA 90B.
 - a. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - b. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Natural-Fiber Casing Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor, and complying with NFPA 90A or NFPA 90B.
 - a. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature when tested according to ASTM C 518.
 - b. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - c. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).



4. Insulation Pins and Washers:
 - a. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - b. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized **OR** stainless, **as directed**, steel, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 5. Shop or Factory Application of Casing Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
 - a. Adhere a single layer of indicated thickness of casing liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of casing liner is prohibited.
 - b. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 - c. Butt transverse joints without gaps, and coat joint with adhesive.
 - d. Fold and compress liner in corners of casings or cut and fit to ensure butted-edge overlapping.
 - e. Apply adhesive coating on longitudinal seams in casings with air velocity of 2500 fpm (12.7 m/s).
 - f. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
 - g. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from casing wall. Fabricate edge facings at the following locations:
 - 1) Fan discharges.
 - 2) Intervals of lined casing preceding unlined duct.
 - 3) Upstream edges of transverse joints in casings where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.
 - h. Secure insulation between perforated sheet metal inner wall of same thickness as specified for outer wall. Use mechanical fasteners that maintain inner wall at uniform distance from outer wall without compressing insulation.
- E. Sealant Materials
1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 2. Water-Based Joint and Seam Sealant:
 - a. Application Method: Brush on.
 - b. Solids Content: Minimum 65 percent.
 - c. Shore A Hardness: Minimum 20.
 - d. Water resistant.
 - e. Mold and mildew resistant.
 - f. VOC: Maximum 75 g/L (less water).
OR
For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - g. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
 - h. Service: Indoor or outdoor.
 - i. Substrate: Compatible with galvanized sheet steel or stainless steel.
 3. Solvent-Based Joint and Seam Sealant:
 - a. Application Method: Brush on.
 - b. Base: Synthetic rubber resin.
 - c. Solvent: Toluene and heptane.
 - d. Solids Content: Minimum 60 percent.



- e. Shore A Hardness: Minimum 60.
- f. Water resistant.
- g. Mold and mildew resistant.
- h. VOC: Maximum 395 g/L.
- OR**
- For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- i. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
- j. Service: Indoor or outdoor.
- k. Substrate: Compatible with galvanized sheet steel or stainless steel.
- 4. Flanged Joint Sealant: Comply with ASTM C 920.
 - a. General: Single component, acid curing, silicone, elastomeric.
 - b. Type: S.
 - c. Grade: NS.
 - d. Class: 25.
 - e. Use: O.
 - f. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 5. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

1.3 EXECUTION

A. Installation

1. Install casings according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Equipment Mounting: Install HVAC casings on concrete base. Comply with requirements for concrete base specified in Division 07 Section "Manufactured Roof Expansion Joints".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported casings, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install seismic restraints on casings. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment"
4. Apply sealant to joints, connections, and mountings.
5. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
6. Support casings on floor or foundation system. Secure and seal to base.
7. Support components rigidly with ties, braces, brackets, seismic restraints, **as directed**, and anchors of types that will maintain housing shape and prevent buckling.
8. Align casings accurately at connections, with 1/8-inch (3-mm) misalignment tolerance and with smooth interior surfaces.

B. Field Quality Control

1. Tests and Inspections:
 - a. Perform field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual."
 - b. Test the following systems:
 - 1) Systems required by ASHRAE/IESNA 90.1.
 - 2) Supply Air: 100 **OR** 50, **as directed**, percent of total installed duct area with a pressure class of 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**, or higher.



- c. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
 - d. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.
 - e. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. HVAC casings will be considered defective if they do not pass tests and inspections.
 3. Prepare test and inspection reports.
- C. Cleaning
1. Comply with requirements for cleaning in Division 23 Section "Metal Ducts".

END OF SECTION 23 31 13 13a



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SECTION 23 31 13 16 - TAILPIPE EXHAUST EQUIPMENT

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of tailpipe exhaust equipment. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Capacity and Performance

1. Based on standard air density (0.075 pound per cubic foot). Fans shall have a peak static efficiency of not less than 60 percent.

B. Blowers and Accessories

1. Comply with AMCA 210, 300, and 301. Fan impellers shall be constructed of heavy gauge steel and accurately balanced both statically and dynamically when installed in the assembled fan unit. Impeller and housing in the air stream shall be coated with neoprene, epoxy, phenolic resins, or other material suitable to resist the corrosive gases and temperatures encountered. Fans to be mounted on exterior of building shall be provided with weatherproof covers.

C. Exhaust Duct and Fittings for Vehicle Tailpipe Exhaust Systems

1. Constructed of galvanized sheet steel, conforming to ASTM A 525. Ductwork shall be constructed with minimum metal gauge thickness and reinforced as required in the SMACNA Duct Construction Standards - Metal and Flexible.
 - a. Tailpipe Adapter shall be not less than 20-gauge corrosion-resisting steel. The adapter shall be of the tapered cone type with spring clip or other suitable device for exhaust pipe attachment.
 - b. Flexible Exhaust Tubing shall be 0.012 minimum thickness galvanized sheet steel or heat-resistant, reinforced wire, fiberglass, and neoprene tubing.
 - c. Dampers shall be of the circular disk type with quadrant locking device or blast gate type.
 - d. A Flexible Tubing Suspension System shall be furnished and installed for repaired tailpipe exhaust systems where no such suspension system exists. The flexible tubing suspension system shall suspend the flexible tubing overhead when not in use, allowing it to be lowered to the operating level, when required. The suspension system installed shall be complete with cable, pulleys, and operating mechanism.

1.3 EXECUTION

- #### A. Ductwork joints in galvanized sheet steel ductwork shall be soldered or otherwise sealed. The lock seam in straight sections shall be located on top of the duct. Seams shall be suitable for 10-inch water gauge static pressure. Ductwork shall be constructed with minimum metal gauge thickness and reinforced as required in the SMACNA Duct Construction Standards - Metal and Flexible.

- #### B. Weather-Resistant Finishes of items located outdoors shall meet the requirements of ASTM B 117.



END OF SECTION 23 31 13 16



Task	Specification	Specification Description
23 31 13 16	23 31 13 13	Metal Ducts
23 31 13 16	23 31 13 13a	HVAC Casings
23 31 13 19	23 31 13 13	Metal Ducts
23 31 13 19	23 31 13 13a	HVAC Casings
23 31 13 23	23 31 13 13	Metal Ducts
23 31 13 23	23 31 13 13a	HVAC Casings



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SECTION 23 31 13 33 - DUCT ACCESSORIES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for duct accessories. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Backdraft and pressure relief dampers.
 - b. Barometric relief dampers.
 - c. Manual volume dampers.
 - d. Control dampers.
 - e. Fire dampers.
 - f. Ceiling dampers.
 - g. Smoke dampers.
 - h. Combination fire and smoke dampers.
 - i. Corridor dampers.
 - j. Flange connectors.
 - k. Duct silencers.
 - l. Turning vanes.
 - m. Remote damper operators.
 - n. Duct-mounted access doors.
 - o. Flexible connectors.
 - p. Flexible ducts.
 - q. Duct security bars.
 - r. Duct accessory hardware.

C. Submittals

1. Product Data: For each type of product indicated.
 - a. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.
2. LEED Submittal:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
 - a. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - 1) Special fittings.
 - 2) Manual volume damper installations.
 - 3) Control damper installations.
 - 4) Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - 5) Duct security bars.
 - 6) Wiring Diagrams: For power, signal, and control wiring.
4. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.



5. Source quality-control reports.
6. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

D. Quality Assurance

1. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
2. Comply with AMCA 500-D testing for damper rating.

1.2 PRODUCTS

A. Materials

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - a. Galvanized Coating Designation: G60 (Z180) **OR** G90 (Z275), **as directed**.
 - b. Exposed-Surface Finish: Mill phosphatized.
3. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and **<Insert finish designation>** finish for exposed ducts.
4. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
5. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.
6. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
7. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

B. Backdraft And Pressure Relief Dampers

1. Description: Gravity balanced.
2. Maximum Air Velocity: 2000 fpm (10 m/s) **OR** 3000 fpm (15 m/s), **as directed**.
3. Maximum System Pressure: 1-inch wg (0.25 kPa) **OR** 2-inch wg (0.5 kPa), **as directed**.
4. Frame: 0.052-inch- (1.3-mm-) thick, galvanized sheet steel **OR** 0.063-inch- (1.6-mm-) thick extruded aluminum **OR** 0.052-inch- (1.3-mm-) thick stainless steel, **as directed**, with welded corners and mounting flange, **as directed**.
5. Blades: Multiple single-piece blades, center-pivoted, **as directed**, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum **OR** 0.050-inch- (1.2-mm-) thick aluminum sheet **OR** noncombustible, tear-resistant, neoprene-coated fiberglass, **as directed**, with sealed edges.
6. Blade Action: Parallel.
7. Blade Seals: Felt **OR** Vinyl foam **OR** Extruded vinyl, mechanically locked **OR** Neoprene, mechanically locked, **as directed**.
8. Blade Axles:
 - a. Material: Nonferrous metal **OR** Galvanized steel **OR** Plated steel **OR** Stainless steel **OR** Non-metallic **OR** Aluminum, **as directed**.
 - b. Diameter: 0.20 inch (5 mm).
9. Tie Bars and Brackets: Aluminum **OR** Galvanized steel, **as directed**.
10. Return Spring: Adjustable tension.
11. Bearings: Steel ball **OR** Synthetic pivot bushings **OR** Steel ball or synthetic pivot bushings, **as directed**.
12. Accessories:
 - a. Adjustment device to permit setting for varying differential static pressure.
 - b. Counterweights and spring-assist kits for vertical airflow installations.



- c. Electric actuators.
 - d. Chain pulls.
 - e. Screen Mounting: Front mounted in sleeve.
 - 1) Sleeve Thickness: 20-gage (1.0-mm) minimum.
 - 2) Sleeve Length: 6 inches (152 mm) minimum.**OR**
 - Screen Mounting: Rear mounted.
 - f. Screen Material: Galvanized steel **OR** Aluminum, **as directed**.
 - g. Screen Type: Bird **OR** Insect, **as directed**.
 - h. 90-degree stops.
- C. Barometric Relief Dampers
- 1. Suitable for horizontal or vertical mounting.
 - 2. Maximum Air Velocity: 2000 fpm (10 m/s) **OR** 2500 fpm (13 m/s), **as directed**.
 - 3. Maximum System Pressure: 2-inch wg (0.5 kPa).
 - 4. Frame: 0.064-inch- (1.6-mm-) thick, galvanized sheet steel **OR** 0.063-inch- (1.6-mm-) thick extruded aluminum, **as directed**, with welded corners and mounting flange, **as directed**.
 - 5. Blades:
 - a. Multiple, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum **OR** 0.050-inch- (1.2-mm-) thick aluminum sheet, **as directed**.
 - b. Maximum Width: 6 inches (150 mm).
 - c. Action: Parallel.
 - d. Balance: Gravity.
 - e. Eccentrically pivoted.
 - 6. Blade Seals: Vinyl **OR** Neoprene, **as directed**.
 - 7. Blade Axles: Galvanized steel **OR** Nonferrous metal, **as directed**.
 - 8. Tie Bars and Brackets:
 - a. Material: Aluminum **OR** Galvanized steel, **as directed**.
 - b. Rattle free with 90-degree stop.
 - 9. Return Spring: Adjustable tension.
 - 10. Bearings: Synthetic **OR** Stainless steel **OR** Bronze, **as directed**.
 - 11. Accessories:
 - a. Flange on intake.
 - b. Adjustment device to permit setting for varying differential static pressures.
- D. Manual Volume Dampers
- 1. Standard, Steel, Manual Volume Dampers:
 - a. Standard leakage rating, with linkage outside airstream, **as directed**.
 - b. Suitable for horizontal or vertical applications.
 - c. Frames:
 - 1) Hat-shaped, galvanized-steel **OR** stainless-steel, **as directed**, channels, 0.064-inch (1.62-mm) minimum thickness.
 - 2) Mitered and welded corners.
 - 3) Flanges for attaching to walls and flangeless frames for installing in ducts.
 - d. Blades:
 - 1) Multiple or single blade.
 - 2) Parallel- or opposed-blade design.
 - 3) Stiffen damper blades for stability.
 - 4) Galvanized-steel **OR** Stainless-steel, **as directed**, 0.064 inch (1.62 mm) thick.
 - e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
 - f. Bearings:
 - 1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
 - 2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - g. Tie Bars and Brackets: Galvanized steel.



2. Standard, Aluminum, Manual Volume Dampers:
 - a. Standard leakage rating, with linkage outside airstream, **as directed**.
 - b. Suitable for horizontal or vertical applications.
 - c. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 - d. Blades:
 - 1) Multiple or single blade.
 - 2) Parallel- or opposed-blade design.
 - 3) Stiffen damper blades for stability.
 - 4) Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
OR
Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
 - e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
 - f. Bearings:
 - 1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
 - 2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - g. Tie Bars and Brackets: Aluminum.
3. Low-Leakage, Steel, Manual Volume Dampers:
 - a. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
 - b. Suitable for horizontal or vertical applications.
 - c. Frames:
 - 1) Hat **OR** U **OR** Angle, **as directed**, shaped.
 - 2) Galvanized-steel **OR** Stainless-steel, **as directed**, channels, 0.064 inch (1.62 mm) thick.
 - 3) Mitered and welded corners.
 - 4) Flanges for attaching to walls and flangeless frames for installing in ducts.
 - d. Blades:
 - 1) Multiple or single blade.
 - 2) Parallel- or opposed-blade design.
 - 3) Stiffen damper blades for stability.
 - 4) Galvanized **OR** Stainless, **as directed**, roll-formed steel, 0.064 inch (1.62 mm) thick.
 - e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
 - f. Bearings:
 - 1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
 - 2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - g. Blade Seals: Felt **OR** Vinyl **OR** Neoprene, **as directed**.
 - h. Jamb Seals: Cambered stainless steel **OR** aluminum, **as directed**.
 - i. Tie Bars and Brackets: Galvanized steel **OR** Aluminum, **as directed**.
 - j. Accessories:
 - 1) Include locking device to hold single-blade dampers in a fixed position without vibration.
4. Low-Leakage, Aluminum, Manual Volume Dampers:
 - a. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
 - b. Suitable for horizontal or vertical applications.
 - c. Frames: Hat **OR** U **OR** Angle, **as directed**, -shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 - d. Blades:
 - 1) Multiple or single blade.



- 2) Parallel- or opposed-blade design.
 - 3) Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
OR
Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
 - e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
 - f. Bearings:
 - 1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
 - 2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - g. Blade Seals: Felt **OR** Vinyl **OR** Neoprene, **as directed**.
 - h. Jamb Seals: Cambered stainless steel **OR** aluminum, **as directed**.
 - i. Tie Bars and Brackets: Galvanized steel **OR** Aluminum, **as directed**.
 - j. Accessories:
 - 1) Include locking device to hold single-blade dampers in a fixed position without vibration.
5. Jackshaft:
 - a. Size: 1-inch (25-mm) diameter.
 - b. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - c. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
 6. Damper Hardware:
 - a. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
 - b. Include center hole to suit damper operating-rod size.
 - c. Include elevated platform for insulated duct mounting.
- E. Control Dampers
1. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
 2. Frames:
 - a. Hat **OR** U **OR** Angle, **as directed**, shaped.
 - b. Galvanized-steel **OR** Stainless-steel, **as directed**, channels, 0.064 inch (1.62 mm) thick.
 - c. Mitered and welded corners.
 3. Blades:
 - a. Multiple blade with maximum blade width of 8 inches (200 mm).
 - b. Parallel **OR** Parallel- and opposed **OR** Opposed, **as directed**, -blade design.
 - c. Galvanized **OR** Stainless, **as directed**, steel.
 - d. 0.064 inch (1.62 mm) thick.
 - e. Blade Edging: Closed-cell neoprene edging.
OR
Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
 4. Blade Axles: 1/2-inch- (13-mm-) diameter; galvanized steel **OR** stainless steel **OR** nonferrous metal, **as directed**; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 - a. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 5. Bearings:
 - a. Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - c. Thrust bearings at each end of every blade.
- F. Fire Dampers



1. Type: Static **OR** Dynamic **OR** Static and dynamic, **as directed**; rated and labeled according to UL 555 by an NRTL.
2. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.
3. Fire Rating: 1-1/2 **OR** 3, **as directed**, hours.
4. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
5. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - a. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) thick, as indicated, and of length to suit application.
 - b. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
6. Mounting Orientation: Vertical or horizontal as indicated.
7. Blades: Roll-formed, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
8. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
9. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated, fusible links.
OR
Heat-Responsive Device: Electric **OR** Pneumatic, **as directed**, resettable link and switch package, factory installed, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated.

G. Ceiling Dampers

1. General Requirements:
 - a. Labeled according to UL 555C by an NRTL.
 - b. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."
2. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.
3. Blades: Galvanized sheet steel with refractory insulation.
4. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated, fusible links.
5. Fire Rating: 2 **OR** 3, **as directed**, hours.

H. Smoke Dampers

1. General Requirements: Label according to UL 555S by an NRTL.
2. Smoke Detector: Integral, factory wired for single-point connection.
3. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
4. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
5. Leakage: Class I **OR** Class II, **as directed**.
6. Rated pressure and velocity to exceed design airflow conditions.
7. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking, **as directed**.
8. Damper Motors: Modulating **OR** Two-position, **as directed**, action.
9. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".



- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section(s) "Instrumentation And Control For Hvac" OR Division 22, **as directed**.
 - c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
 - e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
 - f. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
 - g. Electrical Connection: 115 V, single phase, 60 Hz.
10. Accessories:
- a. Auxiliary switches for signaling **OR** fan control **OR** position indication, **as directed**.
 - b. Momentary test switch **OR** Test and reset switches, **as directed**, damper **OR** remote, **as directed**, mounted.
- I. Combination Fire And Smoke Dampers
1. Type: Static **OR** Dynamic **OR** Static and dynamic, **as directed**; rated and labeled according to UL 555 and UL 555S by an NRTL.
 2. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.
 3. Fire Rating: 1-1/2 **OR** 3, **as directed**, hours.
 4. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
 5. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated, fusible links.
OR
Heat-Responsive Device: Electric **OR** Pneumatic, **as directed**, resettable link and switch package, factory installed, rated.
 6. Smoke Detector: Integral, factory wired for single-point connection.
 7. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
 8. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
 9. Leakage: Class I **OR** Class II, **as directed**.
 10. Rated pressure and velocity to exceed design airflow conditions.
 11. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking, **as directed**.
 12. Master control panel for use in dynamic smoke-management systems.
 13. Damper Motors: Modulating **OR** Two-position, **as directed**, action.
 14. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".



- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section(s) "Instrumentation And Control For Hvac" OR Division 22, **as directed**.
 - c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
 - e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
 - f. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
 - g. Electrical Connection: 115 V, single phase, 60 Hz.
15. Accessories:
- a. Auxiliary switches for signaling **OR** fan control **OR** position indication, **as directed**.
 - b. Momentary test switch **OR** Test and reset switches, **as directed**, damper **OR** remote, **as directed**, mounted.

J. Corridor Dampers

1. General Requirements: Label combination fire and smoke dampers according to UL 555 for 1-1/2-hour rating by an NRTL.
2. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated, fusible links.
OR
Heat-Responsive Device: Electric **OR** Pneumatic, **as directed**, resettable link and switch package, factory installed, rated.
3. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
4. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
5. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.
6. Damper Motors: Modulating **OR** Two-position, **as directed**, action.
7. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section(s) "Instrumentation And Control For Hvac" OR Division 22, **as directed**.
 - c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).



- e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
 - f. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
 - g. Electrical Connection: 115 V, single phase, 60 Hz.
- K. Flange Connectors
- 1. Description: Add-on **OR** Roll-formed, **as directed**, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
 - 2. Material: Galvanized steel.
 - 3. Gage and Shape: Match connecting ductwork.
- L. Duct Silencers
- 1. General Requirements:
 - a. Factory fabricated.
 - b. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
 - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 2. Shape:
 - a. Rectangular straight with splitters or baffles.
 - b. Round straight with center bodies or pods.
 - c. Rectangular elbow with splitters or baffles.
 - d. Round elbow with center bodies or pods.
 - e. Rectangular transitional with splitters or baffles.
 - 3. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275) **OR** G60 (Z180), **as directed**, galvanized sheet steel, 0.034 inch (0.85 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
 - 4. Round Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275) **OR** G60 (Z180), **as directed**, galvanized sheet steel.
 - a. Sheet Metal Thickness for Units up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85 mm) thick.
 - b. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in Diameter: 0.040 inch (1.02 mm) thick.
 - c. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in Diameter: 0.052 inch (1.3 mm) thick.
 - d. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in Diameter: 0.064 inch (1.62 mm) thick.
 - 5. Inner Casing and Baffles: ASTM A 653/A 653M, G90 (Z275) **OR** G60 (Z180), **as directed**, galvanized sheet metal, 0.034 inch (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations.
 - 6. Special Construction:
 - a. Suitable for outdoor use.
 - b. High transmission loss to achieve STC 45, **as directed**.
 - 7. Connection Sizes: Match connecting ductwork unless otherwise indicated.
 - 8. Principal Sound-Absorbing Mechanism:
 - a. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 - b. Dissipative **OR** Film-lined, **as directed**, type with fill material.
 - 1) Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression **OR** Inert and vermin-proof fibrous material, packed under not less than 15 percent compression **OR** Moisture-proof nonfibrous material, **as directed**.
 - 2) Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.



- c. Lining: None **OR** Mylar **OR** Tedlar **OR** Fiberglass cloth, **as directed**.
9. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
 - a. Lock form and seal or continuously weld joints **OR** Flange connections, **as directed**.
 - b. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 - c. Reinforcement: Cross or trapeze angles for rigid suspension.
10. Accessories:
 - a. Integral 1-1/2 **OR** 3, **as directed**,-hour fire damper with access door. Access door to be high transmission loss to match silencer, **as directed**.
 - b. Factory-installed end caps to prevent contamination during shipping.
 - c. Removable splitters.
 - d. Airflow measuring devices.
 - e. Source Quality Control: Test according to ASTM E 477.
 - f. Testing to be witnessed by the Owner.
 - g. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm (10-m/s) face velocity.
 - h. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.

M. Turning Vanes

1. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - a. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
2. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
3. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
4. Vane Construction: Single **OR** Double, **as directed**, wall.
OR
Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

N. Remote Damper Operators

1. Description: Cable system designed for remote manual damper adjustment.
2. Tubing: Brass.
3. Cable: Stainless steel.
4. Wall-Box Mounting: Recessed, 3/4 inches (19 mm) deep **OR** Recessed, 2 inches (50 mm) deep **OR** Surface, **as directed**.
5. Wall-Box Cover-Plate Material: Steel **OR** Stainless steel, **as directed**.

O. Duct-Mounted Access Doors

1. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
 - a. Door:
 - 1) Double wall, rectangular.
 - 2) Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - 3) Vision panel.
 - 4) Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
 - 5) Fabricate doors airtight and suitable for duct pressure class.



- b. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- c. Number of Hinges and Locks:
 - 1) Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
 - 2) Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
 - 3) Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles, **as directed**.
 - 4) Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.
- 2. Pressure Relief Access Door:
 - a. Door and Frame Material: Galvanized sheet steel.
 - b. Door: Single wall **OR** Double wall with insulation fill, **as directed**, with metal thickness applicable for duct pressure class.
 - c. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
 - d. Factory set at 10-inch wg (2500 Pa).
 - e. Doors close when pressures are within set-point range.
 - f. Hinge: Continuous piano.
 - g. Latches: Cam.
 - h. Seal: Neoprene or foam rubber.
 - i. Insulation Fill: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.
- P. Duct Access Panel Assemblies
 - 1. Labeled according to UL 1978 by an NRTL.
 - 2. Panel and Frame: Minimum thickness 0.0528-inch (1.3-mm) carbon **OR** 0.0428-inch (1.1-mm) stainless, **as directed**, steel.
 - 3. Fasteners: Carbon **OR** Stainless, **as directed**, steel. Panel fasteners shall not penetrate duct wall.
 - 4. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).
 - 5. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.
- Q. Flexible Connectors
 - 1. Materials: Flame-retardant or noncombustible fabrics.
 - 2. Coatings and Adhesives: Comply with UL 181, Class 1.
 - 3. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) **OR** 5-3/4 inches (146 mm), **as directed**, wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
 - 4. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - a. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 - b. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 - c. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
 - 5. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - a. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
 - b. Minimum Tensile Strength: 500 lbf/inch (88 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 - c. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
 - 6. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - a. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
 - b. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
 - c. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).



7. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 - a. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
 - b. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
 - c. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
8. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - a. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - b. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - g. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

R. Flexible Ducts

1. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
 - a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - b. Maximum Air Velocity: 4000 fpm (20 m/s).
 - c. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
2. Noninsulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.
 - a. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
 - b. Maximum Air Velocity: 4000 fpm (20 m/s).
 - c. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
3. Noninsulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.
 - a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - b. Maximum Air Velocity: 4000 fpm (20 m/s).
 - c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
4. Noninsulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire.
 - a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - b. Maximum Air Velocity: 4000 fpm (20 m/s).
 - c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
5. Noninsulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil.
 - a. Pressure Rating: 8-inch wg (2280 Pa) positive or negative.
 - b. Maximum Air Velocity: 5000 fpm (25 m/s).
 - c. Temperature Range: Minus 100 to plus 435 deg F (Minus 73 to plus 224 deg C).
6. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
 - a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - b. Maximum Air Velocity: 4000 fpm (20 m/s).
 - c. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
 - d. Insulation R-value: Comply with ASHRAE/IESNA 90.1.
7. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.



- a. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
 - b. Maximum Air Velocity: 4000 fpm (20 m/s).
 - c. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
 - d. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.
8. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
- a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - b. Maximum Air Velocity: 4000 fpm (20 m/s).
 - c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
 - d. Insulation R-value: Comply with ASHRAE/IESNA 90.1.
9. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
- a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - b. Maximum Air Velocity: 4000 fpm (20 m/s).
 - c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
 - d. Insulation R-value: Comply with ASHRAE/IESNA 90.1.
10. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
- a. Pressure Rating: 8-inch wg (2280 Pa) positive or negative.
 - b. Maximum Air Velocity: 5000 fpm (25 m/s).
 - c. Temperature Range: Minus 20 to plus 250 deg F (Minus 29 to plus 121 deg C).
 - d. Insulation R-value: Comply with ASHRAE/IESNA 90.1.
11. Flexible Duct Connectors:
- a. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action **OR** Nylon strap, **as directed**, in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
 - b. Non-Clamp Connectors: Adhesive **OR** Liquid adhesive plus tape **OR** Adhesive plus sheet metal screws, **as directed**.
- S. Duct Security Bars
1. Description: Field-fabricated **OR** Factory-fabricated and field-installed **OR** Field- or factory-fabricated and field-installed, **as directed**, duct security bars.
 2. Configuration:
 - a. Frame: 10 gage by 2 inches (3.57 mm by 50 mm).
 - b. Sleeve: 3/16-inch (4.8-mm), continuously welded **OR** bent, **as directed**, steel frames with 1-by-1-by-3/16-inch (25-by-25-by-4.8-mm) angle frame factory welded to 1 end **OR** furnished loose for field welding on other end, **as directed**. To be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
 - c. Horizontal Bars: 1/2 inch (13 mm) **OR** 2 by 1/4 inch (50 by 6 mm), **as directed**.
 - d. Vertical Bars: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
 - e. Bar Spacing: 6 inches (150 mm).
 - f. Mounting: Metal deck or roofing **OR** Bolted or welded **OR** Bolted or welded with masonry anchors **OR** Ductwork or other framing **OR** Poured in place or set with concrete block **OR** Welded or bolted to one wall (one side only) **OR** Bar extends 6 inches (150 mm) into wall, **as directed**.
- T. Duct Accessory Hardware
1. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
 2. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.



1.3 EXECUTION

A. Installation

1. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
2. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
3. Install backdraft **OR** control, **as directed**, dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
4. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - a. Install steel volume dampers in steel ducts.
 - b. Install aluminum volume dampers in aluminum ducts.
5. Set dampers to fully open position before testing, adjusting, and balancing.
6. Install test holes at fan inlets and outlets and elsewhere as indicated.
7. Install fire and smoke, **as directed**, dampers according to UL listing.
8. Install duct security bars. Construct duct security bars from 0.164-inch (4.18-mm) steel sleeve, continuously welded at all joints and 1/2-inch- (13-mm-) diameter steel bars, 6 inches (150 mm) o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch (63-by-63-by-6-mm) steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch (300-by-300-mm) hinged access panel with cam lock in duct in each side of sleeve.
9. Connect ducts to duct silencers with flexible duct connectors **OR** rigidly, **as directed**.
10. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - a. On both sides of duct coils.
 - b. Upstream **OR** Upstream and downstream, **as directed**, from duct filters.
 - c. At outdoor-air intakes and mixed-air plenums.
 - d. At drain pans and seals.
 - e. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - f. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - g. At each change in direction and at maximum 50-foot (15-m) spacing.
 - h. Upstream **OR** Upstream and downstream, **as directed**, from turning vanes.
 - i. Upstream or downstream from duct silencers.
 - j. Control devices requiring inspection.
 - k. Elsewhere as indicated.
11. Install access doors with swing against duct static pressure.
12. Access Door Sizes:
 - a. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 - b. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 - c. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 - d. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 - e. Body Access: 25 by 14 inches (635 by 355 mm).
 - f. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
13. Label access doors according to Division 21 Section "Fire-suppression Systems Insulation" to indicate the purpose of access door.
14. Install flexible connectors to connect ducts to equipment.



15. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
16. Connect terminal units to supply ducts directly or, **as directed**, with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.
17. Connect diffusers or light troffer boots to ducts directly or, **as directed**, with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
18. Connect flexible ducts to metal ducts with adhesive **OR** liquid adhesive plus tape **OR** draw bands **OR** adhesive plus sheet metal screws, **as directed**.
19. Install duct test holes where required for testing and balancing purposes.
20. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

B. Field Quality Control

1. Tests and Inspections:
 - a. Operate dampers to verify full range of movement.
 - b. Inspect locations of access doors and verify that purpose of access door can be performed.
 - c. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
 - d. Inspect turning vanes for proper and secure installation.
 - e. Operate remote damper operators to verify full range of movement of operator and damper.

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**SECTION 23 31 16 13 - NONMETAL DUCTS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for nonmetal ducts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Fibrous-glass ducts and fittings.
 - b. Phenolic-foam ducts and fittings.
 - c. Thermoset FRP ducts and fittings.
 - d. PVC ducts and fittings.

C. Performance Requirements

1. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with SMACNA's "Fibrous Glass Duct Construction Standards" and performance requirements and design criteria indicated.
 - a. Static-Pressure Classes:
 - 1) Supply Ducts (except in Mechanical Rooms): 1-inch wg (250 Pa).
 - 2) Supply Ducts (Upstream from Air Terminal Units): 2-inch wg (500 Pa).
 - 3) Supply Ducts (Downstream from Air Terminal Units): 1-inch wg (250 Pa).
 - 4) Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg (500 Pa).
 - 5) Return Ducts (Negative Pressure): 1-inch wg (250 Pa).
 - 6) Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa).
2. Structural Performance: Duct hangers and supports and seismic restraints, **as directed**, shall withstand the effects of gravity and seismic, **as directed**, loads and stresses within limits and under conditions to comply with ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
 - a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
OR
Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
OR
Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
 - c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
 - d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-Up."
 - e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:



- a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - b. Duct layout indicating sizes and pressure classes.
 - c. Elevation of top of ducts.
 - d. Dimensions of main duct runs from building grid lines.
 - e. Fittings.
 - f. Reinforcement and spacing.
 - g. Seam and joint construction.
 - h. Penetrations through fire-rated and other partitions.
 - i. Equipment installation based on equipment being used on Project.
 - j. Hangers and supports, including methods for duct and building attachment, seismic restraints, **as directed**, and vibration isolation.
4. Delegated-Design Submittal:
 - a. Duct materials and thicknesses.
 - b. Joint and seam construction and sealing.
 - c. Reinforcement details and spacing.
 - d. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation, **as directed**, for selecting hangers and supports and seismic restraints, **as directed**.
 5. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 - b. Suspended ceiling components.
 - c. Structural members to which duct will be attached.
 - d. Size and location of initial access modules for acoustical tile.
 - e. Penetrations of smoke barriers and fire-rated construction.
 - f. Items penetrating finished ceiling including the following:
 - 1) Lighting fixtures.
 - 2) Air outlets and inlets.
 - 3) Speakers.
 - 4) Sprinklers.
 - 5) Access panels.
 - 6) Perimeter moldings.
 6. Welding certificates.
 7. Field quality-control reports.

E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports **OR** AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports, **as directed**.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
4. NFPA Compliance:
 - a. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - b. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.2 PRODUCTS

A. Fibrous-Glass Ducts And Fittings



1. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistant FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.
 - a. Duct Board: Factory molded into rectangular boards.
 - b. Round Duct: Factory molded into straight round duct and smooth fittings.
 - c. Temperature Limits: 40 to 250 deg F (5 to 121 deg C) inside ducts; 150 deg F (66 deg C) ambient temperature surrounding ducts.
 - d. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.035 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - e. Moisture Absorption: Not exceeding 5 percent by weight at 120 deg F (49 deg C) and 95 percent relative humidity for 96 hours when tested according to ASTM C 1104/C 1104M.
 - f. Permeability: 0.02 perms (1.15 ng/Pa x s x sq. m) maximum when tested according to ASTM E 96/E 96M, Procedure A.
 - g. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
 - h. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C 423, Mounting A.
 - i. Required Markings: EI rating, UL label, and other markings required by UL 181 on each full sheet of duct board.
2. Closure Materials:
 - a. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-P," the manufacturer's name, and a date code.
 - 1) Tape: Aluminum foil-scrim tape imprinted with listing information.
 - 2) Minimum Tape Width: 2-1/2 inches (64 mm); 3 inches (76 mm) for duct board thicker than 1 inch (25 mm).
 - 3) Staples: 1/2-inch (13-mm) outward clinching, 2 inches (51 mm) o.c. in tabs, one tab per joint.
 - 4) Water resistant.
 - 5) Mold and mildew resistant.
 - b. Heat-Activated Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-H," the manufacturer's name, and a date code.
 - 1) Tape: Aluminum foil-scrim tape imprinted with listing information.
 - 2) Minimum Tape Width: 3 inches (76 mm).
 - 3) Heat-Sensitive Imprint: Printed indicator on tape to show proper heating during application has been achieved.
 - 4) Water resistant.
 - 5) Mold and mildew resistant.
 - c. Two-Part Tape Sealing System: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-M," the manufacturer's name, and a date code.
 - 1) Tape: Woven glass fiber impregnated with mineral gypsum.
 - 2) Minimum Tape Width: 3 inches (76 mm).
 - 3) Sealant: Modified styrene acrylic.
 - 4) Water resistant.
 - 5) Mold and mildew resistant.
 - 6) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fabrication:
 - a. Select joints, seams, transitions, elbows, and branch connections and fabricate according to SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 2, "Specifications and Closure," and Chapter 4, "Fittings and Connections" **OR** NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section II, "Fabrication of Straight Duct Modules," Section III, "Fabrication of Fittings from Modules or Flat Board," and Section IV, "Closure", **as directed**.
 - b. Fabricate 90-degree mitered elbows to include turning vanes.
 - c. Reinforcements: Comply with requirements in SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 5, "Reinforcement" **OR** NAIMA AH116, "Fibrous Glass



Duct Construction Standards," Section V, "Reinforcement", **as directed**, for channel- and tie-rod reinforcement materials, spacing, and fabrication.

- d. Preformed Round Duct: Comply with NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VII, "Preformed Round Duct."

B. Phenolic-Foam Ducts And Fittings

1. Duct Panel: CFC-free phenolic-foam bonded on both sides with factory-applied 0.001-inch- (0.025-mm-) thick, aluminum foil reinforced with fiberglass scrim.
 - a. Maximum Temperature: 158 deg F (70 deg C) inside ducts or ambient temperature surrounding ducts.
 - b. Maximum Thermal Conductivity: 0.13 Btu x in./h x sq. ft. x deg F (0.019 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - c. Permeability: 0.0002 perms (0.0115 ng/Pa x s x sq. m) maximum when tested according to ASTM E 96/E 96M, Procedure A.
 - d. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
 - e. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C 423, Mounting A.
 - f. Required Markings: UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for closure materials.
2. Closure Materials:
 - a. V-Groove Adhesive: Silicone.
 - 1) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-P," the manufacturer's name, and a date code.
 - 1) Tape: Aluminum foil tape imprinted with listing information.
 - 2) Minimum Tape Width: 3 inches (76 mm).
 - 3) Water resistant.
 - 4) Mold and mildew resistant.
 - c. Polymeric Sealing System:
 - 1) Structural Membrane: Woven glass fiber.
 - 2) Minimum Tape Width: 3 inches (76 mm).
 - 3) Sealant: Water based.
 - 4) Color: White.
 - 5) Water resistant.
 - 6) Mold and mildew resistant.
 - 7) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fabrication:
 - a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to Knauf Insulation's "Knauf KoolDuct System Design Guide," Section 4, "Duct Construction," and Section 5, "Ductwork System General."
 - b. Fabricate 90-degree mitered elbows to include turning vanes.

C. Thermoset FRP Ducts And Fittings

1. Duct and Fittings:
 - a. Thermoset FRP Resin: Manufacture duct with resin that complies with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E 84.
 - b. Inner Liner: FSK liner rated by an NRTL to comply with UL 181, Class 1.
 - c. Round Duct: ASTM D 2996, Type I, Grade 2, Class E, filament-wound duct, minimum 0.125-inch (3.2-mm) wall thickness, with tapered bell and spigot ends for adhesive joints, or plain ends with couplings.



- d. Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and joining method as duct.
 - e. Rectangular Fittings: Minimum 0.125-inch- (3.2-mm-) thick flat sheet with fiberglass roving and resin-reinforced joints and seams.
 - f. Double-Wall Insulated Duct: Inner and outer duct complying with requirements for "Round Duct" description above. Polyurethane foam or isocyanurate insulation with maximum thermal conductivity of 0.14 Btu x in./h x sq. ft. x deg F (0.020 W/m x K) at 75 deg F (24 deg C) mean temperature.
2. Joining Materials: Roving and polyester resin.
 - a. Use fiberglass adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Fabrication:
 - a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."
 - b. Fabricate 90-degree rectangular mitered elbows to include turning vanes, 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
 4. Drains: Formed drain pockets with a minimum of NPS 1 (DN 25) threaded pipe connections.
- D. PVC Ducts And Fittings
1. Duct and Fittings:
 - a. Round Duct: Comply with cell Classification 12454-B in ASTM D 1784, with external loading properties of ASTM D 2412.
 - b. Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.
 - c. Rectangular Fittings: Minimum 0.125-inch- (3.2-mm-) thick flat sheet with heat-formed corners and continuous welded butt joints.
 2. Joining Materials: PVC solvent cement complying with ASTM D 2564.
 - a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Fabrication:
 - a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Chapter 3, "Standards of Construction for PVC Duct Systems."
 - b. Fabricate 90-degree rectangular mitered elbows to include turning vanes, 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
 4. Drains: PVC drain pockets with a minimum of NPS 1 (DN 25) threaded PVC pipe connections.
- E. Hangers And Supports
1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
 2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 3. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
 4. Steel Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**, steel with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
 5. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
 6. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.



F. Seismic-Restraint Devices

1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
3. Restraint Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**, steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.3 EXECUTION

A. Duct Installation

1. Install ducts with fewest possible joints.
2. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
3. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
4. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
5. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
6. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
7. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines", **as directed**.
8. Install fibrous-glass ducts and fittings to comply with NAIMA AH116, "Fibrous Glass Duct Construction Standards" **OR** SMACNA's "Fibrous Glass Duct Construction Standards", **as directed**.
9. Install foam ducts and fittings to comply with Knauf Insulation's "Knauf KoolDuct System Design Guide."
10. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."
11. Install PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."

B. Hanger And Support Installation

1. Install hangers and supports for fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 6, "Hangers and Supports" **OR** NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VI, "Hangers and Supports", **as directed**.
2. Install hangers and supports for phenolic-foam ducts and fittings to comply with Knauf Insulation's "Knauf KoolDuct System Design Guide," Section 5, "Ductwork System General."



3. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."
 4. Install hangers and supports for PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Chapter 3, "Standards of Construction for PVC Duct Systems."
 5. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - a. Install concrete inserts before placing concrete.
 - b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 - e. Do not use powder-actuated concrete fasteners for seismic restraints.
 6. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- C. Seismic-Restraint-Device Installation
1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR** ASCE/SEI 7, **as directed**.
 - a. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - b. Brace a change of direction longer than 12 feet (3.7 m).
 2. Select sizes of components so strength will be adequate to carry present and future static and seismic loads within restraint device capacity.
 3. Install cables so they do not bend across edges of adjacent equipment or building structure.
 4. Install cable restraints where ducts are suspended with vibration isolators.
 5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
 6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure to flanges of beams, to upper truss chords of bar joists, or to concrete members.
 7. Drilling for and Setting Anchors:
 - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - d. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - e. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.
- D. Painting
1. Paint interior of thermoset FRP and PVC ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 07.
- E. Field Quality Control
1. Perform tests and inspections.
 2. Leakage Tests:



- a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - b. Test the following systems:
 - 1) Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - 2) Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
 - 3) Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
 - 4) Exhaust Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
 - 5) Outdoor Air Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
 - c. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - d. Test for leaks before applying external insulation.
 - e. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Duct System Cleanliness Tests:
 - a. Visually inspect duct system to ensure that no visible contaminants are present.
 - b. Test sections of nonmetal duct system, chosen randomly by the Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - 1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
 4. Duct system will be considered defective if it does not pass tests and inspections.
 5. Prepare test and inspection reports.
- F. Duct Cleaning
1. Clean new **OR** existing **OR** new and existing, **as directed**, duct system(s) before testing, adjusting, and balancing.
 2. Use service openings for entry and inspection.
 - a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch duct as recommended by duct manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 - b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - c. Remove and reinstall ceiling to gain access during the cleaning process.
 3. Particulate Collection and Odor Control:



- a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
- b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
4. Clean the following components by removing surface contaminants and deposits:
 - a. Air outlets and inlets (registers, grilles, and diffusers).
 - b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - d. Coils and related components.
 - e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - f. Supply-air ducts, dampers, actuators, and turning vanes.
 - g. Dedicated exhaust and ventilation components and makeup air systems.
5. Mechanical Cleaning Methodology:
 - a. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - b. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.
 - c. Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - d. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - e. Provide drainage and cleanup for wash-down procedures.
 - f. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

G. Start Up

1. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, And Balancing For Hvac".

H. Duct Schedule

1. Indoor Ducts and Fittings:
 - a. Fibrous-Glass Rectangular Ducts and Fittings:
 - 1) Minimum Flexural Rigidity: EI-475 **OR** 800 **OR** 1400, **as directed**.
 - 2) Minimum Board Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**.
 - b. Fibrous-Glass Round Ducts and Fittings:
 - 1) Minimum Thickness: 1 inch (25 mm).
 - c. Phenolic-Foam Rectangular Ducts and Fittings:
 - 1) Minimum Panel Thickness: 7/8 inch (22 mm) **OR** 1-3/32 inches (28 mm), **as directed**.
 - 2) Aluminum Cladding: Minimum 0.025 inch (0.635 mm) thick.
2. Outdoor Ducts and Fittings:
 - a. Phenolic-Foam Rectangular Ducts and Fittings:
 - 1) Minimum Panel Thickness: 7/8 inch (22 mm) **OR** 1-3/32 inches (28 mm), **as directed**.
 - 2) Aluminum Cladding: Minimum 0.032 inch (0.813 mm) thick.



- 3) Polymeric Sealing System: Coat ducts, including gang-nail couplings, grip flanges, and couplings.
- b. Thermoset FRP Round Ducts and Fittings:
 - 1) Double-Wall Insulated Ducts: Minimum 5/8-inch (15.9-mm) **OR** 7/8-inch (22.2-mm), **as directed**, insulation thickness.
- c. PVC Round Ducts and Fittings:
- 3. Underground Ducts:
 - a. Thermoset FRP Round Ducts and Fittings:
 - 1) Insulation Thickness: 1 inch (25 mm).
 - 2) Drain: Minimum NPS 1 (DN 25) PVC pipe with P-trap to air-gap drain.
 - b. PVC Round Ducts and Fittings:
 - 1) Drain: Minimum NPS 1 (DN 25) PVC pipe with P-trap to air-gap drain.

END OF SECTION 23 31 16 13



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 31 16 13	23 31 13 13	Metal Ducts
23 31 16 16	23 31 13 13	Metal Ducts
23 31 16 16	23 31 16 13	Nonmetal Ducts



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SECTION 23 33 13 13 - DRAFT CONTROL DEVICES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for draft control devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Draft inducer fans.
 - b. Venturi-draft inducer fans.
 - c. Mechanical-draft vent fans.
 - d. Vent exhaust fans.
 - e. Barometric dampers.
 - f. Vent dampers.
 - g. Combustion-air fans.

C. Submittals

1. Product Data: For each type of product indicated.
2. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and Maintenance Data.
4. Warranty: Warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, barometric dampers, vent dampers, and/or combustion-air fans that fail in materials or workmanship within two **OR 10, as directed**, years from date of Final Completion.
 - a. Failures include failure of the fan due to corrosion.

1.2 PRODUCTS

A. Draft Inducer Fans

1. Fan Construction: Galvanized **OR** Aluminized, **as directed**,-steel housing and radial-blade centrifugal fan.
 - a. Fan Motor: Permanent split-capacitor type.
2. Controls:
 - a. Draft proving switch.
 - b. Control kit to cycle fan with gas flow to a single burner.

B. Venturi-Draft Inducer Fans

1. Fan Construction: Enameled-steel venturi tube for vents 20 inches (508 mm) in diameter and smaller, and ASTM A 666, Type 304, stainless-steel venturi tube for vents 22 to 48 inches (559 to 1219 mm) in diameter. Galvanized **OR** Enameled, **as directed**,-steel fan housing with radial-blade centrifugal wheel.



- a. Fan Motor: Permanent split-capacitor type.
 2. Controls:
 - a. Draft proving switch.
 - b. Control kit to cycle fan with gas flow to a single burner.
- C. Mechanical-Draft Vent Fans
 1. Fan Construction: Forward-curved centrifugal fan and scroll fabricated of aluminized **OR** galvanized, **as directed**, steel; direct-drive, ball-bearing motor lubricated with synthetic oil; internal cooling fan; stainless-steel shaft; and integral pressure-sensing switch.
 - a. Fan Motor: Permanent split-capacitor type.
 2. Controls:
 - a. Draft proving switch.
 - b. Control kit to cycle fan with gas flow to single **OR** multiple, **as directed**, burner(s).
 3. Accessories:
 - a. Aluminized **OR** Stainless, **as directed**, -steel, wall-vent hood.
- D. Vent Exhaust Fans
 1. General: Centrifugal fan with variable **OR** constant, **as directed**, -speed control mounted at end of sidewall **OR** vertical, **as directed**, vent.
 2. Test Standard: UL 378, for fans exposed to flue gases up to 640 deg F (337 deg C).
 3. Fan Construction: Cast-aluminum **OR** Galvanized-steel **OR** Stainless-steel, **as directed**, housing painted manufacturer's standard color of baked enamel, **as directed**. Galvanized **OR** Stainless, **as directed**, -steel vent. Cast-aluminum **OR** Stainless-steel, **as directed**, wheel. Backward-inclined centrifugal or axial fan wheel statically and dynamically balanced. Provide access to clean the discharge area. Concentric makeup air inlet duct surrounding the vent to allow zero clearance to combustibles, **as directed**.
 4. Motor: Fully enclosed, variable-speed duty, **as directed**, permanent split capacitor, out of the airstream, with prelubricated and sealed ball bearings.
 5. Constant-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure switch permits burner operation via interlock with boiler. Fan proving switch is adjustable between minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa).
 6. Variable-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure controller, control transformer, and miscellaneous controls for automatic modulation of fan speed to maintain preset negative pressure between 0- and minus 1.0-inch wg (0 and minus 249 Pa). Include controller with indicator lights, pressure differential transmitter, chimney pressure sensor probe, and fan proving switch adjustable between minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa). Include tubing.
- E. Barometric Dampers
 1. Damper Construction: High-temperature-enamel-painted steel damper and housing with galvanized-steel breeching connection. Adjustable counterweight with lock. Include knife-edge bearings that do not require lubrication.
- F. Vent Dampers
 1. Damper Construction: Stainless-steel damper blade, shaft, and vent pipe with metal, prelubricated bearings.
 - a. Electric motor sized to power damper open and closed in approximately 15 seconds in each direction. Power is off when damper is at rest.
 - b. Comply with ANSI Z21.66.
 2. Controls:
 - a. Control transformer.
 - b. Keyed wiring harness.
 - c. Damper end-switch to prove damper is open.
 - d. Interlock with boiler to permit burner operation when damper is open.
 - e. Hold-open switch for troubleshooting boiler controls.



- G. Combustion-Air Fans
1. Fan Construction: Galvanized **OR** Aluminized, **as directed**,-steel housing; steel forward-curved fan and scroll; direct-drive, totally enclosed, fan-cooled motor with ball bearings; stainless-steel shaft; and integral pressure-sensing switch.
 - a. Internal bypass to temper supply-air temperature to room.
 2. Controls:
 - a. Fan proving switch to permit burner operation when combustion-air fan is operating.
 - b. Multiple appliance control starts fan with operation of any one of three **OR** four, **as directed**, appliances.
 - c. Modulating combustion-air fan speed to control pressure differential in room with respect to outdoors.
 - d. Manual-reset, high-limit switch stops operation with 160 deg F (71 deg C) room temperature.
 - e. Optional Controls:
 - 1) Alarm circuit.
 - 2) Excessive negative pressure limit.
 - 3) Interface relay for vent exhaust fan, draft inducer fan, or mechanical-draft vent fan.
 - 4) Galvanized-steel **OR** Aluminum, **as directed**, intake hood.
- H. Motors
1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

1.3 EXECUTION

- A. Installation
1. Install listed components in a manner complying with the listing.
 2. Secure barometric dampers to breechings with hardware compatible with connected materials.
 3. Locate barometric and motorized vent dampers as close to draft hood collar as possible.
 4. Secure barometric and motorized vent dampers to appliances, breechings, or chimneys with hardware compatible with connected materials.
 5. Install draft inducer fans in single-wall vent section that is designed to couple with other vent materials.
 6. Secure draft inducer fans to appliances, breechings, or stacks with hardware compatible with connected materials.
 7. Install draft inducer fans with clearances for service and maintenance.
 8. Install PVC, **as directed**, intake duct that is sized according to manufacturer's written instructions.
- B. Connections
1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 2. Remove and replace malfunctioning components and recheck.
- D. Adjusting
1. Set field-adjustable switches and controls as indicated.
- E. Demonstration
1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, Owner's maintenance personnel to adjust, operate, and maintain draft control devices.



END OF SECTION 23 33 13 13



Task	Specification	Specification Description
23 33 13 13	23 31 13 33	Duct Accessories
23 33 13 16	23 31 13 33	Duct Accessories
23 33 13 29	23 33 13 13	Draft Control Devices
23 33 13 29	23 31 13 33	Duct Accessories
23 33 13 33	23 31 13 33	Duct Accessories
23 33 13 43	23 31 13 33	Duct Accessories
23 33 23 00	23 31 13 33	Duct Accessories
23 33 33 00	23 31 13 33	Duct Accessories
23 33 43 00	23 31 13 33	Duct Accessories
23 33 46 00	23 31 13 13	Metal Ducts
23 33 46 00	23 31 13 33	Duct Accessories
23 33 53 00	01 22 16 00	No Specification Required
23 33 53 00	23 31 13 13	Metal Ducts
23 33 53 00	23 31 13 13a	HVAC Casings
23 33 56 00	23 31 13 13	Metal Ducts
23 33 56 00	23 31 13 33	Duct Accessories
23 33 59 00	23 31 13 33	Duct Accessories



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SECTION 23 34 13 00 - AXIAL FANS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for axial fans. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Tubeaxial fans.
 - b. Vaneaxial fans.
 - c. Mixed-flow fans.

C. Performance Requirements

1. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
2. Operating Limits: Classify according to AMCA 99.

D. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - a. Certified fan performance curves with system operating conditions indicated.
 - b. Certified fan sound-power ratings.
 - c. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - d. Material thickness and finishes, including color charts.
 - e. Dampers, including housings, linkages, and operators.
 - f. Fan speed controllers.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Wiring Diagrams: Power, signal, and control wiring.
 - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - c. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
3. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For axial fans to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
3. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

F. Delivery, Storage, And Handling



1. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
2. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.
3. Lift and support units with manufacturer's designated lifting or supporting points.

G. Coordination

1. Coordinate size and location of structural-steel support members.
2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 31..
3. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories".

1.2 PRODUCTS

A. Tubeaxial Fans

1. Description: Fan wheel and housing, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
2. Housings: Steel **OR** Galvanized steel **OR** Aluminum **OR** Fiberglass-reinforced plastic **OR** Stainless steel, **as directed**, with flanged inlet and outlet connections.
3. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key **OR** Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft **OR** Cast aluminum, machined and fitted to shaft, **as directed**.
4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
 - b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
 - c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 - d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - f. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
 - g. Motor Mount: Adjustable base.
 - h. Shaft Bearings: Radial, self-aligning ball or roller bearings.
 - 1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
OR
Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
 - 2) Extend lubrication lines to outside of casing and terminate with grease fittings.
5. Accessories:
 - a. Companion Flanges: Rolled flanges of same material as housing.
 - b. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
 - c. Propeller Access Section Door: Short duct section bolted to fan inlet **OR** outlet **OR** inlet and outlet, **as directed**, allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
 - d. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
 - e. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed**, clips welded to fan housing, of same material as housing.
 - f. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
 - g. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.



- h. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
 - i. Backdraft Dampers: Butterfly style, for bolting to the discharge of fan or outlet cone, of same material as housing.
 - j. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (149 deg C).
 - k. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
 - l. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
 - m. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing **OR** aluminum, **as directed**.
 - n. Inlet Cones: Round-to-round transition of same material as housing.
 - o. Outlet Cones: Round-to-round transition of same material as housing.
 - p. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
6. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
 - b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing, **as directed**.
7. Factory Finishes:
- a. Sheet Metal Parts: Prime coat before final assembly.
 - b. Exterior Surfaces: Baked-enamel finish coat after assembly.
 - c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
 - 1) Apply to finished housings.
 - 2) Apply to fan wheels.
- B. Vaneaxial Fans
- 1. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
 - a. Variable-Pitch Fans: Internally mounted pneumatic **OR** electric **OR** electronic, **as directed**, actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.
 - 2. Housings: Steel **OR** Galvanized steel **OR** Aluminum **OR** Fiberglass-reinforced plastic **OR** Stainless steel, **as directed**.
 - a. Inlet and Outlet Connections: Flanges.
 - b. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
 - 3. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key **OR** Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft **OR** Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, cast-aluminum blades; factory mounted and balanced, **as directed**.
 - 4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
 - b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
 - c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 - d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.



- f. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
 - g. Motor Mount: Adjustable base.
 - h. Shaft Bearings: Radial, self-aligning ball or roller bearings.
 - 1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
OR
Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
 - 2) Extend lubrication lines to outside of casing and terminate with grease fittings.
5. Accessories:
- a. Companion Flanges: Rolled flanges of same material as housing.
 - b. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
 - c. Propeller Access Section Door: Short duct section bolted to fan inlet **OR** outlet **OR** inlet and outlet, **as directed**, allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
 - d. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
 - e. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed**, clips welded to fan housing, of same material as housing.
 - f. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
 - g. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
 - h. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
 - i. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
 - j. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
 - k. Flow Measurement Port: Pressure measurement taps installed in the inlet of fan to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
 - l. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (148 deg C).
 - m. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
 - n. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
 - o. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
 - p. Inlet Cones: Round-to-round transition of same material as housing.
 - q. Outlet Cones: Round-to-round transition of same material as housing.
 - r. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
6. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
 - b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing, **as directed**.
7. Factory Finishes:
- a. Sheet Metal Parts: Prime coat before final assembly.
 - b. Exterior Surfaces: Baked-enamel finish coat after assembly.



- c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
 - 1) Apply to finished housings.
 - 2) Apply to fan wheels.
- C. Mixed-Flow Fans
- 1. Description: Fan wheel and housing, straightening vane section, **as directed**, factory-mounted motor with belt drive, and accessories.
 - 2. Housings: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**.
 - a. Inlet and Outlet Connections: Outer mounting frame and companion flanges.
 - b. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
 - c. Mixed-Flow Outlet Connection: One **OR** Two, **as directed**, flanged discharge(s) perpendicular to fan inlet.
 - 3. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.
 - 4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
 - b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
 - c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 - d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - f. Motor Mount: Adjustable base.
 - g. Shaft Bearings: Radial, self-aligning ball or roller bearings.
 - 1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
OR
Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
 - 2) Extend lubrication lines to outside of casing and terminate with grease fittings.
 - 5. Accessories:
 - a. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed**, clips welded to fan housing, of same material as housing.
 - b. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
 - c. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
 - d. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
 - e. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
 - f. Inlet Cones: Round-to-round transition of same material as housing.
 - g. Outlet Cones: Round-to-round transition of same material as housing.
 - h. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
 - 6. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
 - b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.
 - 7. Factory Finishes:
 - a. Sheet Metal Parts: Prime coat before final assembly.
 - b. Exterior Surfaces: Baked-enamel finish coat after assembly.



- c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
 - 1) Apply to finished housings.
 - 2) Apply to fan wheels.

D. Source Quality Control

- 1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- 2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

1.3 EXECUTION

A. Installation

- 1. Install axial fans level and plumb.
- 2. Support floor-mounting units using spring isolators **OR** restrained spring isolators, **as directed**, having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
- 3. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
- 4. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
- 5. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- 6. Install units with clearances for service and maintenance.
- 7. Label fans according to requirements specified in Division 23 Section "Identification For Hvac Piping And Equipment".

B. Connections

- 1. Duct installation and connection requirements are specified in other Division 21. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories".
- 2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
- 3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

- 1. Perform the following field tests and inspections and prepare test reports:
 - a. Verify that shipping, blocking, and bracing are removed.
 - b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - c. Verify that cleaning and adjusting are complete.



- d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - e. Adjust belt tension.
 - f. Adjust damper linkages for proper damper operation.
 - g. Verify lubrication for bearings and other moving parts.
 - h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - i. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - j. Shut unit down and reconnect automatic temperature-control operators.
 - k. Remove and replace malfunctioning units and retest as specified above.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Adjusting

1. Adjust damper linkages for proper damper operation.
2. Adjust belt tension.
3. Lubricate bearings.

END OF SECTION 23 34 13 00



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SECTION 23 34 16 00 - CENTRIFUGAL FANS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for centrifugal fans. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Airfoil centrifugal fans.
 - b. Backward-inclined centrifugal fans.
 - c. Forward-curved centrifugal fans.
 - d. Plenum fans.
 - e. Plug fans.

C. Performance Requirements

1. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
2. Operating Limits: Classify according to AMCA 99.

D. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Field quality-control test reports.
4. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
3. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.

F. Delivery, Storage, And Handling

1. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
2. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
3. Lift and support units with manufacturer's designated lifting or supporting points.

1.2 PRODUCTS

A. Airfoil Centrifugal Fans

1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.



2. Housings: Formed panels to make curved-scroll housings with shaped cutoff, with doors or panels to allow access to internal parts and components.
 - a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - b. Horizontally split, bolted-flange housing.
 - c. Spun inlet cone with flange.
 - d. Outlet flange.
3. Airfoil Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating, **as directed**.
4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
 - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
 - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - f. Motor Mount: Adjustable for belt tensioning.
9. Accessories:
 - a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
 - b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed**, gasketed door allowing access to fan scroll, of same material as housing.
 - c. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
 - d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 - e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
 - f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed**, blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.



- g. Inlet Screens: Grid screen of same material as housing.
 - h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 - i. Spark-Resistant Construction: AMCA 99.
 - j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
 - k. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
10. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Enclosure Type: Totally enclosed, fan cooled.
- B. Backward-Inclined Centrifugal Fans
- 1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.
 - 2. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.
 - a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - b. Spun inlet cone with flange.
 - c. Outlet flange.
 - 3. Backward-Inclined Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate, **as directed**, and fastened to shaft with set screws.
 - 4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
 - 5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - 6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - 7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - 8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**].
 - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - f. Motor Mount: Adjustable for belt tensioning.
 - 9. Accessories:



- a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
 - b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed**, gasketed door allowing access to fan scroll, of same material as housing.
 - c. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
 - d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 - e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
 - f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed**, blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
 - g. Inlet Screens: Grid screen of same material as housing.
 - h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 - i. Spark-Resistant Construction: AMCA 99.
 - j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
 - k. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
10. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Enclosure Type: Totally enclosed, fan cooled.

C. Forward-Curved Centrifugal Fans

1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
2. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.
 - a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - b. Horizontally split, bolted-flange housing.
 - c. Spun inlet cone with flange.
 - d. Outlet flange.
3. Forward-Curved Wheels: Black-enameled or galvanized steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
 - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.



8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - a. Service Factor Based on Fan Motor Size: 1.5.
 - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - f. Motor Mount: Adjustable for belt tensioning.
9. Accessories:
 - a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
 - b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed**, gasketed door allowing access to fan scroll, of same material as housing.
 - c. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
 - d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 - e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
 - f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed**, blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
 - g. Inlet Screens: Grid screen of same material as housing.
 - h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 - i. Spark-Resistant Construction: AMCA 99.
 - j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
 - k. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
10. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Enclosure Type: Totally enclosed, fan cooled.

D. Plenum Fans

1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
2. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating.
3. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
 - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
5. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.



- a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
- b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
 - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - f. Motor Mount: Adjustable for belt tensioning.
8. Accessories:
 - a. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 - b. Spark-Resistant Construction: AMCA 99.
 - c. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
9. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Enclosure Type: Totally enclosed, fan cooled.

E. Plug Fans

1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
2. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating, **as directed**.
3. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
 - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
5. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
 - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.



- a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
 - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - f. Motor Mount: Adjustable for belt tensioning.
8. Accessories:
- a. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 - b. Spark-Resistant Construction: AMCA 99.
 - c. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
9. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Enclosure Type: Totally enclosed, fan cooled.

F. Source Quality Control

1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

1.3 EXECUTION

A. Installation

1. Install centrifugal fans level and plumb.
2. Support floor-mounting units using spring isolators **OR** restrained spring isolators, **as directed**, having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
3. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
5. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install units with clearances for service and maintenance.
7. Label fans according to requirements specified in Division 23 Section "Identification For Hvac Piping And Equipment".

B. Connections

1. Duct installation and connection requirements are specified in other Division 21. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with



flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories".

2. Install ducts adjacent to fans to allow service and maintenance.
3. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.
4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
5. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
 - a. Verify that shipping, blocking, and bracing are removed.
 - b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - c. Verify that cleaning and adjusting are complete.
 - d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - e. Adjust belt tension.
 - f. Adjust damper linkages for proper damper operation.
 - g. Verify lubrication for bearings and other moving parts.
 - h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - i. Refer to Division 23 Section "Testing, Adjusting, And Balancing For Hvac" for testing, adjusting, and balancing procedures.
 - j. Remove and replace malfunctioning units and retest as specified above.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 34 16 00



SECTION 23 34 16 00a - POWER VENTILATORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for power ventilators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Utility set fans.
 - b. Centrifugal roof ventilators.
 - c. Axial roof ventilators.
 - d. Upblast propeller roof exhaust fans.
 - e. Centrifugal wall ventilators.
 - f. Ceiling-mounting ventilators.
 - g. In-line centrifugal fans.
 - h. Propeller fans.

C. Performance Requirements

1. Project Altitude: Base fan-performance ratings on actual Project site elevations **OR** sea level, **as directed**.
2. Operating Limits: Classify according to AMCA 99.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
 - a. Certified fan performance curves with system operating conditions indicated.
 - b. Certified fan sound-power ratings.
 - c. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - d. Material thickness and finishes, including color charts.
 - e. Dampers, including housings, linkages, and operators.
 - f. Roof curbs.
 - g. Fan speed controllers.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
4. Field quality-control reports.
 - a. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

E. Quality Assurance



1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended use.
2. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
3. UL Standard: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.2 PRODUCTS

A. Utility Set Fans

1. Description: Direct **OR** Belt, **as directed**, -driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
2. Housing: Fabricated of galvanized, **as directed**, steel with side sheets fastened with a deep lock seam or welded to scroll sheets.
 - a. Housing Discharge Arrangement: Adjustable to eight standard positions.
3. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
 - a. Blade Materials: Steel **OR** Aluminum, **as directed**.
 - b. Blade Type: Backward inclined **OR** Forward curved **OR** Airfoil, **as directed**.
 - c. Spark-Resistant Construction: AMCA 99, Type A **OR** B **OR** C, **as directed**.
4. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
5. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L₅₀ of 200,000 hours **OR** L₁₀ of 80,000 hours, **as directed**.
6. Belt Drives:
 - a. Factory mounted, with final alignment and belt adjustment made after installation.
 - b. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
 - c. Motor Pulleys: Adjustable pitch for use with motors through 5, **as directed**, hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - e. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
7. Accessories:
 - a. Inlet and Outlet: Flanged.
 - b. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 - c. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
 - d. Access Door: Gasketed door in scroll with latch-type handles.
 - e. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
 - f. Inlet Screens: Removable wire mesh.
 - g. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
 - h. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
 - i. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed**, blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
 - j. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
 - k. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

B. Centrifugal Roof Ventilators

1. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.



2. Housing: Removable, spun-aluminum, dome top and outlet baffle **OR** extruded-aluminum, rectangular top **OR** galvanized steel, mushroom-domed top, **as directed**; square, one-piece, aluminum base with venturi inlet cone.
 - a. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector, **as directed**.
 - b. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
 3. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
 4. Belt-Driven Drive:
 - a. Resiliently mounted to housing.
 - b. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - c. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - d. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - e. Fan and motor isolated from exhaust airstream.
 5. Accessories:
 - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - b. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside **OR** outside, **as directed**, fan housing, factory wired through an internal aluminum conduit.
 - c. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
 - d. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 - e. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
 6. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
 - a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.
 - b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
 - c. Sound Curb: Curb with sound-absorbing insulation matrix.
 - d. Pitch Mounting: Manufacture curb for roof slope.
 - e. Metal Liner: Galvanized steel.
 - f. Burglar Bars: 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, thick steel bars welded in place to form 6-inch (150-mm) squares.
 - g. Mounting Pedestal: Galvanized steel with removable access panel.
 - h. Vented Curb: Unlined with louvered vents in vertical sides.
- C. Axial Roof Ventilators
1. Description: Direct- or belt-driven axial fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
 2. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.
 - a. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
 3. Fan Wheel: Aluminum **OR** Steel, **as directed**, hub and blades.
 4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
 - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 5. Accessories:
 - a. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside **OR** outside, **as directed**, fan housing, factory wired through an internal aluminum conduit.
 - b. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.



- c. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 - d. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
- a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.
 - b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
 - c. Sound Curb: Curb with sound-absorbing insulation matrix.
 - d. Pitch Mounting: Manufacture curb for roof slope.
 - e. Metal Liner: Galvanized steel.
 - f. Burglar Bars: 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, thick steel bars welded in place to form 6-inch (150-mm) squares.
 - g. Mounting Pedestal: Galvanized steel with removable access panel.
- D. Upblast Propeller Roof Exhaust Fans
1. Description: Direct- or belt-driven propeller fans consisting of housing, wheel, butterfly-type discharge damper, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
 2. Wind Band, Fan Housing, and Base: Reinforced and braced galvanized steel **OR** aluminum, **as directed**, containing galvanized-steel **OR** aluminum, **as directed**, butterfly dampers and rain trough, motor and drive assembly, and fan wheel.
 - a. Damper Rods: Steel with bronze **OR** nylon, **as directed**, bearings.
 - b. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
 3. Fan Wheel: Replaceable, cast **OR** extruded, **as directed**, -aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
 4. Belt-Driven Drive Assembly: Resiliently mounted to housing; weatherproof housing of same material as fan housing with the following features:
 - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - b. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
 - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - d. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.
 5. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
 - a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.
 - b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
 - c. Sound Curb: Curb with sound-absorbing insulation matrix.
 - d. Pitch Mounting: Manufacture curb for roof slope.
 - e. Metal Liner: Galvanized steel.
 - f. Burglar Bars: 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, thick steel bars welded in place to form 6-inch (150-mm) squares.
 - g. Mounting Pedestal: Galvanized steel with removable access panel.
- E. Centrifugal Wall Ventilators
1. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
 2. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.
 3. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.



4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
 - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - d. Fan and motor isolated from exhaust airstream.
 5. Accessories:
 - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - b. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
 - c. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
 - d. Wall Grille: Ring type for flush mounting.
 - e. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
 - f. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- F. Ceiling-Mounting Ventilators
1. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.
 2. Housing: Steel, lined with acoustical insulation.
 3. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
 4. Grille: Plastic **OR** Stainless steel **OR** Aluminum **OR** Painted aluminum, **as directed**, louvered grille with flange on intake and thumbscrew attachment to fan housing.
 5. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
 6. Accessories:
 - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - b. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 - c. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
 - d. Motion Sensor: Motion detector with adjustable shutoff timer.
 - e. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
 - f. Filter: Washable aluminum to fit between fan and grille.
 - g. Isolation: Rubber-in-shear vibration isolators.
 - h. Manufacturer's standard roof jack or wall cap, and transition fittings.
- G. In-Line Centrifugal Fans
1. Description: In-line, direct **OR** belt, **as directed**, -driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
 2. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
 3. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door, **as directed**.
 4. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
 5. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
 6. Accessories:
 - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - b. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - c. Companion Flanges: For inlet and outlet duct connections.



- d. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
- e. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

H. Propeller Fans

1. Description: Direct- or belt-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.
2. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
3. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
4. Fan Wheel: Replaceable, cast **OR** extruded, **as directed**, -aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
5. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - a. Service Factor Based on Fan Motor Size: 1.4.
 - b. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - c. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 1) Ball-Bearing Rating Life: ABMA 9, L₁₀ of 100,000 hours.
 - d. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 - e. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - f. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - g. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
6. Accessories:
 - a. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
 - b. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
 - c. Wall Sleeve: Galvanized steel to match fan and accessory size.
 - d. Weathershield Hood: Galvanized steel to match fan and accessory size.
 - e. Weathershield Front Guard: Galvanized steel with expanded metal screen.
 - f. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - g. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

I. Motors

1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
2. Enclosure Type: Open dripproof **OR** Totally enclosed, fan cooled, **as directed**.

J. Source Quality Control

1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."



1.3 EXECUTION

A. Installation

1. Install power ventilators level and plumb.
2. Support units using elastomeric mounts **OR** restrained elastomeric mounts **OR** spring isolators **OR** restrained spring isolators, **as directed**, having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
3. For projects not in seismic areas, install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. For projects in seismic areas, install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
5. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
6. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
7. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
8. Install units with clearances for service and maintenance.
9. Label units according to requirements specified in Division 23 Section "Identification For Hvac Piping And Equipment".
10. Duct installation and connection requirements are specified in other Division 21. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories".
11. Install ducts adjacent to power ventilators to allow service and maintenance.
12. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
13. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

B. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
 - a. Verify that shipping, blocking, and bracing are removed.
 - b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - c. Verify that cleaning and adjusting are complete.
 - d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - e. Adjust belt tension.
 - f. Adjust damper linkages for proper damper operation.
 - g. Verify lubrication for bearings and other moving parts.
 - h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - i. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - j. Shut unit down and reconnect automatic temperature-control operators.
 - k. Remove and replace malfunctioning units and retest as specified above.



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2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 34 16 00a



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 34 16 00	01 22 16 00	No Specification Required
23 34 23 00	23 34 16 00a	Power Ventilators
23 34 23 00	07 72 13 00a	Intake and Relief Ventilators



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SECTION 23 34 33 00 - AIR CURTAINS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for air curtains. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes air curtains with hot-water heat, steam heat, electric heat, and gas-fired heater.

C. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories for each unit indicated.
2. Shop Drawings: For air curtains. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: Power, signal, and control wiring.
3. Delegated-Design Submittal: For air curtains indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of air-curtain mounting assemblies.
 - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.
4. Operation and maintenance data: For air curtains to include in maintenance manuals.
5. Warranties: Sample of special warranties.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified and marked for intended location and application.
2. Comply with AMCA 220, "Laboratory Methods of Testing Air Curtains for Aerodynamic Performance Ratings," for airflow, outlet velocity, and power consumption.
3. Comply with ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.
 - a. Certify coils according to ARI 410.
4. Comply with NSF 37, "Air Curtains for Entranceways in Food and Food Service Establishments."

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air curtains that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period (Nonheating Units): 24 months.
 - b. Warranty Period (Water or Steam Heating Units): 18 **OR** 24 months, **as directed**.
 - c. Warranty Period (Gas Heating Units): 18 **OR** 24 months, **as directed**.

1.2 PRODUCTS

A. Air-Curtain Unit

1. Housing:



- a. Materials: Galvanized steel with electrostatically applied epoxy enamel finish over powdered mirror
 - b. Materials: One-piece, molded, high-impact, white polymer material
 - c. Materials: Heavy-gage, electroplated-zinc steel with welded construction and polyester-coated finish.
 - d. Materials: Heavy-gage, aluminum construction.
 - 1) Anodized Finish: Match finish and color of adjacent architectural metals. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 2) Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - a) Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
 - b) Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).
 - e. Materials: Stainless steel.
 - f. Discharge Nozzle: Integral part of the housing, containing fixed air-directional vanes.
 - g. Discharge Nozzle: Integral part of the housing, containing adjustable air-directional vanes with 40 **OR** 20 **OR** 15-degree sweep front to back, **as directed**.
 - h. Discharge Nozzle: Integral part of the housing, containing air-directional vanes adjustable in 5-degree increments through a 45-degree sweep front to back.
2. Mounting Brackets: Steel, for wall **OR** ceiling mounting, **as directed**.
3. Air-Intake Louvers: Comply with requirements in Division 08 Section "Louvers And Vents".
4. Air-Intake Louvers **OR** Grille, **as directed**.
- a. Louvers: Integral part of the housing, mechanically field adjustable and capable of reducing air-outlet velocity by 60 percent with louver in totally closed position.
 - b. Grille: Integral part of and same material as the housing.
 - c. Insect Screen: Aluminum **OR** Stainless steel, **as directed**, removable.
5. Fans
- a. Centrifugal, forward curved, double width, double inlet **OR** Vane axial, **as directed**.
 - b. Galvanized steel **OR** Painted steel **OR** Aluminum, **as directed**.
 - c. Statically and dynamically balanced.
 - d. Direct drive **OR** Belt drive and equipped with belt guards and adjustable sheaves and pulleys for adjusting air-outlet velocity, **as directed**.
6. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Single speed **OR** Two speed Multispeed, **as directed**.
 - c. Resiliently mounted.
 - d. Continuous duty.
 - e. Totally enclosed, air over **OR** totally enclosed, fan cooled, **OR**, open, dripproof **OR** explosion proof, **as directed**.
 - f. Integral thermal-overload protection.
 - g.
 - h. Bearings: Permanently sealed, lifetime, prelubricated, ball bearings.
 - i. Disconnect: Internal power cord with plug and receptacle.
7. Water Coils
- a. Type: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**.
 - b. Piping Connections: Threaded on same end **OR** opposite ends, **as directed**.



- c. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).
 - 1) Tube Diameter: 0.625 inch (15.9 mm).
 - d. Fins: Aluminum **OR** Copper, **as directed** with fin spacing 0.167 inch (4.23 mm) **OR** 0.125 inch (3.18 mm) **OR** 0.091 inch (2.31 mm) **OR** 0.071 inch (1.80 mm) **OR** 0.067 inch (1.70 mm) **OR** 0.056 inch (1.42 mm) **OR** 0.0075 inch (0.19 mm), **as directed**.
 - e. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
 - f. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
 - g. Frames: Galvanized-steel channel frame 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.59 mm), **as directed**.
 - h. Ratings: According to ASHRAE 33.
 - i. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
8. Steam Coils Distribution header coil **OR** Single-tube coil, **as directed** with threaded steam supply and condensate connections.
- a. Piping Connections: Same end **OR** Opposite ends **OR** Steam supply on both ends; condensate on one end, **as directed**.
 - b. Tube Material: Copper, complying with ASTM B 75 (ASTM B 75M).
 - c. Tube Diameter: 0.625 inch (15.9 mm).
 - d. Fins: Aluminum **OR** Copper, **as directed** 0.167 inch (4.23 mm) **OR** 0.125 inch (3.18 mm) **OR** 0.091 inch (2.31 mm) **OR** 0.071 inch (1.80 mm) **OR** 0.067 inch (1.70 mm) **OR** 0.056 inch (1.42 mm) **OR** 0.0075 inch (0.19 mm), **as directed**.
 - e. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
 - f. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
 - g. Frames: Galvanized-steel channel frame, 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.59 mm) , **as directed**.
 - h. Pressure and Temperature Ratings: 100 psig (690 kPa), 400 deg F (205 deg C) according to ASHRAE 33.
9. Electric-Resistance Coils:
- a. Coil Assembly: Comply with UL 1995.
 - b. Frame: Galvanized-steel frame.
 - c. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
 - d. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - e. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.
 - 1) Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - f. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection. Include the following controls:
 - 1) Magnetic contactor.
 - 2) Mercury contactor.
 - 3) Solid-state stepless pulse controller.
 - 4) Toggle switches; one per step.
 - 5) Step controller.
 - 6) Time-delay relay.
 - 7) Pilot lights; one per step.
 - 8) Airflow proving switch.
10. Gas-Fired Heaters:
- a. Comply with ANSI Z83.8/CSA, "Gas Unit Heaters and Gas-Fired Duct Furnaces."
 - 1) CSA Approval: Bear AGA label.



- 2) Type of Gas: Natural **OR** LP, **as directed**.
- b. Assembly and Wiring: Heaters factory assembled, piped, wired, and tested for 120-V ac.
- c. Housing: Steel, with integral draft hood and inserts for suspension-mounting rods.
- d. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
- e. Heat Exchanger: Aluminized **OR** Stainless, **as directed**, steel.
- f. Burners: Cast iron or aluminized steel with stainless-steel inserts.
- g. Gravity vent.
- h. Power Venter: 120-V ac, with stainless-steel shaft.
- i. Automatic Gas Control: Single **OR** 2-stage, **as directed**, 24-V ac valve.
- j. Ignition: Standing pilot **OR** Electronically controlled spark with flame sensor, **as directed**.
11. Filters:
 - a. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with glass-fiber media sprayed with nonflammable adhesive in cardboard **OR** galvanized-steel, **as directed**, frame.
 - b. Washable Panel Filters: Removable, stainless-steel, baffle-type filters with spring-loaded fastening; with minimum 0.0781-inch- (1.984-mm-) thick, stainless-steel filter frame.
 - c. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.
12. Controls:
 - a. Built-in **OR** Field-Installed, **as directed**, Thermostat: Line voltage, factory installed and wired to the junction box on air curtain **OR** motor-control panel, **as directed**.
 - b. Automatic Door Switch: Plunger type installed in door area to activate air curtain when door opens and to deactivate air curtain when door closes.
 - c. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.
 - d. Three-Speed Switch: Manually activates, deactivates, and controls air-curtain fan speed.
 - e. Time-Delay Relay: Factory installed and adjustable to allow air curtain to operate from 0.5 seconds to 10 hours.
 - f. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, Type 1 **OR** 12, **as directed**, enclosure.
13. Accessories:
 - a. Mounting Brackets: Adjustable mounting brackets for drum-type roll-up doors.
 - b. Discharge Extension Neck: For ceiling-recessed installation.
- B. Source Quality Control
 1. Source Quality Control: Test to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater.
 2. Testing: Test and inspect steam coils according to ASHRAE 33.
 3. Steam coils will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.

1.3 EXECUTION

A. Examination

1. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
2. Examine roughing-in for hot-water **OR** steam **OR** gas, **as directed**, piping systems to verify actual locations of piping connections before air-curtain installation.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Install air curtains with clearance for equipment service and maintenance.
2. Equipment Installation: Install air curtains with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".



3. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
- C. Connections
1. Comply with requirements for piping specified in Division 26 Section "Grounding And Bonding For Electrical Systems" and Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
 2. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
 3. Breaching: Comply with applicable requirements in Division 23 Section "Breechings, Chimneys, And Stacks". Connect breaching to full size at flue outlet.
- D. Field Quality Control
1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. After installing air curtains completely, perform visual and mechanical check of individual components.
 - b. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
 - c. Inspect for water leaks.
 - d. Test gas train and verify that there are no gas leaks.
 - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Air-curtain unit will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.
- E. Adjusting
1. Adjust belt tension.
 2. Adjust motor and fan speed to achieve specified airflow.
 3. Adjust discharge louver and dampers to regulate airflow.
 4. Adjust air-directional vanes.

END OF SECTION 23 34 33 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 35 13 00	01 22 16 00	No Specification Required
23 35 16 16	23 31 13 16	Tailpipe Exhaust Equipment



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SECTION 23 36 13 00 - DIFFUSERS, REGISTERS, AND GRILLES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for diffusers, registers and grilles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Round ceiling diffusers.
 - b. Rectangular and square ceiling diffusers.
 - c. Perforated diffusers.
 - d. Louver face diffusers.
 - e. Linear bar diffusers.
 - f. Linear slot diffusers.
 - g. Ceiling-integral continuous diffusers.
 - h. Light troffer diffusers.
 - i. Round induction diffusers.
 - j. Linear floor diffuser plenums.
 - k. Drum louvers.
 - l. Modular core supply grilles.
 - m. Continuous tubular diffusers.
 - n. Adjustable bar registers and grilles.
 - o. Security registers and grilles.
 - p. Fixed face registers and grilles.
 - q. Linear bar grilles.

C. Submittals

1. Product Data: For each type of product indicated, include the following:
 - a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - b. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
2. Samples: For each exposed product and for each color and texture specified.

1.2 PRODUCTS

A. Ceiling Diffusers

1. Round Ceiling Diffuser:
 - a. Devices shall be specifically designed for variable-air-volume flows.
 - b. Material: Steel **OR** Aluminum, **as directed**.
 - c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
 - d. Face Style: Four **OR** Three **OR** Two, **as directed**, cone.
 - e. Mounting: Duct connection.
 - f. Pattern: Fully adjustable **OR** Two-position horizontal, **as directed**.
 - g. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
 - h. Accessories:
 - 1) Equalizing grid.



- 2) Plaster ring.
 - 3) Safety chain.
 - 4) Wire guard.
 - 5) Sectorizing baffles.
 - 6) Operating rod extension.
2. Rectangular and Square Ceiling Diffusers:
 - a. Devices shall be specifically designed for variable-air-volume flows.
 - b. Material: Steel **OR** Aluminum, **as directed**.
 - c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
 - d. Face Size: 24 by 24 inches (600 by 600 mm) **OR** 20 by 20 inches (500 by 500 mm) **OR** 12 by 12 inches (300 by 300 mm), **as directed**.
 - e. Face Style: Three cone **OR** Four cone **OR** Plaque, **as directed**.
 - f. Mounting: Surface **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
 - g. Pattern: Fixed **OR** Two position **OR** Adjustable, **as directed**.
 - h. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
 - i. Accessories:
 - 1) Equalizing grid.
 - 2) Plaster ring.
 - 3) Safety chain.
 - 4) Wire guard.
 - 5) Sectorizing baffles.
 - 6) Operating rod extension.
 3. Perforated Diffuser:
 - a. Devices shall be specifically designed for variable-air-volume flows.
 - b. Material: Steel backpan and pattern controllers, with steel **OR** aluminum, **as directed**, face.
 - c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
 - d. Face Size: 12 by 12 inches (300 by 300 mm) **OR** 24 by 12 inches (600 by 300 mm) **OR** 36 by 12 inches (900 by 300 mm) **OR** 48 by 12 inches (1200 by 300 mm) **OR** 16 by 16 inches (400 by 400 mm) **OR** 20 by 20 inches (500 by 500 mm) **OR** 24 by 24 inches (600 by 600 mm) **OR** 36 by 24 inches (900 by 600 mm) **OR** 48 by 24 inches (1200 by 600 mm), **as directed**.
 - e. Duct Inlet: Round **OR** Square, **as directed**.
 - f. Face Style: Flush **OR** Drop extended, **as directed**.
 - g. Mounting: Surface **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
 - h. Pattern Controller: Four louvered deflector patches **OR** Fixed with curved blades at inlet **OR** Adjustable with louvered pattern modules at inlet **OR** None, **as directed**.
 - i. Dampers: Opposed blade **OR** Radial opposed blade **OR** Butterfly **OR** Combination damper and grid **OR** Combination volume and fire, **as directed**.
 - j. Accessories:
 - 1) Equalizing grid.
 - 2) Plaster ring.
 - 3) Safety chain.
 - 4) Wire guard.
 - 5) Sectorizing baffles.
 - 6) Operating rod extension.
 4. Louver Face Diffuser:
 - a. Devices shall be specifically designed for variable-air-volume flows.
 - b. Material: Steel **OR** Aluminum, **as directed**.
 - c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
 - d. Face Size: as directed by the Owner.



- e. Mounting: Surface **OR** Surface with beveled frame **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
 - f. Pattern: One-way **OR** Two-way **OR** Two-way corner **OR** Three-way **OR** Four-way **OR** Adjustable, **as directed**, core style.
 - g. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
 - h. Accessories:
 - 1) Square to round neck adaptor.
 - 2) Adjustable pattern vanes.
 - 3) Throw reducing vanes.
 - 4) Equalizing grid.
 - 5) Plaster ring.
 - 6) Safety chain.
 - 7) Wire guard.
 - 8) Sectorizing baffles.
 - 9) Operating rod extension.
- B. Ceiling Linear Slot Outlets
- 1. Linear Bar Diffuser:
 - a. Devices shall be specifically designed for variable-air-volume flows.
 - b. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
 - c. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
 - d. Narrow Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/4 inch (6 mm) apart, zero **OR** 15, **as directed**, -degree deflection.
 - e. Wide Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/2 inch (13 mm) apart, zero **OR** 15, **as directed**, -degree deflection.
 - f. Wide Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 1/2 inch (13 mm) apart, zero **OR** 15 **OR** 30, **as directed**, -degree deflection.
 - g. Pencil-Proof Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 7/16 inch (11 mm) apart, zero **OR** 15 **OR** 30, **as directed**, -degree deflection.
 - h. One **OR** Two, **as directed**, -Way Deflection Vanes: Extruded construction fixed louvers with removable core.
 - i. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm) **OR** 3/4 inch (19 mm) **OR** 1/2 inch (13 mm) **OR** 3/16 inch (5 mm), **as directed**, wide.
 - j. Mounting Frame: Filter.
 - k. Mounting: Countersunk screw **OR** Concealed bracket **OR** Spring clip, **as directed**.
 - l. Damper Type: Adjustable opposed-blade assembly **OR** Hinged single blade, **as directed**.
 - m. Accessories: Plaster frame **OR** Directional vanes **OR** Alignment pins **OR** Core clips **OR** Blank-off strips, **as directed**.
 - 2. Linear Slot Diffuser:
 - a. Devices shall be specifically designed for variable-air-volume flows.
 - b. Material - Shell: Steel **OR** Aluminum, **as directed**, insulated **OR** noninsulated, **as directed**.
 - c. Material - Pattern Controller and Tees: Aluminum.
 - d. Finish - Face and Shell: Baked enamel, black.
 - e. Finish - Pattern Controller: Baked enamel, black.
 - f. Finish - Tees: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
 - g. Slot Width: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - h. Number of Slots: One **OR** Two **OR** Three **OR** Four, **as directed**.
 - i. Length: 24 inches (600 mm) **OR** 30 inches (750 mm) **OR** 36 inches (900 mm) **OR** 48 inches (1200 mm) **OR** 60 inches (1500 mm), **as directed**.
 - j. Accessories: Plaster frame **OR** T-bar slot **OR** Center notch **OR** T-bar on inlet side **OR** T-bar on both sides **OR** T-bar clip on one side **OR** T-bar clips on both sides, **as directed**.
 - 3. Ceiling-Integral Continuous Diffuser:



- a. Slot Width: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 2-1/2 inches (63 mm) **OR** 3 inches (76 mm), **as directed**.
 - b. Section Length: 12 feet (3.7 m).
 - c. Straight and curved sections as required to accommodate layout.
 - d. Mitered tees and corners.
 - e. Pattern Controllers: 24 inches (600 mm) o.c.
 - f. Material: Aluminum, extruded, heavy wall.
 - g. Finishes:
 - 1) Exterior: Standard white.
 - 2) Interior: Standard black.
 - h. Throw: Standard **OR** High, **as directed**.
 - i. Mounting: Ceiling **OR** Sidewall, **as directed**.
 - j. Plenum: Noninsulated **OR** Insulated, **as directed**.
 - k. Other Features:
 - 1) Painted interior.
 - 2) Blank-offs.
4. Light Troffer Diffuser:
- a. Devices shall be specifically designed for variable-air-volume flows.
 - b. Material: Steel with external insulation, **as directed**.
 - c. Finish: None **OR** Black enamel on visible surfaces, **as directed**.
 - d. Slot Width: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - e. Number of Sides: One **OR** Two, **as directed**.
 - f. Length: 24 inches (600 mm) **OR** 36 inches (900 mm) **OR** 48 inches (1200 mm), **as directed**.
 - g. Pattern: Fixed **OR** Adjustable, **as directed**.
 - h. Inlet: Top **OR** Side, **as directed**.
 - i. Inlet Size: 5 inches (125 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**.
- C. Underfloor Air Distribution Diffusers
1. Round Induction Diffusers:
 - a. Airflow Principle: Swirl-pattern induction.
 - b. Material: Plastic, high impact, and resistant to cart and foot traffic.
 - c. Color: Gray **OR** Black, **as directed**.
 - d. Components:
 - 1) Diffuser core.
 - 2) Flow regulator.
 - 3) Dirt and liquid catch pan.
 - 4) Spacer flange.
 - 5) Gasketed, underfloor compression ring.
 2. Linear Floor Diffuser Plenums:
 - a. Material: Steel.
 - b. Finish: White baked acrylic.
 - c. Deflection: Zero **OR** 15, **as directed**, degrees.
 - d. Components:
 - 1) Aluminum diffuser core.
 - 2) Diffuser frame.
 - 3) Plenum, 0.034-inch (0.85-mm) steel.
- D. High-Capacity Diffusers
1. Drum Louver:
 - a. Airflow Principle: Extended distance for high airflow rates.
 - b. Material: Aluminum, heavy gage extruded.
 - c. Finish: White baked acrylic.
 - d. Border: 1-1/4-inch (32-mm) width with countersunk screw holes.



- e. Gasket between drum and border.
 - f. Body: Drum shaped; adjustable vertically.
 - g. Blades: Individually adjustable horizontally.
 - h. Mounting: Surface to duct **OR** wall, **as directed**.
 - i. Inlet Width: 6 inches (150 mm) **OR** 10 inches (250 mm) **OR** 12 inches (300 mm) **OR** 15 inches (380 mm), **as directed**.
 - j. Inlet Length: 12 inches (300 mm) **OR** 24 inches (600 mm) **OR** 36 inches (900 mm) **OR** 60 inches (1500 mm), **as directed**.
 - k. Accessories:
 - 1) Opposed-blade steel damper.
 - 2) Duct-mounting collars with countersunk screw holes.
2. Modular Core Supply Grilles:
- a. Throw: Extended distance for airflow rates.
 - b. Material: Steel.
 - c. Grilles per Unit: One **OR** Two **OR** Three **OR** Four, **as directed**.
 - d. Finish: White baked acrylic.
 - e. Border: 1-1/2-inch (38-mm) width with countersunk screw holes.
 - f. Blades:
 - 1) Airfoil, individually adjustable horizontally.
 - 2) Double deflection.
 - 3) Set in modules.
 - g. Modules: Removable; rotatable.
 - h. Mounting: Surface.
 - i. Accessory: Opposed-blade steel damper.
- E. Flexible Diffusion Outlets
1. Continuous Tubular Diffuser:
- a. Material: Flame-retardant, woven polyethylene fabric **OR** Flame-retardant, coated polyester and fiberglass fabric **OR** Flame-retardant, permeable polyester and fiberglass fabric **OR** Polyethylene, **as directed**.
 - b. Duct Connection: Round.
 - c. Duct Connection Size: as directed by the Owner.
 - d. Diffusion Hole Size: as directed by the Owner.
 - e. Diffusion Hole Frequency - Number per 100 Feet (30 m): **<Insert number>**.
 - f. Accessories:
 - 1) Quick-connect joint.
 - 2) Snap hooks.
 - 3) Cleanout zipper.
 - 4) Condensate drain.
- F. Registers And Grilles
1. Adjustable Bar Register:
- a. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
 - b. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
 - c. Face Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced 3 inches (76 mm) **OR** 1-1/2 inches (38 mm) **OR** 3/4 inch (19 mm) **OR** 1/2 inch (13 mm), **as directed**, apart.
 - d. Core Construction: Integral **OR** Removable, **as directed**.
 - e. Rear-Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced 3/4 inch (19 mm) **OR** 1/2 inch (13 mm), **as directed**, apart.
 - f. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm), **as directed**, wide.
 - g. Mounting Frame: Filter.
 - h. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
 - i. Damper Type: Adjustable opposed blade **OR** NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), **as directed**.
 - j. Accessories:
 - 1) Front **OR** Rear, **as directed**, -blade gang operator.



- 2) Filter.
2. Adjustable Bar Grille:
 - a. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
 - b. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
 - c. Face Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced 3 inches (76 mm) **OR** 1-1/2 inches (38 mm) **OR** 3/4 inch (19 mm) **OR** 1/2 inch (13 mm), **as directed**, apart.
 - d. Core Construction: Integral **OR** Removable, **as directed**.
 - e. Rear-Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced 3/4 inch (19 mm) **OR** 1/2 inch (13 mm), **as directed**, apart.
 - f. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm), **as directed**, wide.
 - g. Mounting Frame: Filter.
 - h. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
3. Security Register:
 - a. Security Level: Maximum **OR** Medium **OR** Minimum, **as directed**, and suicide deterrent, **as directed**.
 - b. Application: Ducted return **OR** Air transfer **OR** Barrier, **as directed**.
 - c. Material: Steel **OR** Aluminum, **as directed**.
 - d. Material Thickness: 0.19 inch (4.8 mm).
 - e. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
 - f. Face Arrangement:
 - 1) Shape: Square **OR** Rectangular **OR** Round, **as directed**.
 - 2) Design: Fixed bar **OR** Perforated **OR** Lattice, **as directed**.
 - 3) Frame: Yes **OR** No, **as directed**.
 - 4) Deflection: Zero **OR** 38, **as directed**, degrees.
 - 5) Core: None **OR** Louvered, **as directed**.
 - 6) 3/16-inch- (5-mm-) thick, front lattice plate with 2-by-2-inch- (50-by-50-mm-) square holes and 1-inch (25-mm) frets, 0.135-inch (3.43-mm) wire mesh, and 1/4-inch- (6-mm-) thick backer plate.
 - 7) 3/16-inch- (5-mm-) thick, perforated faceplate with 5/16-inch- (8-mm-) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
 - 8) 1-1/2-inch (38-mm) bars and mandrel tubes and rods with zero **OR** 15, **as directed**, -degree deflection in 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) angle border.
 - 9) 1-3/8-inch (35-mm) bars and double mandrel tubes with zero **OR** 15, **as directed**, -degree deflection in 1-3/4-inch (45-mm) angle border.
 - g. Damper Operation: None **OR** Face operated **OR** Rear operated, **as directed**.
 - h. Damper Type: Adjustable opposed blade **OR** NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), **as directed**.
 - i. Wall Sleeve: 3/16 inch (5 mm) welded to face **OR** 1/8 inch (3 mm) welded to face **OR** Mechanically fastened to border, **as directed**.
 - j. Mounting: 1-by-1-by-3/16-inch (25-by-25-by-5-mm) retaining angle frame **OR** 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) retaining angle frame **OR** 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) cast-in-place frame and tamperproof machine screws, **as directed**.
4. Security Grille:
 - a. Security Level: Maximum **OR** Medium **OR** Minimum, **as directed**, and suicide deterrent, **as directed**.
 - b. Application: Ducted return **OR** Air transfer **OR** Barrier, **as directed**.
 - c. Material: Steel **OR** Aluminum, **as directed**.
 - d. Material Thickness: 0.19 inch (4.8 mm).
 - e. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
 - f. Face Arrangement:
 - 1) Shape: Square **OR** Rectangular **OR** Round, **as directed**.
 - 2) Design: Fixed bar **OR** Perforated **OR** Lattice, **as directed**.
 - 3) Frame: Yes **OR** No, **as directed**.
 - 4) Deflection: Zero **OR** 38, **as directed**, degrees.
 - 5) Core: None **OR** Louvered, **as directed**.



- 6) 3/16-inch- (5-mm-) thick, front lattice plate with 2-by-2-inch- (50-by-50-mm-) square holes and 1-inch (25-mm) frets, 0.135-inch (3.43-mm) wire mesh, and 1/4-inch- (6-mm-) thick backer plate.
- 7) 3/16-inch- (5-mm-) thick perforated faceplate with 5/16-inch- (8-mm-) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
- 8) 1-1/2-inch (38-mm) bars and mandrel tubes and rods with zero **OR 15, as directed**, -degree deflection in 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) angle border.
- 9) 1-3/8-inch (35-mm) bars and double mandrel tubes with zero **OR 15, as directed**, -degree deflection in 1-3/4-inch (45-mm) angle border.
- g. Wall Sleeve: 3/16 inch (5 mm) welded to face **OR 1/8 inch (3 mm) welded to face OR Mechanically fastened to border, as directed.**
- h. Mounting: 1-by-1-by-3/16-inch (25-by-25-by-5-mm) retaining angle frame **OR 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) retaining angle frame OR 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) cast-in-place frame and tamperproof machine screws, as directed.**
5. Fixed Face Register:
 - a. Material: Steel **OR Aluminum, as directed.**
 - b. Finish: Baked enamel, white **OR Baked enamel, color selected, as directed.**
 - c. Face Arrangement: 1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm) grid **OR Perforated, as directed, core.**
 - d. Core Construction: Integral **OR Removable, as directed.**
 - e. Frame: 1-1/4 inches (32 mm) **OR 1 inch (25 mm), as directed, wide.**
 - f. Mounting Frame: Filter.
 - g. Mounting: Countersunk screw **OR Concealed OR Lay in, as directed.**
 - h. Damper Type: Adjustable opposed blade **OR NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), as directed.**
 - i. Accessory: Filter.
6. Fixed Face Grille:
 - a. Material: Steel **OR Aluminum, as directed.**
 - b. Finish: Baked enamel, white **OR Baked enamel, color selected.**
 - c. Face Arrangement: 1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm) grid **OR Perforated, as directed, core.**
 - d. Core Construction: Integral **OR Removable, as directed.**
 - e. Frame: 1-1/4 inches (32 mm) **OR 1 inch (25 mm), as directed, wide.**
 - f. Mounting Frame: Filter.
 - g. Mounting: Countersunk screw **OR Concealed OR Lay in, as directed.**
 - h. Accessory: Filter.
7. Linear Bar Grille:
 - a. Material: Steel **OR Aluminum, as directed.**
 - b. Finish: Baked enamel, white **OR Baked enamel, color selected, as directed.**
 - c. Face Arrangement: 1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm) grid **OR Perforated, as directed, core.**
 - d. Distribution plenum.
 - 1) Internal insulation.
 - 2) Inlet damper.
 - e. Frame: 1-1/4 inches (32 mm) **OR 1 inch (25 mm), as directed, wide.**
 - f. Mounting Frame: Filter.
 - g. Mounting: Countersunk screw **OR Concealed OR Lay in, as directed.**
 - h. Damper Type: Adjustable opposed blade **OR NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), as directed.**

G. Source Quality Control

1. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."



1.3 EXECUTION

A. Installation

1. Install diffusers, registers, and grilles level and plumb.
2. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify the Owner for a determination of final location.
3. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

B. Adjusting

1. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 36 13 00

**SECTION 23 36 16 00 - AIR TERMINAL UNITS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for air terminal units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Bypass, single-duct air terminal units.
 - b. Dual-duct air terminal units.
 - c. Fan-powered air terminal units.
 - d. Induction air terminal units.
 - e. Shutoff, single-duct air terminal units.
 - f. Diffuser-type air terminal units.

C. Performance Requirements

1. Structural Performance: Hangers and supports and seismic restraints, **as directed**, shall withstand the effects of gravity and seismic, **as directed**, loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
 - a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
 - b. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
 - c. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
 - c. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
4. Delegated-Design Submittal:
 - a. Materials, fabrication, assembly, and spacing of hangers and supports.
 - b. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation, **as directed**, for selecting hangers and supports and seismic restraints, **as directed**.
5. Field quality-control reports.
6. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."



1.2 PRODUCTS

A. Bypass, Single-Duct Air Terminal Units

1. Configuration: Diverting-damper assembly inside unit casing with control components inside a protective metal shroud.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
 - a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.
OR
Cover liner with nonporous foil and perforated metal.

OR

 Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - b. Air Inlet: Round stub connection for duct attachment.
 - c. Air Outlet: S-slip and drive connections.
 - d. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.
 - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Diverter Assembly: Galvanized-steel gate, with polyethylene linear bearings **OR** Aluminum blade, with nylon-fitted pivot points, **as directed**.
4. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 10-inch- (250-mm-), **as directed**, diameter collars, each with locking butterfly balancing damper.
5. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

OR

 Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
 - a. Access door interlocked disconnect switch.
 - b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
 - c. Nickel chrome 80/20 heating elements.
 - d. Airflow switch for proof of airflow.
 - e. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
 - f. Mercury contactors.
 - g. Pneumatic-electric switches and relays.
 - h. Magnetic contactor for each step of control (for three-phase coils).
6. Electric Controls: Damper actuator and thermostat.
 - a. Damper Actuator: 24 V, powered closed, powered open with microswitch to energize heating control circuit, **as directed**.
 - b. Thermostat: Wall-mounted electric type with temperature display in Fahrenheit and Celsius, and space temperature set point.



- c. Changeover Thermostat: Duct-mounted, field-adjustable, electric type reverses action of zone thermostat when air temperature reaches 70 deg F (21 deg C).

OR

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- d. Damper Actuator: 24 V, powered closed, powered open.
- e. Thermostat: Wall-mounted electronic type with the following features:
 - 1) Temperature set-point display in Fahrenheit and Celsius.
 - 2) Auxiliary switch to energize heating control circuit.
 - 3) Changeover thermistor to reverse action.

B. Dual-Duct Air Terminal Units

- 1. Configuration: Two volume dampers inside unit casing with mixing attenuator section and control components inside a protective metal shroud with a third primary air inlet with volume damper, **as directed**.
- 2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
 - a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.

OR

Cover liner with nonporous foil and perforated metal.

OR

Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 - c. Air Outlet: S-slip and drive connections.
 - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
- 3. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - a. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
- 4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.
- 5. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.
 - a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.

OR

Cover liner with nonporous foil and perforated metal.

OR

Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index



- of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
- b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
6. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 10-inch- (250-mm-) **OR** 12-inch- (300-mm-), **as directed**, diameter collars, each with locking butterfly balancing damper.
 7. Pneumatic Controls: Damper operator, velocity controllers, and thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:
 - a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
 - b. Velocity Controllers: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor. Locate velocity sensors in cold- and hot-deck **OR** cold-, hot-, and ventilation- deck **OR** cold-deck, **as directed**, air inlets and supply air outlets.
 - c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

OR

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

 - a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
 - b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlets and air outlets.
 - c. Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius, **as directed**.

OR

Direct Digital Controls: Single-package unitary controller and actuator specified in Division 23 Section "Instrumentation And Control For Hvac"

OR

Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

 - d. Damper Actuators: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
 - e. Terminal Unit Controller: Pressure-independent, variable-air **OR** constant, **as directed**, -volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes, and having the following features:
 - 1) Occupied and unoccupied operating mode.
 - 2) Remote reset of airflow or temperature set points.
 - 3) Adjusting and monitoring with portable terminal.
 - 4) Communication with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
 - f. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
 8. Control Sequence:
 - a. Modulate cold-air damper to maintain room temperature.
 - b. Modulate warm-air damper to maintain constant airflow.

C. Parallel Fan-Powered Air Terminal Units



1. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
 - a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.
OR
Cover liner with nonporous foil and perforated metal.
 - OR**
Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 - c. Air Outlet: S-slip and drive connections.
 - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
 - e. Fan: Forward-curved centrifugal, located at plenum air inlet.
 - f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
 - a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
 - b. Damper Position: Normally open **OR** closed, **as directed**.
4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.
5. Motor:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - b. Type: Permanent-split capacitor with SCR for speed adjustment **OR** Electronically commutated motor, **as directed**.
 - c. Fan-Motor Assembly Isolation: Rubber isolators.
 - d. Enclosure: Open dripproof **OR** Totally enclosed, fan cooled **OR** Totally enclosed, air over **OR** Open, externally ventilated **OR** Totally enclosed, nonventilated **OR** Severe duty **OR** Explosion proof **OR** Dust-ignition-proof machine, **as directed**.
 - e. Enclosure Materials: Cast iron **OR** Cast aluminum **OR** Rolled steel, **as directed**.
6. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
 - a. Material: Polyurethane foam having 70 percent arrestance and 3 MERV.
OR
Material: Glass fiber treated with adhesive; having 80 percent arrestance and 5 MERV.
OR
Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
 - b. Thickness: 2 inches (50 mm) **OR** 1 inch (25 mm), **as directed**.
7. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.
 - a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and



having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

- 1) Cover liner with nonporous foil.

OR

Cover liner with nonporous foil and perforated metal.

- b. Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
8. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.
- a. Location: Plenum air inlet.
- OR**
- Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
- a. Location: Plenum air inlet.
 - b. Stage(s): 1 **OR** 2 **OR** 3, **as directed**.
 - c. Access door interlocked disconnect switch.
 - d. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
 - e. Nickel chrome 80/20 heating elements.
 - f. Airflow switch for proof of airflow.
 - g. Fan interlock contacts.
 - h. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
 - i. Mercury contactors.
 - j. Pneumatic-electric switches and relays.
 - k. Magnetic contactor for each step of control (for three-phase coils).
9. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
- a. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 - b. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
 - c. Disconnect Switch: Factory-mounted, fuse type.
10. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
11. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.

OR

Pneumatic Controls: Damper operator, velocity controller, and thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
- b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while pressure independent up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
- c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

OR



Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
12. Control Sequence:
- a. Occupied (Primary Airflow On):
 - 1) Operate as throttling control for cooling.
 - 2) As cooling requirement decreases, control valve throttles toward minimum airflow.
 - 3) As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps, **as directed**.
 - b. Unoccupied (Primary Airflow Off):
 - 1) When pressure at primary inlet is zero or less, fan is de-energized.
 - 2) As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps, **as directed**.

D. Series Fan-Powered Air Terminal Units

1. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling and within a raised access floor, **as directed**.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
 - a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.
OR
Cover liner with nonporous foil and perforated metal.**OR**
Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 - c. Air Outlet: S-slip and drive connections.
 - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
 - e. Fan: Forward-curved centrifugal.
 - f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
 - a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
 - b. Damper Position: Normally open **OR** closed, **as directed**.
4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.
5. Motor:



- a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - b. Type: Permanent-split capacitor with SCR for speed adjustment **OR** Electronically commutated motor, **as directed**.
 - c. Fan-Motor Assembly Isolation: Rubber isolators.
 - d. Enclosure: Open dripproof **OR** Totally enclosed, fan cooled **OR** Totally enclosed, air over **OR** Open, externally ventilated **OR** Totally enclosed, nonventilated **OR** Severe duty **OR** Explosion proof **OR** Dust-ignition-proof machine, **as directed**.
 - e. Enclosure Materials: Cast iron **OR** Cast aluminum **OR** Rolled steel, **as directed**.
6. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
- a. Material: Polyurethane foam having 70 percent arrestance and 3 MERV.
OR
Material: Glass fiber treated with adhesive; having 80 percent arrestance and 5 MERV.
OR
Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
 - b. Thickness: 2 inches (50 mm) **OR** 1 inch (25 mm), **as directed**.
7. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.
- a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.
OR
Cover liner with nonporous foil and perforated metal.
OR
Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
8. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.
OR
Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
- a. Stage(s): 1 **OR** 2 **OR** 3, **as directed**.
 - b. Access door interlocked disconnect switch.
 - c. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
 - d. Nickel chrome 80/20 heating elements.
 - e. Airflow switch for proof of airflow.
 - f. Fan interlock contacts.
 - g. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
 - h. Mercury contactors.
 - i. Pneumatic-electric switches and relays.
 - j. Magnetic contactor for each step of control (for three-phase coils).
9. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.



- a. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 - b. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
 - c. Disconnect Switch: Factory-mounted, fuse type.
10. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
11. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.

OR

Pneumatic Controls: Damper operator, velocity controller, and thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
- b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while pressure independent up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
- c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

OR

Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Occupied and unoccupied operating mode.
- b. Remote reset of airflow or temperature set points.
- c. Adjusting and monitoring with portable terminal.
- d. Communication with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".

12. Control Sequence:

- a. Occupied (Primary Airflow On):
 - 1) When pressure at inlet is at least 1.2-inch wg (300 Pa).
 - 2) As cooling requirement decreases, control valve throttles toward minimum airflow.
- b. Unoccupied (Primary Airflow Off):
 - 1) When pressure at primary inlet is zero or less, fan is de-energized.

E. Induction Air Terminal Units

1. Configuration: Volume-damper assembly inside unit casing with mechanical induction damper mounted on casing and control components inside a protective metal shroud.
 2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
 - a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.
- OR**
- Cover liner with nonporous foil and perforated metal.
- OR**
- Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.



- b. Air Inlet: Round stub connection for duct attachment.
 - c. Air Outlet: S-slip and drive connections, size matching inlet size, **as directed**.
 - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 - e. Fan: Forward-curved centrifugal.
 - f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
- a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
 - b. Damper Position: Normally open **OR** closed, **as directed**.
4. Induction Damper: Galvanized-steel, multiblade assembly with self-lubricating bearings.
5. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.
- OR**
- Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
- a. Access door interlocked disconnect switch.
 - b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
 - c. Nickel chrome 80/20 heating elements.
 - d. Airflow switch for proof of airflow.
 - e. Fan interlock contacts.
 - f. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
 - g. Mercury contactors.
 - h. Pneumatic-electric switches and relays.
 - i. Magnetic contactor for each step of control (for three-phase coils).
6. Pneumatic Controls: Damper operator, velocity controller, and induction damper operator. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:
- a. Damper Operator: Pneumatic, 0- to 13-psig (0- to 90-kPa) spring range.
 - b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
 - c. Induction Damper Operator: Pneumatic, spring range matching reset range of controller.
 - d. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.
- OR**
- Electronic Controls: Pneumatic damper operators, electronic controller integral airflow transducer, and electronic thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:
- a. Damper Actuator: Pneumatic, 0- to 13-psig (0- to 90-kPa) spring range.
 - b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
 - c. Induction Damper Operator: Pneumatic, spring range matching reset range of controller.
 - d. Thermostat: Wall-mounted electronic type with the following features:
 - 1) Proportional, plus integral control of room temperature.
 - 2) Time-proportional reheat-coil control.
 - 3) Temperature set-point display in Fahrenheit and Celsius.



F. Shutoff, Single-Duct Air Terminal Units

1. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
 - a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.
OR
Cover liner with nonporous foil and perforated metal.
 - OR**
Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - b. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - c. Air Outlet: S-slip and drive connections, size matching inlet size, **as directed**.
 - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from 0 to 140 deg F (minus 18 to plus 60 deg C), shall be impervious to moisture and fungus, shall be suitable for 10-inch wg (2500-Pa) static pressure, and shall be factory tested for leaks.
4. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
 - b. Damper Position: Normally open **OR** closed, **as directed**.
5. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.
 - a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 1) Cover liner with nonporous foil.
OR
Cover liner with nonporous foil and perforated metal.
 - OR**
Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
6. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 10-inch- (250-mm-), **as directed**, diameter collars, each with locking butterfly balancing damper.
7. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.
OR



Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

- a. Access door interlocked disconnect switch.
 - b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
 - c. Nickel chrome 80/20 heating elements.
 - d. Airflow switch for proof of airflow.
 - e. Fan interlock contacts.
 - f. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
 - g. Mercury contactors.
 - h. Pneumatic-electric switches and relays.
 - i. Magnetic contactor for each step of control (for three-phase coils).
8. Electric Controls: Damper actuator and thermostat.
- a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
 - b. Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.

OR

Pneumatic Controls: Damper operator and velocity controller. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
- b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
- c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

OR

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
- b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
- c. Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.

OR

Direct Digital Controls: Single-package unitary controller and actuator specified in Division 23 Section "Instrumentation And Control For Hvac".

OR

Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
- b. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
 - 1) Occupied and unoccupied operating mode.



- 2) Remote reset of airflow or temperature set points.
 - 3) Adjusting and monitoring with portable terminal.
 - 4) Communication with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
 - c. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
 9. Control Sequence:
 - a. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.
 - b. System-powered, wall-mounted thermostat.
 - G. Diffuser-Type Air Terminal Units
 1. Configuration: Volume-damper, diffuser, controller assembly and electric heater, **as directed**, and wall-mounted thermostat with master-slave capability, **as directed**.
 2. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - a. Damper Position: Normally open **OR** closed, **as directed**.
 3. Diffuser: Galvanized steel with white baked-enamel finish.
 4. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:
 - a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
 - b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
 - c. Thermostat: Wall-mounted electronic type with the following features:
 - 1) Proportional, plus integral control of room temperature.
 - 2) Temperature set-point display in Fahrenheit and Celsius.
 5. Integral thermally powered actuators control diffusion dampers based on duct and room temperature.
 - H. Hangers And Supports
 1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
 2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 3. Steel Cables: Galvanized steel complying with ASTM A 603 **OR** Stainless steel complying with ASTM A 492, **as directed**.
 4. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
 5. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
 6. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.
 - I. Seismic-Restraint Devices
 1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
 2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to



braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

3. Restraint Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**, -steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

J. Source Quality Control

1. Factory Tests, as directed: Test factory-assembled air terminal units according to ARI 880.
 - a. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, **as directed**, and ARI certification seal.

1.3 EXECUTION

A. Installation

1. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
2. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
3. Install wall-mounted thermostats.

B. Hanger And Support Installation

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
2. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - a. Where practical, install concrete inserts before placing concrete.
 - b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.
 - d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.
 - e. Do not use powder-actuated concrete fasteners for seismic restraints.
3. Hangers Exposed to View: Threaded rod and angle or channel supports.
4. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

C. Seismic-Restraint-Device Installation

1. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR** ASCE/SEI 7, **as directed**.
2. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install cable restraints on air terminal units that are suspended with vibration isolators.
5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.



7. Drilling for and Setting Anchors:
 8. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 9. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 10. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
 11. Set anchors to manufacturer's recommended torque, using a torque wrench.
 12. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.
- D. Connections
1. Install piping adjacent to air terminal unit to allow service and maintenance.
 2. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping", connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
 3. Connect ducts to air terminal units according to Division 23 Section(s) "Metal Ducts" OR "Nonmetal Ducts", **as directed**.
 4. Make connections to air terminal units with flexible connectors complying with requirements in Division 23 Section "Air Duct Accessories".
- E. Identification
1. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification For Hvac Piping And Equipment" for equipment labels and warning signs and labels.
- F. Field Quality Control
1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - b. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Air terminal unit will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.
- G. Startup Service
1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - c. Verify that controls and control enclosure are accessible.
 - d. Verify that control connections are complete.
 - e. Verify that nameplate and identification tag are visible.
 - f. Verify that controls respond to inputs as specified.



H. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 36 16 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 37 13 00	23 31 13 33	Duct Accessories
23 37 13 00	23 36 13 00	Diffusers, Registers, And Grilles
23 38 13 16	01 22 16 00	No Specification Required
23 38 13 16	11 21 63 00	Food Service Equipment
23 38 13 16	23 31 13 13	Metal Ducts



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SECTION 23 41 13 00 - AIR FILTERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for particulate air infiltration. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Metal panel filters.
 - b. Flat panel filters.
 - c. Pleated panel filters.
 - d. Ring panel filters.
 - e. Nonsupported bag filters.
 - f. Supported bag filters.
 - g. Rigid cell box filters.
 - h. V-bank cell filters.
 - i. Self-supported pocket filters.
 - j. Automatic roll filters.
 - k. Bulk media.
 - l. Front- and rear-access filter frames.
 - m. Side-service housings.
 - n. Filter gages.

C. Submittals

1. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
2. LEED Submittals:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
 - a. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
 - b. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
 - c. Wiring Diagrams: For power, signal, and control wiring.
4. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
 - a. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."



- b. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
3. Comply with NFPA 90A and NFPA 90B.

E. Coordination

1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.2 PRODUCTS

A. Metal Panel Filters

1. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.
2. Media: Four **OR** Six, **as directed**, alternate layers of galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, flat and herringbone-crimp screen.
 - a. Nonoiled for grease removal application.
 - b. Adhesive coating.
 - 1) Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Filter-Media Frame: Galvanized steel **OR** Hot-dip galvanized steel **OR** Aluminum **OR** Stainless steel, **as directed**, hinged, and with pull and retaining handles fastened to the media.
 - a. Drain holes.

B. Flat Panel Filters

1. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Interlaced glass or synthetic fibers **OR** Cotton and synthetic fibers, **as directed**, coated with nonflammable adhesive.
 - a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Media shall be coated with an antimicrobial agent.
 - c. Metal Retainer: Upstream side and downstream side.
4. Filter-Media Frame: Cardboard with perforated metal retainer **OR** Galvanized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles, **as directed**, sealed or bonded to the media.
5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

C. Pleated Panel Filters

1. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Interlaced glass or synthetic fibers **OR** Cotton and synthetic fibers, **as directed**, coated with nonflammable adhesive.
 - a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Media shall be coated with an antimicrobial agent.
 - c. Separators shall be bonded to the media to maintain pleat configuration.
 - d. Welded wire grid shall be on downstream side to maintain pleat.
 - e. Media shall be bonded to frame to prevent air bypass.
 - f. Support members on upstream and downstream sides to maintain pleat spacing.
4. Filter-Media Frame: Cardboard frame with perforated metal retainer **OR** Galvanized steel **OR** Aluminized steel, **as directed**, with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles, **as directed**, sealed or bonded to the media.



5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- D. Ring Panel Filters
1. Description: Internally supported, flat panel filters for installation in a filter track.
 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 3. Media: Two **OR** Three **OR** Four, **as directed**, -ply polyester with sealed edges.
 - a. Panel Construction: Single with one edge unsealed for support removal, **as directed**, **OR** Linked, **as directed**.
 - b. Media shall be coated with an antimicrobial agent.
 4. Internal Support: 9-gage steel wire frame.
- E. Nonsupported Bag Filters
1. Description: Factory-fabricated, dry, extended-surface, nonsupported filters with header frames.
 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 3. Media: Glass-fiber **OR** Synthetic, **as directed**, material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports.
 - a. Media shall be coated with an antimicrobial agent.
 4. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
 5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- F. Supported Bag Filters
1. Description: Factory-fabricated, dry, extended-surface, self-supported filters with holding frames in steel, basket-type retainers.
 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
 - a. Media shall be coated with an antimicrobial agent.
 4. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
 5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- G. Rigid Cell Box Filters
1. Description: Factory-fabricated, adhesive-coated, **as directed**, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
 - a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Media shall be coated with an antimicrobial agent.
 4. Filter-Media Frames: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
 5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- H. V-Bank Cell Filters
1. Description: Factory-fabricated, adhesive-coated, **as directed**, disposable, packaged air filters with media angled to airflow, and with holding frames.
 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
 - a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Media shall be coated with an antimicrobial agent.
 4. Filter-Media Frames: Galvanized steel **OR** Hard polyurethane foam, **as directed**.



5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- I. Self-Supported Pocket Filters
1. Description: Factory-fabricated, panel-type, disposable air filters with contoured media for extended surface.
 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
 - a. Media shall be coated with an antimicrobial agent.
 4. Configuration: Single-pocket cube **OR** Multipocket, **as directed**.
 5. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
 6. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- J. Automatic Roll Filters
1. Description: Factory-fabricated, automatic, motor-driven, roll-type filters with holding casing.
 2. Arrangement: Horizontal **OR** Vertical, **as directed**.
 3. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 4. Media: Compressed and rolled, fibrous-glass material; viscous coated.
 - a. Media shall be coated with an antimicrobial agent.
 5. Holding Frame: Galvanized steel with enclosed, clean media roll arranged to allow upstream replacement of filter media.
 - a. Auxiliary Frame: Locate on downstream side of unit with downstream **OR** side, **as directed**, access.
 - b. Final Filter: Extended-surface, retained **OR** nonsupported, **as directed**, media.
 6. Control and Drive: Electric, gear-reducer, motor-driven, feed-control mechanism equipped with manual media advance and runout switches for stopping media movement of filter bank and operating remote warning signal lights.
 - a. Manual Control: Manual switch to advance media, and wired to override automatic controls.
 - b. Automatic Control: Prewired control package to advance media when filter resistance exceeds preselected high limit **OR** after preselected operating time, **as directed**.
- K. Bulk Media
1. Description: Air-filter media, factory custom cut or rolled.
 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 3. Media: Spun glass **OR** Synthetic **OR** Polyester, **as directed**, in a roll **OR** cut into pads, **as directed**.
- L. Front- And Rear-Access Filter Frames
1. Framing System: Galvanized-steel **OR** Aluminum, **as directed**, framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 2. Prefilters: Incorporate a separate track with spring clips, **as directed**, removable from front or back, **as directed**.
 3. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.
- M. Side-Service Housings
1. Description: Factory-assembled, side-service housings, constructed of galvanized steel **OR** aluminum, **as directed**, with flanges to connect to duct or casing system.
 2. Prefilters: Integral tracks to accommodate 2-inch- (50-mm-) deep, disposable or washable, **as directed**, filters.



3. Access Doors: Hinged, with continuous **OR** Continuous, **as directed**, gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.
4. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

N. Filter Gages

1. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 - a. Diameter: 4-1/2 inches (115 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
 - c. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
 - d. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
 - e. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
 - f. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).
2. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of the full scale range.
3. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

1.3 EXECUTION

A. Installation

1. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
2. Install filters in position to prevent passage of unfiltered air.
3. Install filter gage for each filter bank.
4. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
5. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
6. Coordinate filter installations with duct and air-handling-unit installations.

B. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Operate automatic roll filters to demonstrate compliance with requirements.
 - b. Test for leakage of unfiltered air while system is operating.
3. Air filter will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

C. Cleaning

1. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 13 00



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SECTION 23 41 13 00a - ELECTRONIC AIR CLEANERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for electronic air cleaners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Electronic air cleaners.
 - b. Side-service housings.
 - c. Front- and rear-access filter frames.
 - d. Filter gages.

C. Submittals

1. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
2. LEED Submittal:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For each electronic air cleaner. Include plans, elevations, sections, details, and attachments to other work.
 - a. Show filter assembly, dimensions, materials, and methods of assembly of components.
 - b. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
 - c. Wiring Diagrams: For power, signal, and control wiring.
4. Field quality-control reports.
5. Operation and Maintenance Data: For each type of filter and housing to include in emergency, operation, and maintenance manuals.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
 - a. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," and Section 7 - "Construction and Startup."
 - b. Comply with ASHRAE 52.1 for arrestance and with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
3. Comply with NFPA 90A and NFPA 90B.
4. Comply with ARI 850.
5. Comply with UL 867.

1.2 PRODUCTS

A. Electronic Air Cleaners

1. Description: Factory-fabricated electronic air cleaner operating by electrostatic precipitation principles.



2. Prefilter Media: Four **OR** Six, **as directed**, alternate layers of galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, flat and herringbone-crimp screen.
 3. Prefilter: Comply with requirements in Division 23 Section "Particulate Air Filtration" for flat **OR** pleated **OR** ring, **as directed**, panel. Size and airflow capacity shall match those of electronic air cleaners.
 - a. Depth: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
 - b. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 - c. Arrestance: 85 percent when tested according to ASHRAE 52.1.
 - d. MERV: 8 when tested according to ASHRAE 52.2.
 4. Final Filter: Comply with requirements in Division 23 Section "Particulate Air Filtration" for supported bag **OR** unsupported bag **OR** rigid-cell box **OR** V-bank cell **OR** self-supported pocket, **as directed**. Size and airflow capacity shall match those of gas-phase filters.
 - a. Depth: 12 inches (300 mm) **OR** 18 inches (450 mm) **OR** 24 inches (600 mm), **as directed**.
 - b. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
 - c. Arrestance: 85 percent when tested according to ASHRAE 52.1.
 - d. MERV: 13 when tested according to ASHRAE 52.2.
 5. Collection Cells: Aluminum, independently supported and nested.
 - a. Ionizing Section: Alternately spaced grounded struts and charged ionizing wires.
 - b. Collecting Section: Alternately grounded and charged plates, with insulators located out of airstream.
 6. Power Pack: Self-contained, prewired rectifying unit to convert 120 **OR** 208/240 **OR** 480, **as directed**, -V ac, single-phase, 60-Hz power to approximately 12,000-V dc for ionizer and 6000-V dc for collector; include overload protection, on-off switch, pilot light showing operating status, and access door interlock.
 7. Safety Accessories: Manual-reset safety switches and warning lights for filter plenum access doors, signal lights and safety switching upstream and downstream from unit within duct, and enameled high-voltage warning signs.
 8. Collection Section Cleaning System:
 - a. Detergent Reservoir Tank: 30 gal. (110 L) **OR** 55 gal. (200 L), **as directed**, with pump, motor, solenoid valve, level sensor, backflow preventer, wye-strainer, and ball valve.
 - b. Detergent.
 - c. Dispensing System: Motor-driven oscillating copper manifolds with brass spray nozzles on each side of the collector.
 9. Mist Eliminators: Upstream **OR** Upstream and downstream **OR** Downstream, **as directed**.
 10. Controls: Programmable logic controller in remotely mounted NEMA 250, Type 12 enclosure; with integral time clock and manual override.
 - a. Contacts for enable-disable control by building automation system.
 11. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Fan Section
1. Fan: Forward curved, belt driven.
 2. Motor:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - b. Type: Permanent-split capacitor with SCR for speed adjustment **OR** Electronically commutated motor, **as directed**.
 - c. Fan-Motor Assembly Isolation: Rubber isolators.
 - d. Enclosure: Totally enclosed, fan cooled, and explosion proof **OR** dust-ignition proof, **as directed**.
 - e. Enclosure Materials: Cast iron **OR** Cast aluminum **OR** Rolled steel, **as directed**.
 - f. Motor Bearings: Sealed ball.
 - g. Unusual Service Conditions:
 - 1) Ambient Temperature: <Insert deg F (deg C)>.



- 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - h. Efficiency: Premium efficient.
 - i. NEMA Design: **<Insert designation>**.
 - j. Service Factor: **<Insert value>**.
 - k. Motor Speed: Single speed **OR** Multispeed, **as directed**.
 - 1) Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.
- C. Cabinet
1. Description: 16-gage galvanized steel with epoxy powder finish for suspended, wall, frame, or duct mounting.
- D. Side-Service Housings
1. Description: Factory-assembled, side-service housings, with bottom drain, **as directed**, constructed of galvanized steel **OR** aluminum, **as directed**, and configured for stacking, with flanges to connect to duct or casing system.
 2. Access Doors: Hinged with continuous **OR** Continuous, **as directed**, gaskets on perimeter and positive-locking devices.
 3. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.
 4. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Front- And Rear-Access Filter Frames
1. Framing System: Galvanized-steel **OR** Aluminum, **as directed**, framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules with bottom drain, **as directed**, and configured for stacking. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 2. Prefilters: Incorporate a separate track with spring clips, **as directed**, removable from front or back, **as directed**.
 3. Final Filters: Integral tracks to accommodate particulate **OR** gas-phase, **as directed**, disposable filters.
 4. Sealing: Factory-installed, positive-sealing device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.
 5. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- F. Filter Gages
1. Diaphragm type, with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 - a. Diameter: 4-1/2 inches (115 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
 - c. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
 - d. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
 - e. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
 - f. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).
 2. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gage, with integral leveling indicator, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of full-scale range.
 3. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.



1.3 EXECUTION

A. Installation

1. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
2. Install filters in position to prevent passage of unfiltered air.
3. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
4. Operate electronic air cleaners for 24 hours as part of startup before filters are put into operation.
5. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
6. Install and connect water-supply and drainage piping.
7. Coordinate filter installations with duct and air-handling-unit installations.

B. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections: Test for leakage of unfiltered air while system is operating.
3. Air filter will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

C. Cleaning

1. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new prefilter and final-filter media.

END OF SECTION 23 41 13 00a



Task	Specification	Specification Description
23 41 16 00	23 41 13 00	Air Filters
23 41 16 00	23 41 13 00a	Electronic Air Cleaners
23 41 19 00	23 41 13 00	Air Filters
23 41 19 00	23 41 13 00a	Electronic Air Cleaners
23 41 33 00	23 41 13 00	Air Filters
23 41 33 00	22 13 19 13	High-Efficiency Particulate Filtration



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SECTION 23 42 13 00 - GAS-PHASE AIR FILTRATION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for gas-phase air infiltration. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Activated-carbon panel filters.
 - b. Activated-carbon, deep-V filters.
 - c. Activated carbon, V-cell filters.
 - d. Cylindrical-canister filters.
 - e. Permanganate filters.
 - f. Supported adsorber bag filters.
 - g. Front-access filter housings.
 - h. Side-service housings.
 - i. Filter gages.

C. Submittals

1. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
2. LEED Submittal:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment."
3. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
 - a. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
 - b. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
4. Field quality-control reports.
5. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

D. Quality Assurance

1. ASHRAE Compliance:
 - a. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Comply with NFPA 90A and NFPA 90B.

1.2 PRODUCTS

A. Activated-Carbon Panel Filters

1. Description: Factory-fabricated unit with activated-carbon media.
2. Media: Flat-panel, disposable multilayer filter with an inlet layer of polyester fibers, a layer of activated-carbon granules bonded to fibers, and a layer of polyurethane foam; housed in a cardboard frame.



3. Media: Flat-panel, disposable honeycombed cellulose with cells filled with activated-carbon granules and a perforated mesh grid; housed in a cardboard frame.
4. Media: Pleated, multilayer filter with an inlet layer of cotton and synthetic fibers and a layer of activated-carbon granules bonded to synthetic fibers; media formed into deep-V-shaped pleats, held by self-wire grid, and housed in a cardboard frame.
5. Mounting Frames: Welded, galvanized, sheet-steel frame and galvanized-steel fasteners with polyurethane, **as directed**, gaskets; capable of bolting together into built-up filter banks.

B. Activated-Carbon, Deep-V Filters

1. Description: Factory-fabricated unit with activated-carbon trays in deep-V arrangement with disposable panel prefilter, **as directed**, and final filter, **as directed**.
2. Module Housing: 0.064-inch- (1.6-mm-) thick, galvanized steel **OR** stainless steel **OR** double-wall casing with 1-inch- (25-mm-) thick insulation, **as directed**, to hold media-filled panels; with side servicing through gasketed access doors on both sides and able to connect to other housings. Equip housings with metal slide channel tracks to hold activated-carbon trays and particulate prefilter, **as directed**, and final filter, **as directed**.
 - a. Finish: Factory primed **OR** primed and painted, **as directed**, outside **OR** inside and outside **OR** inside, **as directed**.
 - b. Pressure tap and fitting.
3. Media-Holding Panels: 1-inch- (25-mm-) thick, perforated polystyrene to allow airflow through contained loose-fill media; with removable service cap for recharging.
OR
Media-Holding Panels: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, deep and containing granular carbon bonded into a briquette form with a galvanized **OR** stainless, **as directed**, -steel frame.
4. Media: 45 lb (20.3 kg) per 1000 cfm (470 L/s) of loose-fill **OR** loose-fill or bonded-briquette **OR** bonded-briquette, **as directed**, coconut-shell activated carbon.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
 - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
 - e. Hardness Factor: 95 when tested according to ASTM D 3802.
5. Media: loose-fill **OR** loose-fill or bonded-briquette **OR** bonded-briquette, **as directed**, activated alumina impregnated with potassium permanganate.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
 - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
 - e. Hardness Factor: 95 when tested according to ASTM D 3802.
6. Media: loose-fill **OR** loose-fill or bonded-briquette **OR** bonded-briquette, **as directed**, impregnated carbon.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
 - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
 - e. Hardness Factor: 95 when tested according to ASTM D 3802.
7. Media: loose-fill **OR** loose-fill or bonded-briquette **OR** bonded-briquette, **as directed**, blended carbon and alumina impregnated with potassium permanganate.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).



- d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
- e. Hardness Factor: 95 when tested according to ASTM D 3802.

C. Activated-Carbon, V-Cell Filters

- 1. Description: Factory-fabricated, dry, V-shaped cartridges containing loose-fill media with holding frames.
- 2. Cartridges: V-cell configuration, plastic enclosure caps, galvanized-steel frame with vertical galvanized-steel channel supports. Integral, 1-inch- (25-mm-) deep panels constructed of honeycombed paper and nylon mesh.
- 3. Fill Media: Coconut-shell activated carbon; 45 lb (20.3 kg) of activated carbon per 1000 cfm (470 L/s) of airflow.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
 - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
 - e. Hardness Factor: 95 when tested according to ASTM D 3802.
- 4. Fill Media: Activated alumina impregnated with potassium permanganate; 10.5 lb (4.8 kg) of adsorbent per 500 cfm (236 L/s) of airflow.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
 - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
 - e. Hardness Factor: 95 when tested according to ASTM D 3802.
- 5. Fill Media: Impregnated carbon; 8.0 lb (3.6 kg) of adsorbent per 500 cfm (236 L/s) of airflow.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
 - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
 - e. Hardness Factor: 95 when tested according to ASTM D 3802.
- 6. Fill Media: Blended carbon and alumina impregnated with potassium permanganate; 7.0 lb (3.1 kg) of adsorbent per 500 cfm (236 L/s) of airflow.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
 - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
 - e. Hardness Factor: 95 when tested according to ASTM D 3802.
- 7. Mounting Frames: Welded, galvanized, sheet-steel frame and galvanized-steel fasteners with gaskets; capable of bolting together into built-up filter banks.

D. Cylindrical-Canister Filters

- 1. Description: Factory-fabricated, dry, cylindrical canisters containing loose-fill adsorbent with holding frames.
- 2. Cylinders: 0.0455-inch- (1.2-mm-) thick, perforated, electroplated **OR** stainless, **as directed**, steel, with end plate.
- 3. Fill Media: 5.0 lb (2.3 kg) **OR** 6.7 lb (3.0 kg), **as directed**, of coconut-shell activated carbon **OR** activated alumina impregnated with potassium permanganate **OR** impregnated carbon **OR** blended carbon and alumina impregnated with potassium permanganate, **as directed**, per canister.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).



- d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
- e. Hardness Factor: 95 when tested according to ASTM D 3802.
4. Mounting Frames: Welded galvanized, sheet steel with galvanized-steel fasteners **OR** stainless steel with stainless-steel fasteners, **as directed**, with gaskets; designed for bolting together into built-up filter banks.

E. Permanganate Filters

1. Description: Factory-fabricated modules containing loose-fill adsorbent with holding frames.
2. Modules: Permanent type, 24 inches wide by 24 inches high by 24 inches deep (600 mm wide by 600 mm high by 600 mm deep); shall hold both potassium permanganate and activated carbon. Manufactured in two pieces, each 12 inches (300 mm) wide for ease of installation.
3. Media: Porous spherical pellets formed from a combination of powdered, activated carbon and other binders, impregnated with potassium permanganate.
 - a. Leach Test: 180 minutes.
 - b. Potassium Permanganate Content: 4 percent minimum.
 - c. Moisture Content: 20 percent maximum.
 - d. Bulk Density: 34 lb/cu. ft. (0.54 g/mL) **OR** 50 lb/cu. ft. (0.8 g/mL), **as directed**.
 - e. Crush Strength: 40 **OR** 50 **OR** 60, **as directed**, percent maximum.
 - f. Abrasion: 4 percent maximum.
 - g. Nominal Pellet Diameter: 0.125 inch (3.175 mm).
 - h. Percent of Pellet Sizes: 80 to 85 percent after screening.
4. Media: High-grade carbon, manufactured from coconut shells, bituminous coal, or a combination of both.
 - a. Ash Content: 2 to 3 percent.
 - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
 - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
 - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
 - e. Hardness Factor: 95 when tested according to ASTM D 3802.
5. Frame: Galvanized steel **OR** Hot-dip galvanized steel **OR** Aluminum **OR** Stainless steel, **as directed**, hinged, and with pull and retaining handles fastened to the media.

F. Supported Adsorber Bag Filters

1. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames.
2. Media: Carbon-filled fibrous material constructed so individual pleats are maintained under rated-airflow conditions in tapered form by flexible internal supports.
3. Filter-Media Frame: Galvanized steel.
4. Mounting Frames: Welded, galvanized, sheet-steel frame and galvanized-steel fasteners with gaskets; capable of bolting together into built-up filter banks.

G. Front-Access Filter Frames

1. Framing System: Galvanized-steel **OR** Aluminum, **as directed**, framing members with access for upstream (front) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
2. Prefilters: Incorporate a separate track with spring clips, **as directed**, removable from front or back, **as directed**.
3. Sealing: Factory-installed, positive-sealing device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.

H. Side-Service Housings

1. Description: Factory-assembled, side-service housings constructed of galvanized steel **OR** aluminum, **as directed**, with flanges to connect to duct or casing system.
2. Prefilters: Integral tracks to accommodate 2-inch- (50-mm-) thick, disposable or washable, **as directed**, filters.



3. Access Doors: Hinged with continuous **OR** Continuous, **as directed**, gaskets on perimeter and with positive-locking devices. Arrange so filter cartridges can be loaded from either access door.
4. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

I. Filter Gages

1. Diaphragm type, with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 - a. Diameter: 4-1/2 inches (115 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
 - c. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
 - d. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
 - e. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
 - f. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).
2. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage; graduated to read from 0- to 3.0-inch wg (0 to 750 Pa) and accurate within 3 percent of full-scale range.
3. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

1.3 EXECUTION

A. Installation

1. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
2. Install filters in position to prevent passage of unfiltered air.
3. Install filter gage for each filter bank.
4. Do not operate fan system until particulate filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
5. Do not install gas-phase filters until fan system is clean and there is no risk of construction debris loading the filter.
6. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
7. Coordinate filter installations with duct and air-handling unit installations.

B. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Test for leakage of unfiltered air while system is operating.
3. Air filter will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

C. Cleaning

1. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new particulate filter media.

END OF SECTION 23 42 13 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 42 13 00	23 41 13 00	Air Filters



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SECTION 23 51 13 00 - BREECHINGS, CHIMNEYS, AND STACKS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for breechings, chimneys, and stacks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Listed chimney liners.
 - b. Listed single-wall and double-wall vents and chimneys.
 - c. Listed, refractory-lined breechings and stacks.
 - d. Field-fabricated metal breechings and chimneys.
 - e. Listed grease and dishwasher ducts.

C. Submittals

1. Product Data: For the following:
 - a. Chimney liners.
 - b. Type B and BW vents.
 - c. Type L vents.
 - d. Special gas vents.
 - e. Building-heating-appliance chimneys.
 - f. Grease ducts.
 - g. Refractory-lined metal breechings and chimneys.
 - h. Guy wires and connectors.
2. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
3. Welding certificates.
4. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Warranty: Warranty specified in this Section.

D. Quality Assurance

1. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within 10 **OR** 15 **OR** 25, **as directed**, years from date of Final Completion. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1.2 PRODUCTS

A. Listed Chimney Liners

1. Description: Straight **OR** Corrugated, **as directed**, single-wall chimney liner tested according to UL 1777 and rated for 1000 deg F (538 deg C) continuously, or 2100 deg F (1150 deg C) for 10 minutes; with negative or positive flue pressure complying with NFPA 211.



2. Straight Liner Materials: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
 3. Corrugated Liner Materials: ASTM A 240/A 240M, Type 321 **OR** ASTM A 240/A 240M, Type 430 **OR** ASTM A 959, Type 29-4C, **as directed**, stainless steel.
 4. Accessories:
 - a. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
 - b. Sealant: Manufacturer's standard high-temperature sealant.
 - c. Insulating Fill: Manufacturer's standard high-temperature insulation fill material in annular space surrounding chimney liner including high-temperature, ceramic-fiber insulation required to seal chimney at top and bottom.
- B. Listed Type B And BW Vents
1. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B, or 550 deg F (288 deg C) continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.
 2. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.
 3. Inner Shell: ASTM B 209 (ASTM B 209M), Type 1100 aluminum **OR** ASTM B 209 (ASTM B 209M), Type 3003 aluminum **OR** ASTM B 209 (ASTM B 209M), Type 3105 aluminum **OR** ASTM A 666, Type 430 stainless steel, **as directed**.
 4. Outer Jacket: Galvanized **OR** Aluminized, **as directed**, steel.
 5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - a. Termination:
 - 1) Stack cap designed to exclude minimum 90 percent of rainfall.
OR
Round chimney top designed to exclude minimum 98 percent of rainfall.
OR
Exit cone with drain section incorporated into riser.
OR
Antibackdraft.
- C. Listed Type L Vents
1. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F (300 deg C) continuously, or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
 2. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) **OR** 1-inch (25-mm) **OR** 2-inch (50-mm) **OR** 4-inch (100-mm), **as directed**, airspace filled with high-temperature, ceramic-fiber **OR** mineral-wool, **as directed**, insulation.
 3. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
 4. Outer Jacket: Galvanized **OR** Aluminized **OR** Stainless, **as directed**, steel.
 5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - a. Termination:
 - 1) Stack cap designed to exclude 90 percent of rainfall.
OR
Round chimney top designed to exclude 98 percent of rainfall.
OR
Exit cone with drain section incorporated into riser.
- D. Listed Special Gas Vents
1. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F (248 deg C) continuously, with positive or negative flue pressure complying with NFPA 211.



2. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (13-mm) airspace.
 3. Inner Shell: ASTM A 959, Type 29-4C stainless steel.
 4. Outer Jacket: Aluminized **OR** Stainless, **as directed**, steel.
 5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - a. Termination:
 - 1) Stack cap designed to exclude minimum 90 percent of rainfall.
OR
Round chimney top designed to exclude minimum 98 percent of rainfall.
OR
Exit cone with drain section incorporated into riser.
- E. Listed Building-Heating-Appliance Chimneys
1. Description for building-heating-appliance chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously, or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
 - a. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (25-mm) **OR** 1-inch (50-mm) **OR** 2-inch (50-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation, **as directed**.
 - b. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
 2. Description for 1400 deg F (760 deg C) chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines: Double-wall metal vents tested according to UL 103 and UL 959 and rated for 1400 deg F (760 deg C) continuously, or 1800 deg F (982 deg C) for 10 minutes; with positive or negative flue pressure complying with NFPA 211.
 - a. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) **OR** 2-inch (50-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
 - b. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
 3. Description for Type HT chimneys suitable for fireplaces and other solid-fuel-burning appliances: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously, or 2100 deg F (1150 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
 - a. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) **OR** 1-1/2-inch (38-mm) **OR** 2-inch (50-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
 - b. Inner Shell: ASTM A 666, Type 304 **OR** ASTM A 666, Type 316 **OR** ASTM A 240/A 240M, Type 430, **as directed**, stainless steel.
 4. Outer Jacket: Galvanized **OR** Aluminized **OR** Stainless, **as directed**, steel.
 5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - a. Termination:
 - 1) Stack cap designed to exclude minimum 90 percent of rainfall.
OR
Round chimney top designed to exclude minimum 98 percent of rainfall.
OR
Exit cone with drain section incorporated into riser.
- F. Listed Grease Ducts
1. Description: Double-wall metal vents tested according to UL 1978 and rated for 500 deg F (260 deg C) continuously, or 2000 deg F (1093 deg C) for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.



2. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) **OR** 2-inch (50-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
 3. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
 4. Outer Jacket: Aluminized **OR** Stainless, **as directed**, steel where concealed. Stainless steel where exposed.
 5. Accessories: Tees, elbows, increasers, hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters and drain fittings.
- G. Listed, Refractory-Lined Metal Breechings And Chimneys
1. Comply with ASME STS-1.
 2. Design Wind Loads: 150 mph (241 km/h), **as directed**.
 3. Design for seismic conditions at Project site.
 4. Chimney Outer Jacket: Aluminized **OR** Galvanized, **as directed**, steel with riveted **OR** welded, **as directed**, seams.
 5. Refractory Lining: Tested according to UL 959 for temperature and acid resistance, and bearing the testing laboratory label.
 - a. Temperature Rating: 1800 deg F (982 deg C) continuously, and 2000 deg F (1093 deg C) intermittently.
 - b. Acid Extraction: Maximum of 0.2 percent.
 - c. Cold Crushing Strength: Minimum of 3200 psig (22 MPa).
 - d. Thickness: Minimum of 2 inches (50 mm).
 6. Finish: Factory-applied, high-heat-resistant paint; color as selected.
 7. Base Section: Acid-resistant-coated, cast-iron anchor lugs for securing stack to foundation with anchorage designed by manufacturer, **as directed**.
 8. Reinforced Cleanout Section: Smoke-tight connection, with gasketed and bolt-tightened inspection plate; neck shall be welded to stack section.
 9. T or Y Sections: Smoke-tight connection, with welded joints and refractory lining; finished with smooth transition and with no exposed metal on inside.
 10. Spark Screen: ASTM A 666, Type 316 stainless steel, 0.0625 inch (1.6 mm) thick, maximum 1/2-by-1/2-inch (13-by-13-mm) mesh, with ASTM A 666, Type 304 stainless-steel rolled angle and drawband.
 11. Guy Bands: 8-inch- (200-mm-) wide bands of same material as jacket, with bolted fasteners.
 12. Roof Penetration: Factory-fabricated thimbles, flashings, and counterflashings.
 13. Fabricate sections, fittings, and accessories as individual pieces or in combination lengths for field handling.
 14. Fabricate components with centrifugally cast refractory lining in lengths suitable for connection with drawbands.
 15. Bond refractory to steel jacket with calcium aluminate cement to prevent separation in finished product during shipping, handling, and installation.
 16. Fabricate stacks with anchor lugs; cleanout; T sections; flashings and counterflashings; and provisions for support, expansion, and contraction.
- H. Field-Fabricated Metal Breechings And Chimneys
1. Fabricate freestanding chimneys according to SMACNA's "Guide for Steel Stack Design and Construction."
 2. Fabricate breechings and chimneys from ASTM A 1011/A 1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.
 - a. Equal to or Less Than 1.069 Sq. Ft. (0.099 Sq. m.) or 14 Inches (356 mm) in Diameter: 0.053 inch (1.35 mm).
 - b. Up to 1.396 Sq. Ft. (0.129 Sq. m) or 16 Inches (406 mm) in Diameter: 0.067 inch (1.7 mm).



- c. Up to 1.764 Sq. Ft. (0.164 Sq. m.) or 18 Inches (457 mm) in Diameter: 0.093 inch (2.36 mm).
 - d. Larger Than Above: 0.123 inch (3.12 mm).
 3. Fabricate chimneys and vent connectors from galvanized steel, complying with NFPA 211 for minimum metal thickness.
 - a. Equal to or Less Than 6 Inches (152 mm) in Diameter: 0.019 inch (0.48 mm).
 - b. Up to 10 Inches (254 mm) in Diameter: 0.024 inch (0.61 mm).
 - c. Up to 16 Inches (406 mm) in Diameter: 0.029 inch (0.74 mm).
 - d. Larger Than Above: 0.056 inch (1.42 mm).
 4. Fabricate chimneys and vent connectors from ASTM B 209 (ASTM B 209M), Type 1100 or 3003, aluminum or stainless steel, complying with NFPA 211 for the following minimum metal thicknesses:
 - a. Aluminum: 0.027 inch (0.69 mm).
 - b. Stainless Steel: 0.012 inch (0.31 mm).
 5. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.
 6. Fabricate engine exhaust from ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** Schedule 80, **as directed**, pipe; with welded joints and carbon-steel fittings and flanges.
 - a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 - b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, including bolts, nuts, and gaskets.
- I. Guying And Bracing Materials
1. Cable: Three **OR** Four, **as directed**, galvanized, stranded wires of the following thickness:
 - a. Minimum Size: 1/4 inch (6 mm) in diameter.
 - b. For ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).
 - c. For ID Sizes 18 to 24 Inches (457 to 610 mm): 3/8 inch (9.5 mm).
 - d. For ID Sizes 27 to 30 Inches (685 to 762 mm): 7/16 inch (11 mm).
 - e. For ID Sizes 33 to 36 Inches (838 to 915 mm): 1/2 inch (13 mm).
 - f. For ID Sizes 39 to 48 Inches (990 to 1220 mm): 9/16 inch (14.3 mm).
 - g. For ID Sizes 51 to 60 Inches (1295 to 1524 mm): 5/8 inch (16 mm).
 2. Pipe: Two **OR** Three, **as directed**, galvanized steel, NPS 1-1/4 (DN 32).
 3. Angle Iron: Two **OR** Three, **as directed**, galvanized steel, 2 by 2 by 0.25 inch (50 by 50 by 6 mm).

1.3 EXECUTION

A. Application

1. Listed Chimney Liners: High-efficiency boiler or furnace vents in masonry chimney, dishwasher exhaust, or Type II commercial kitchen hood.
2. Listed Type B and BW Vents: Vents for certified gas appliances.
3. Listed Type L Vents: Vents for low-heat appliances.
4. Listed Special Gas Vents: Condensing gas appliances.
5. Listed Building-Heating-Appliance Chimneys: Dual-fuel boilers, oven vents, water heaters, and exhaust for engines. Fireplaces and other solid-fuel-burning appliances.
6. Listed Grease Ducts: Type I commercial kitchen grease duct.
7. Listed, Refractory-Lined Metal Breechings and Chimneys: Freestanding dual-fuel boiler vents, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.
8. Field-Fabricated Metal Breechings and Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.
9. Field-Fabricated Metal Breechings and Chimneys: Steel pipe for use with engine exhaust.

B. Installation Of Listed Vents And Chimneys



1. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
 2. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
 3. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
 4. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
 5. Lap joints in direction of flow.
 6. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.
 7. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.
 8. Erect stacks plumb to finished tolerance of no more than 1 inch (25 mm) out of plumb from top to bottom.
- C. Installation Of Unlisted, Field-Fabricated Breechings And Chimneys
1. Suspend breechings and chimneys independent of their appliance connections.
 2. Install, support, and restrain according to seismic requirements.
 3. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch (3-mm) misalignment tolerance.
 4. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
 5. Lap joints in direction of flow.
 6. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.
- D. Cleaning
1. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
 2. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.
 3. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 23 51 13 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 51 16 00	23 51 13 00	Breechings, Chimneys, And Stacks



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SECTION 23 52 13 00 - ELECTRIC BOILERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for electric boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged, factory-fabricated and -assembled electric boilers, trim, and accessories for generating hot water or steam.

C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. NFPA Compliance: Design and fabricate boilers to comply with NFPA 70, "National Electrical Code," Article 424, Paragraphs G and H.
4. UL Compliance: Test boilers for compliance with UL 834, "Heating, Water Supply, and Power Boilers--Electric." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace pressure vessels of boilers that fail in materials or workmanship within five years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units

1. Description: Factory-fabricated, -assembled, and -tested electric boilers with trim and controls necessary to generate hot water **OR** steam, **as directed**.



2. Pressure Vessel: Carbon-steel **OR** Cast-iron, **as directed**, pressure vessel mounted on structural-steel base.
3. Nozzles: Flanges for water inlet and **OR** steam, **as directed**, outlet and heating element inserts; threaded connections for trim and controls.
4. Insulation: One layer **OR** Two layers, **as directed**, of minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, glass-fiber insulation.
5. Jacket: Galvanized, **as directed**, sheet metal casing with baked-enamel **OR** powder-coated, **as directed**, protective finish and removable panels with snap-in or interlocking closures for access to pressure vessel.
6. Lifting Lugs: Welded to pressure vessel, extending above jacket.
7. Heating Elements: Copper **OR** Incoloy, **as directed**, -sheathed, replaceable electric-resistance element, rated 20 kW maximum, with maximum 50 W/sq. in. (7.7 W/sq. cm) **OR** 75 W/sq. in. (11.5 W/sq. cm), **as directed**, over heat-transfer length.
8. Mounting base to secure boiler to concrete base.
 - a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

B. Trim For Hot-Water Boilers

1. Include devices sized to comply with ANSI B31.1, "Power Piping" **OR** ANSI B31.9, "Building Services Piping," **as directed**.
2. Aquastat Controllers: Operating auto-reset high limit.
3. Safety Relief Valve: ASME rated.
4. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
6. Dip-tube in water outlet.
7. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end ball valve sized per requirements of authorities having jurisdiction.
8. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper part of pressure vessel and sealed with fiber gasket.
 - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

C. Trim For Steam Boilers

1. Include devices sized to comply with ANSI B31.1, "Power Piping" **OR** ANSI B31.9, "Building Services Piping," **as directed**.
2. Pressure Controllers: Operating auto-reset high limit.
3. Safety Relief Valve:
 - a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
 - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
4. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure about 50 percent of full range.
5. Water Column: Minimum 12-inch (300-mm) glass gage with shutoff cocks.
6. Drain Valves: Minimum NPS 3/4 (DN 20) or nozzle size with hose-end connection.



7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
10. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of pressure vessel and sealed with fiber gasket.
 - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

D. Controls

1. Boiler operating controls shall include the following devices and features:
 - a. Control transformer.
 - b. Step controller.
 - c. Recycling relay returns controller to off position after power failure.
 - d. Multistage thermostat.
 - e. Control circuit switch.
 - f. Visual indication for each step.
 - g. Supply-voltage indicator.
 - h. Set-Point Adjust: Set points shall be adjustable.
 - i. Operating Level Control: Factory wired and mounted to cycle feedwater pump(s) for makeup water control.
 - j. Sequence of Operation for hot-water boilers: Electric, factory-fabricated and field-installed panel to control element sequence controller to maintain space temperature in response to thermostat with heat anticipator located in heated space.
 - k. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control element sequence controller to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).
 - l. Sequence of Operation for steam boilers: Electric, factory-fabricated and field-installed panel to control element sequence controller to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
 - 1) Include automatic, alternating-operation sequence for multiple boilers to provide equal runtime for boilers.
2. Safety Controls: To maintain safe operating conditions, safety controls limit boiler operation.
 - a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops boiler if operating conditions rise above set point or maximum boiler design temperature **OR** pressure, **as directed**.
 - b. Low-Water Cutoff Switch: Electronic **OR** Float and electronic, **as directed**, probe shall prevent boiler operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
 - c. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
3. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.



- 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
- b. A communication interface with building management system shall enable building management system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building management system.

E. Electrical Power

1. Single-Point Field Power Connection: Factory-installed and -wired switches, transformers, and electrical devices necessary shall provide a single-point field power connection to boiler.
 - a. Field power interface shall be to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - b. Interlock with door to de-energize power with door open.
2. Electrical Enclosures: NEMA 250, Type 1, **as directed**, enclosure with hinged door and key-locking handle.
3. Install factory wiring outside of an enclosure in a metal, **as directed**, raceway.
4. Comply with NFPA 70.
 - a. Electrical Circuits: 48 A, maximum.
5. Connectors: Mechanical lugs bolted to copper bus bars or distribution blocks with pressure connectors.
6. Fuses: NEMA FU 1, Class J or K5; 60 A, maximum.
7. Contactors: 3-pole magnetic contactors, listed for 500,000 cycles at full load.
8. Factory-wired internal control devices and heating elements.
 - a. Wiring shall be numbered and color coded to match the wiring diagram.

F. Source Quality Control

1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
2. Hydrostatic Test: Factory test assembled boiler including hydrostatic test.

1.3 EXECUTION

A. Boiler Installation

1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31..
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm), **as directed**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install electrical devices furnished with boiler but not specified to be factory mounted.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
4. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
5. Install piping from safety relief valves to nearest floor drain.
6. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
7. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.



8. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. Perform installation and startup checks according to manufacturer's written instructions.
 - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 1) Check and adjust initial operating set points and high- and low-limit safety set points of water level and water temperature **OR** steam pressure, **as directed**.
 - 2) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 3. Remove and replace malfunctioning units and retest as specified above.
 4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
- D. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain boilers. Video training sessions, **as directed**.

END OF SECTION 23 52 13 00



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SECTION 23 52 16 13 - CONDENSING BOILERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for condensing boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, pulse-combustion, fire-tube, water-tube, and water-jacketed condensing boilers, trim, and accessories for generating hot water or steam.

C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
 - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
 4. Source quality-control test reports.
 5. Field quality-control test reports.
 6. Operation and maintenance data.
 7. Warranty: Special warranty specified in this Section.
 8. Other Informational Submittals:
 - a. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
5. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.



E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Pulse-Combustion Boilers:
 - 1) Heat Exchanger Damaged by Thermal Shock: 10 years from date of Final Completion.
 - 2) Heat-Exchanger Corrosion: Prorated **OR** Nonprorated, **as directed**, for five years from date of Final Completion.
 - b. Warranty Period for Fire-Tube Condensing Boilers:
 - 1) Leakage and Materials: 10 years from date of Final Completion.
 - 2) Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated **OR** Nonprorated for five years from date of Final Completion.
 - c. Warranty Period for Water-Tube Condensing Boilers: 20 years from date of Final Completion.
 - d. Warranty Period for Water-Jacketed Condensing Boilers:
 - 1) Leakage and Materials: Eight years from date of Final Completion.
 - 2) Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated **OR** Nonprorated, **as directed**, for five years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units: Pulse-Combustion Condensing Boilers.

1. Description: Factory-fabricated, -assembled, and -tested, pulse-combustion condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.
2. Heat Exchanger: Type 316L, stainless-steel **OR** Carbon-steel, **as directed**, primary and secondary combustion chamber.
3. Pressure Vessel: Carbon steel with welded heads and tube connections.
4. Exhaust Decoupler: Fiberglass composite material in a corrosion-resistant steel box.
5. Burner: Natural **OR** Propane, **as directed**, gas, self-aspirating and self-venting after initial start.
6. Blower: Centrifugal fan to operate only during start of each burner sequence.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
7. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
8. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
9. Casing:
 - a. Jacket: Sheet metal, with snap-in or interlocking closures.
 - b. Control Compartment Enclosure: NEMA 250, Type 1A.
 - c. Finish: Baked-enamel **OR** Powder-coated, **as directed**, protective finish.
 - d. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
 - e. Draft Hood: Integral **OR** External, **as directed**.
 - f. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
 - g. Mounting base to secure boiler to concrete base.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.



10. Mufflers: Carbon-steel intake muffler and stainless-steel exhaust.
 11. Condensate Trap: Cast-iron body with stainless-steel internal parts.
- B. Manufactured Units: Fire-Tube Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
 2. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.
 3. Pressure Vessel: Carbon steel with welded heads and tube connections.
 4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft.
 5. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 6. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
 7. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
 8. Casing:
 - a. Jacket: Sheet metal **OR** Plastic, **as directed**, with snap-in or interlocking closures.
 - b. Control Compartment Enclosures: NEMA 250, Type 1A.
 - c. Finish: Baked-enamel **OR** Powder-coated, **as directed**, protective finish for sheet metal jacket.
 - d. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber **OR** polyurethane-foam, **as directed**, insulation surrounding the heat exchanger.
 - e. Combustion-Air Connections: Inlet and vent duct collars.
 - f. Mounting base to secure boiler.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- C. Manufactured Units: Water-Tube Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, water-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
 2. Heat Exchanger: Finned-copper primary and stainless-steel secondary heat exchangers.
 3. Combustion Chamber: Stainless steel, sealed.
 4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft drawing from gas premixing valve.
 5. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 6. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
 7. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.
 8. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.
 9. Casing:
 - a. Jacket: Sheet metal, with snap-in or interlocking closures.
 - b. Control Compartment Enclosures: NEMA 250, Type 1A.



- c. Finish: Textured epoxy.
 - d. Insulation: Minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, mineral-fiber insulation surrounding the heat exchanger.
 - e. Combustion-Air Connections: Inlet and vent duct collars.
 - f. Mounting base to secure boiler.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- D. Manufactured Units: Water-Jacketed Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, water-jacketed condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; water supply, return, and condensate drain connections; and controls. Water heating service only.
 2. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.
 3. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.
 4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft; swing-open front and burner observation port.
 5. Blower: Centrifugal fan, forced draft. Include prepurge and postpurge of the combustion chamber.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 6. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.
 7. Ignition: Electric-spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
 8. Casing:
 - a. Jacket: Sheet metal, with snap-in or interlocking closures.
 - b. Control Compartment Enclosures: NEMA 250, Type 1A.
 - c. Finish: Powder-coated protective finish.
 - d. Insulation: Minimum 4-inch- (100-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
 - e. Combustion-Air Connections: Inlet and vent duct collars.
 - f. Mounting base to secure boiler.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- E. Trim: For Hot-Water Boilers.
1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
 2. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
 3. Safety Relief Valve: ASME rated.
 4. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
 5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
 6. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.



7. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.
- F. Trim: For Steam Boilers.
1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
 2. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
 3. Safety Relief Valve:
 - a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
 - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
 4. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure about 50 percent of full range.
 5. Water Column: Minimum 12-inch (300-mm) glass gage with shutoff cocks.
 6. Drain Valves: Minimum NPS 3/4 (DN 20) or nozzle size with hose-end connection.
 7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
 8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
 9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
- G. Controls
1. Refer to Division 23 Section "Instrumentation And Control For Hvac".
OR
Boiler operating controls shall include the following devices and features:
 - a. Operating Pressure Control for Steam Boilers: Factory wired and mounted to cycle burner.
 - b. Low-Water Cutoff and Pump Control for Steam Boilers: Cycle feedwater pump(s) for makeup water control.
 - c. Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
OR
Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).
 - d. Sequence of Operation for Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
 - 1) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
 2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
 - a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature for hot-water boiler or pressure for steam boiler.



- b. Low-Water Cutoff Switch: Electronic for hot-water boilers or Float and electronic for steam boilers probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
- c. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
- d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- 3. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
 - 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
 - b. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

H. Electrical Power

- 1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
OR
Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 - a. House in NEMA 250, Type 1 enclosure.
 - b. Wiring shall be numbered and color-coded to match wiring diagram.
 - c. Install factory wiring outside of an enclosure in a metal raceway.
 - d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - e. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
 - f. Provide each motor with overcurrent protection.

I. Venting Kits

- 1. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
- 2. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

J. Source Quality Control

- 1. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- 2. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
- 3. Allow the Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

1.3 EXECUTION

A. Boiler Installation



1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31..
 2. Vibration Isolation for Equipment Supported on Slabs-On -Grade: Elastomeric isolation pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 3. Install gas-fired boilers according to NFPA 54.
 4. Assemble and install boiler trim.
 5. Install electrical devices furnished with boiler but not specified to be factory mounted.
 6. Install control wiring to field-mounted electrical devices.
- B. Connections
1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to boiler to allow service and maintenance.
 3. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
 4. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "Common Work Results For Hvac".
 5. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
 6. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
 7. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
 8. Install piping from safety relief valves to nearest floor drain.
 9. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
 10. Boiler Venting:
 - a. Install flue venting kit and combustion-air intake.
 - b. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks".
 11. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 12. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. Perform installation and startup checks according to manufacturer's written instructions.
 - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 1) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature **OR** steam pressure, **as directed**.
 - 2) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 3. Remove and replace malfunctioning units and retest as specified above.



4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
5. Performance Tests, **as directed**:
 - a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
 - c. Perform field performance tests to determine capacity and efficiency of boilers.
 - 1) Test for full capacity.
 - 2) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
 - d. Repeat tests until results comply with requirements indicated.
 - e. Provide analysis equipment required to determine performance.
 - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
 - g. Notify the Owner in advance of test dates.
 - h. Document test results in a report and submit to the Owner.

D. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 23 52 16 13



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 52 33 13	22 34 36 00	Water-Tube Boilers
23 52 33 16	22 34 36 00	Water-Tube Boilers



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SECTION 23 52 36 00 - FIRE-TUBE BOILERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fire-tube boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged, factory-fabricated and -assembled boilers, trim, and accessories for generating hot water **OR** steam, **as directed**, with the following configurations and burners:
 - a. Horizontal, fire-tube, Vertical, fire-tube, and Fire-box boiler.
 - b. Gas, Oil, and Combination gas and oil burner.

C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
 - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.
8. Other Informational Submittals:
 - a. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
 - b. Startup service reports.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. UL Compliance: Test Boilers for compliance with UL 726, "Oil-Fired Boiler Assemblies" **OR** UL 726, "Oil-Fired Boiler Assemblies" and UL 795, "Commercial-Industrial Gas Heating Equipment" **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.



E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace front- and rear-door refractories and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.
 - a. Horizontal, Fire-Tube and Fire-Box Boilers: Refractory in front and rear doors, 10 years from date of startup by factory-authorized personnel.
 - b. Vertical, Fire-Tube Boilers and Heat Exchanger: Five years from date of Final Completion, if following water-treatment program recommended by manufacturer.

1.2 PRODUCTS

A. Manufactured Units - Horizontal, Fire-Tube Boilers

1. Description: Factory-fabricated, -assembled, and -tested, horizontal, fire-tube boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water supply and return connections, and controls.
2. Pressure Vessel Design: Straight, steel tubes rolled **OR** welded, **as directed**, into steel headers. Three **OR** Four, **as directed**, passes with dry-back **OR** wet-back, **as directed**, design. Minimum heat-exchanger surface of 5 sq. ft./bhp (2.1 sq. m/10 kW). Include the following accessories:
 - a. Handholes for water-side inspections.
 - b. Lifting lugs on top of boiler.
 - c. Minimum NPS 1 (DN 25) hose-end drain valves at shell low point.
 - d. For hot-water boilers only:
 - 1) Tappings or flanges for supply- and return-water piping.
 - 2) Built-in air separator.
 - e. For steam boilers only:
 - 1) Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 - 2) Tappings for steam supply, makeup, level controls, and chemical treatment.
3. Front and Rear Doors:
 - a. Bolted **OR** Hinged **OR** Davited, **as directed**, sealed with heat-resistant gaskets and fastened with lugs and cap screws.
 - b. Designed so tube sheets and flues are fully accessible for inspection or cleaning when doors are open.
 - c. Include observation ports in doors at both ends of boiler for inspection of flame conditions.
 - d. Door refractory **OR** insulation, **as directed**, shall be accessible for inspection and maintenance.
4. Casing:
 - a. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the boiler shell.
 - b. Flue Connection: Flange at top of boiler.
 - c. Jacket: Galvanized sheet **OR** Sheet, **as directed**, metal, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
 - d. Mounting base to secure boiler to concrete base.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
 - e. Control Compartment Enclosure: NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**.
5. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum 3-1/2-inch- (89-mm-) diameter dial.

B. Manufactured Units - Vertical, Fire-Tube Boilers



1. Description: Factory-fabricated, -assembled, and -tested, vertical, fire-tube boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water supply and return connections, and controls.
 2. Pressure Vessel Design: Straight, steel pipe welded in a concentric pattern to separate flue-gas and heating media to form two **OR** four, **as directed**, passes with welded fins to improve heat transfer in secondary flue-gas passages. Include the following accessories:
 - a. Handholes for water-side inspections.
 - b. Lifting lugs on top of boiler.
 - c. Minimum NPS 1 (DN 25) hose-end drain valves at water passage low point.
 - d. For hot-water boilers only:
 - 1) Tappings or flanges for supply- and return-water piping.
 - 2) Built-in air separator.
 - e. For steam boilers only:
 - 1) Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 - 2) Tappings for steam supply, makeup, level controls, and chemical treatment.
 3. Combustion Chamber: Equipped with flame retainer to lengthen flame-residence time.
 4. Casing:
 - a. Insulation: Minimum 4-inch- (100-mm-) thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber.
 - b. Flue Connection: Top connection, constructed of aluminized **OR** stainless, **as directed**, steel.
 - c. Jacket: Mirror-finish stainless steel with screw-fastened closures.
OR
Jacket: Galvanized sheet **OR** Sheet, **as directed**, metal, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
 - d. Mounting base to secure boiler to concrete base.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 22 Section "Identification For Plumbing Piping And Equipment" when mounting base is anchored to building structure.
 - e. Control Compartment Enclosure: NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**.
 5. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum 3-1/2-inch- (89-mm-) diameter dial.
- C. Manufactured Units - Fire-Box Boilers
1. Description: Factory-fabricated, -assembled, and -tested, fire-box boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water supply and return connections, and controls.
 2. Pressure Vessel Design: Straight, steel tubes rolled **OR** welded, **as directed**, into steel headers. Three passes with wet-back design. Minimum heat-exchanger surface of 5 sq. ft./bhp (2.1 sq. m/10 kW). Include the following features and accessories:
 - a. Tube Size and Thickness: Minimum NPS 2 (DN 50), minimum 0.105 inch (2.667 mm) thick.
 - b. Brass washout plugs.
 - c. Steel turbulators.
 - d. Lifting lugs on top of boiler.
 - e. Minimum NPS 1 (DN 25) hose-end drain valves at shell low point.
 - f. For hot-water boilers only:
 - 1) Tappings or flanges for supply- and return-water piping.
 - 2) Built-in air separator.
 - g. For steam boilers only:
 - 1) Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 - 2) Tappings for steam supply, makeup, level controls, and chemical treatment.



3. Combustion Chamber: Welded steel, waterwall and -floor design **OR** water-leg design with refractory insulation poured in the floor, **as directed**. Flame observation port.
4. Casing:
 - a. Insulation: Minimum 2-inch- (50-mm-) thick, foil-backed, **as directed**, mineral-fiber insulation surrounding the boiler shell.
 - b. Insulated removable smoke boxes and reversing chamber cover.
 - c. Flue Connection: Steel top **OR** rear, **as directed**.
 - d. Jacket: Sheet metal, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
 - e. Control Compartment Enclosure: NEMA 250, Type 1 **OR** 1A **OR** 4 **OR** 4X **OR** 12, **as directed**.
 - f. Mounting base to secure boiler to concrete base.
 - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
5. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum 3-1/2-inch- (89-mm-) diameter dial.

D. Burner For Forced-Draft Gas Burners

1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for natural **OR** propane, **as directed**, gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
4. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
5. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - a. Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.

E. Burner For Oil Burners

1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 - a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.



- 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
 4. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
 5. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - a. Maximum Oxides of Nitrogen Emissions: 30 ppm.
- F. Burner For Combination Gas And Oil Burners
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and natural **OR** propane, **as directed**, gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
 2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 3. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 - a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
 - 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
 4. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 5. Gas Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
 6. Oil Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
 7. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
 - a. Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
- G. Trim For Hot-Water Boilers
1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
 2. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
 3. Safety Relief Valve: ASME rated.
 4. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
 5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
 6. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
 7. Tankless Heater: Carbon-steel **OR** Bronze, **as directed**, header with copper-tube heat exchanger, mounted in a port of upper drum and sealed with fiber gasket.
 - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.



- b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

H. Trim For Steam Boilers

1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
2. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
3. Safety Relief Valve:
 - a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
 - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
4. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure about 50 percent of full range.
5. Water Column: Minimum 12-inch (300-mm) glass gage with shutoff cocks.
6. Drain Valves: Minimum NPS 3/4 (DN 20) or nozzle size with hose-end connection.
7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve for field installation at boiler outlet with free-blow drain valve for field installation between the two valves and visible when operating stop-check valve.
10. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in a port of upper manifold and sealed with fiber gasket.
 - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

I. Controls

1. Refer to Division 23 Section "Instrumentation And Control For Hvac".
OR
Boiler operating controls shall include the following devices and features:
 - a. Control transformer.
 - b. Set-Point Adjust: Set points shall be adjustable.
 - c. Operating Pressure Control for steam boilers: Factory wired and mounted to cycle burner.
 - d. Low-Water Cutoff and Pump Control for steam boilers: Cycle feedwater pump(s) **OR** Operate feedwater pump(s) continuously and modulate valve, **as directed**, for makeup water control.
 - e. Sequence Of Operation For Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
OR
Sequence Of Operation For Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).



- f. Sequence Of Operation For Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
 - 1) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
 - 2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
 - a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature for hot-water boiler **OR** design pressure for steam boiler, **as directed**.
 - b. Low-Water Cutoff Switch: Electronic for hot-water boilers **OR** Float and electronic for steam boilers, **as directed**, probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
 - c. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
 - 3. Building Automation System Interface: Factory-install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
 - 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
 - b. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.
- J. Electrical Power
- 1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22..
OR
Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 - a. House in NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
 - b. Wiring shall be numbered and color-coded to match wiring diagram.
 - c. Install wiring outside of an enclosure in a metal, **as directed**, raceway.
 - d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - e. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
 - f. Provide each motor with overcurrent protection.
- K. Source Quality Control
- 1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
 - 2. Burner and Hydrostatic Test for factory-assembled boilers: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
 - 3. Allow the Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.



1.3 EXECUTION

A. Boiler Installation

1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install gas-fired boilers according to NFPA 54.
4. Install oil-fired boilers according to NFPA 31.
5. Assemble and install boiler trim.
6. Install electrical devices furnished with boiler but not specified to be factory mounted.
7. Install control wiring to field-mounted electrical devices.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
4. Connect oil piping full size to burner inlet with shutoff valve and union.
5. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
6. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
7. Install piping from safety relief valves to nearest floor drain, for hot-water boilers.
8. Install piping from safety valves to drip-pan elbow and to nearest floor drain, for steam boilers.
9. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
10. Connect breeching full size to boiler outlet. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for venting materials.
11. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for recirculation duct materials.
12. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
13. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Perform installation and startup checks according to manufacturer's written instructions.
 - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 1) Burner Test for field-assembled boilers: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.



- 2) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature **OR** steam pressure, **as directed**.
- 3) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
3. Remove and replace malfunctioning units and retest as specified above.
4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
5. Performance Tests, **as directed**:
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
 - c. Perform field performance tests to determine the capacity and efficiency of boilers.
 - 1) For dual-fuel boilers, perform tests for each fuel.
 - 2) Test for full capacity.
 - 3) Test for boiler efficiency at low fire, 20, 40, 60, 80, 100, 80, 60, 40 and 20, **as directed**, percent of full capacity. Determine efficiency at each test point.
 - d. Repeat tests until results comply with requirements indicated.
 - e. Provide analysis equipment required to determine performance.
 - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
 - g. Notify the Owner in advance of test dates.
 - h. Document test results in a report and submit to the Owner.

D. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 23 52 36 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 52 39 13	23 52 36 00	Fire-Tube Boilers



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SECTION 23 53 16 00 - FEEDWATER EQUIPMENT

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for feedwater equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Feedwater pumps and receivers.
 - b. Vacuum-type feedwater pumps and receivers.

C. Definition

1. NPSH: Net-positive suction head.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacity, temperature and NPSH required, pump performance curves with selection points clearly indicated, and furnished specialties and accessories.
2. Shop Drawings: Include plans, elevations, sections, details, dimensions, weights, loadings, required clearances, method of field assembly, and attachments to other work.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that feedwater equipment, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Field quality-control test reports.
5. Operation and Maintenance Data.

E. Quality Assurance

1. Regulatory Requirements: Fabricate and test unit according to ASME PTC 12.1, "Closed Feedwater Heaters."
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. ASME Compliance: ASME B31.1, "Power Piping," for systems more than 15 psig (104 kPa); ASME B31.9, "Building Services Piping," for systems equal to or less than 15 psig (104 kPa). Safety valves and pressure vessels shall bear the appropriate ASME label.

F. Delivery, Storage, And Handling

1. Preparation for Shipping: Clean flanges and exposed-metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
2. Store units in dry location.
3. Retain protective flange covers and machined-surface protective coatings during storage.
4. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
5. Comply with manufacturer's written rigging instructions.

1.2 PRODUCTS

A. Feedwater Units



1. Description: Factory-assembled and -tested unit consisting of a receiver, simplex **OR** duplex, **as directed**, feedwater pumps, controls, and the following features and accessories:
 - a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.
 - b. Level gage glass, reflex flat type, **as directed**, with stops at top and bottom.
 - c. Lifting eyes.
 - d. Companion flanges.
 - e. Pump, suction and discharge isolation valve, inlet strainer, discharge check valve, and liquid-filled pressure gage.
 - f. Makeup Water Assembly: Float operated with integral valve **OR** Electric level controller and valve, **as directed**; with inlet strainer and three-valve bypass.
 - g. Feedwater Heater: Sparge tube, thermostat, and control valve.
 - h. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
 - 1) Cast-Iron Threaded Fittings: ASME B16.4; Class 125 **OR** 250, **as directed**.
 - 2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
 - 3) Forged-Steel Fittings: ASME B16.11, Class 3000.
 - 4) Malleable-Iron Unions: ASME B16.39; Class 150 **OR** 300, **as directed**.
 - 5) Forged-Steel Unions: MSS SP-83, Class 3000.
 - i. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
 - 1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 - 2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
2. Receiver:
 - a. Material: Close-grain cast iron **OR** Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
 - b. Additional corrosion protection:
 - 1) 0.07-inch (1.8-mm) **OR** 0.13-inch (3.3-mm) **OR** 0.19-inch (4.8-mm), **as directed**, thickness allowance.
 - 2) Electrolytic corrosion-inhibitor anode.
 - c. Finish: Primer **OR** Primer under enamel topcoat **OR** Primer under epoxy topcoat, **as directed**.
 - d. Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
 - e. Mounting Arrangement: Recessed below floor **OR** Floor mounted, **as directed**.
 - f. Mounting Frame: Structural-steel stand to support receiver and pumps. Fabricate stand with bracing adequate for seismic forces according to authorities having jurisdiction and to allow anchoring mounting frame to floor, **as directed**.
3. Vertical Feedwater Pump: Flange-mounted, close-coupled, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
 - a. Impeller: Bronze **OR** Stainless steel, **as directed**.
 - b. Seals: Mechanical.
 - c. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
4. Horizontal Feedwater Pump: Base-mounted, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
 - a. Impeller: Bronze **OR** Stainless steel, **as directed**.



- b. Coupling: Close **OR** Flexible, **as directed**.
 - c. Seals: Mechanical.
 - d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
5. Control panel shall be unit mounted and factory wired and include the following:
- a. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
 - b. Single-point field power interface to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - 1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
 - c. NEMA-rated motor controller for each motor, and include a hand-off-auto switch and overcurrent protection.
 - 1) Alternating controls for duplex units with intermittent operation as indicated by control sequence.
 - d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 - e. Wiring outside of an enclosure in a metal, **as directed**, raceway. Make connections to motor with liquidtight conduit.
 - f. Removable control mounting plate.
 - g. Visual indication of status and alarm with momentary test push button, **as directed**.
 - h. Audible alarm and silence switch.
 - i. Visual indication of elapsed run time, graduated in hours.
 - j. Fused control-circuit transformer.
 - k. Microprocessor-based controller.
6. Feedwater Simplex-Pump Control Sequence:
- a. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
 - b. Visual indication of pump on and off, **as directed**, status.
 - c. Visual and audible, **as directed**, alarm indication of pump failure.
7. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with operating and standby pump):
- a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
 - b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
 - c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
 - d. Visual indication of pump on and off, **as directed**, status.
 - e. Visual indication of pump lead/lag status.
 - f. Visual and audible, **as directed**, alarm indication of pump failure.
8. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with continuous pump operation and modulating control valve):
- a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
 - b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
 - c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
 - d. Lead pump failure automatically starts lag pump.
OR
Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
 - e. Visual indication of pump on and off, **as directed**, status.
 - f. Visual indication of pump lead/lag status.
 - g. Visual and audible, **as directed**, alarm indication of pump failure.
9. Receiver Makeup Water Control Sequence:
- a. Electric level controller operates electric control valve to maintain receiver water-level set point.
OR



- Mechanical float operates integral valve to maintain water-level set point.
- b. Visual and audible, **as directed**, alarm indication of low and high, **as directed**, receiver-water level.
10. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
- a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, receiver low-water-level alarm, receiver high-water-level alarm, feedwater temperature, **as directed**.
- B. Feedwater Unit With Vacuum Producer
1. Description: Receiver mounted, consisting of multijet vacuum producer, centrifugal pump and motor assembly mounted on separation chamber, and automatic pressure and water temperature controls. Include the following accessories:
 - a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.
 - b. Vacuum Gage: Dial-type register in inches of mercury (kPa).
 - c. Level Gage Glass: Stops top and bottom.
 - d. Air-suction check valve.
 - e. Lifting eyes.
 - f. Companion flanges.
 - g. Low-water cutoff switch.
 - h. Cooling-Water Control: Aquastat, inlet strainer, and electric valve.
 - i. Air vent.
 - j. Overflow drain from vacuum-producer receiver.
 - k. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
 - 1) Cast-Iron Threaded Fittings: ASME B16.4; Class 125 **OR** 250, **as directed**.
 - 2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
 - 3) Forged-Steel Fittings: ASME B16.11, Class 3000.
 - 4) Malleable-Iron Unions: ASME B16.39; Class 150 **OR** 300, **as directed**.
 - 5) Forged-Steel Unions: MSS SP-83, Class 3000.
 - l. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
 - 1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 - 2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
 2. Vacuum-Producer Reservoir and Vacuum Receiver:
 - a. Material: Close-grain cast iron **OR** Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
 - b. Additional corrosion protection:
 - 1) 0.07-inch (1.8-mm) **OR** 0.13-inch (3.3-mm) **OR** 0.19-inch (4.8-mm), **as directed**, thickness allowance.
 - 2) Electrolytic corrosion-inhibitor anode.
 - c. Finish: Primer **OR** Primer under enamel topcoat **OR** Primer under epoxy topcoat, **as directed**.
 - d. Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
 - e. Mounting Arrangement: Recessed below floor **OR** Floor mounted, **as directed**.
 - f. Mounting Frame: Structural-steel stand to support receiver and pumps. Fabricate stand with bracing adequate for seismic forces according to authorities having jurisdiction and to allow anchoring mounting frame to floor, **as directed**.



3. Vertical Vacuum-Producer Pump: Flange-mounted, close-coupled, single-stage, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
 - a. Impeller: Bronze.
 - b. Shaft: Stainless steel.
 - c. Seals: Mechanical.
 - d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
4. Horizontal Vacuum-Producer Pump: Base-mounted, single-stage, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
 - a. Impeller: Bronze.
 - b. Shaft: Stainless steel.
 - c. Coupling: Close **OR** Flexible, **as directed**.
 - d. Seals: Mechanical.
 - e. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
5. Vertical Feedwater Pump: Flange-mounted, close-coupled, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
 - a. Impeller: Bronze **OR** Stainless steel, **as directed**.
 - b. Seals: Mechanical.
 - c. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
6. Horizontal Feedwater Pump: Base-mounted, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
 - a. Impeller: Bronze **OR** Stainless steel, **as directed**.
 - b. Coupling: Close **OR** Flexible, **as directed**.
 - c. Seals: Mechanical.
 - d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
7. Control panel shall be unit mounted and factory wired and include the following:
 - a. Vacuum Switches for Simplex Vacuum-Producer Pumps: Include pressure adjustment, and test push button. Factory set to operate pump between 3 and 6 inches of mercury (10.1 and 20.2 kPa).
OR
Vacuum Switches for Duplex Vacuum-Producer Pumps: Include pressure adjustment, and test push button. Factory set so one pump operates for 3 to 5 inches of mercury (10.1 to 16.9 kPa) and both pumps operate for 4 to 6 inches of mercury (13.5 to 20.2 kPa).
 - b. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
 - c. Single-point field power interface to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - 1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
 - d. NEMA-rated motor controller for each motor and include a hand-off-auto switch and overcurrent protection.
 - 1) Alternating control for units with intermittent operation as indicated by control sequence.
 - e. Terminal blocks with numbered and color-coded wiring to match wiring diagram.



- f. Wiring outside of an enclosure in a metal, **as directed**, raceway. Make connections to motor with liquidtight conduit.
- g. Removable control mounting plate.
- h. Visual indication of status and alarm with momentary test push button, **as directed**.
- i. Audible alarm and silence switch.
- j. Visual indication of elapsed run time, graduated in hours.
- k. Fused control-circuit transformer.
8. Vacuum-Producer Control Sequence:
 - a. Cycle pumps to maintain vacuum-pressure set point.
 - b. Visual indication of pump on and off, **as directed**, status.
 - c. Visual and audible, **as directed**, alarm indication of pump failure.
9. Feedwater Simplex-Pump Control Sequence:
 - a. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
 - b. Visual indication of pump on and off, **as directed**, status.
 - c. Visual and audible, **as directed**, alarm indication of pump failure.
10. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with operating and standby pump):
 - a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
 - b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
 - c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
 - d. Visual indication of pump on and off, **as directed**, status.
 - e. Visual indication of pump lead/lag status.
 - f. Visual and audible, **as directed**, alarm indication of pump failure.
11. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with continuous pump operation and modulating control valve):
 - a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
 - b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
 - c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
 - d. Lead pump failure automatically starts lag pump.
OR
Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
 - e. Visual indication of pump on and off, **as directed**, status.
 - f. Visual indication of pump lead/lag status.
 - g. Visual and audible, **as directed**, alarm indication of pump failure.
12. Makeup Water Control Sequence:
 - a. Electric level controller operates electric control valve to maintain water temperature set point.
 - b. Visual and audible, **as directed**, alarm indication of low and high, **as directed**, water level.
13. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
 - a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, receiver low-water-level alarm, receiver high-water-level alarm, feedwater temperature, **as directed**.

1.3 EXECUTION

A. Installation



1. Install feedwater unit level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31.
 2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 3. Install unit to permit access for maintenance.
 4. Support piping independent of pumps.
 5. Install base-mounted pumps on concrete bases with grouted base frames.
 6. Install parts and accessories shipped loose.
 7. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 8. Install piping adjacent to machine to allow service and maintenance.
 9. Connect makeup water piping and cooling-water piping with reduced-pressure backflow preventers.
 10. Install overflow drain piping to nearest floor drain.
 11. Install vents and extend to outdoors; terminate with elbow turned down and an insect screen.
 12. Adjust boiler water-level controls to properly stage unit.
 13. Set field-adjustable, makeup water and cooling-water controls.
 14. Clean equipment internally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions.
 15. Clean strainers.
- B. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with manufacturer's written instructions.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - c. Check bearing lubrication.
 - d. Verify proper motor rotation.
 - e. Start up service.
 - f. Report results in writing.
 3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 23 53 16 00



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SECTION 23 53 16 00a - DEAERATORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for deaerators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged, factory-assembled deaerators.

C. Definitions

1. Feedwater Pump: Pump that moves feedwater from the deaerator to the boiler.
2. Transfer Pump: Pump that moves feedwater from the surge tank to the deaerator.
3. NPSH: Net-positive suction head.

D. Submittals

1. Product Data: For each type of product indicated. Include rated makeup water, feedwater, and steam flow rates; working pressure; tank capacities; storage capacity in minutes; temperature and NPSH required; pump performance curves with selection points clearly indicated; furnished specialties; and accessories.
2. Shop Drawings: For deaerators, signed and sealed by a qualified professional engineer; include plans, elevations, sections, details, dimensions, weights, loadings, required clearances, and attachments to other work.
 - a. For installed products indicated to comply with design loads, include structural analysis data.
 - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing deaerator bases.
 - c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that deaerators, accessories, and components will withstand seismic forces as indicated in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Field quality-control test reports.
5. Operation and Maintenance Data: For deaerators to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: ASME B31.1, "Power Piping," for systems more than 15 psig (104 kPa); ASME B31.9, "Building Services Piping," for systems equal to or less than 15 psig (104 kPa). Safety valves and pressure vessels shall bear the appropriate ASME label.

F. Delivery, Storage, And Handling

1. Protect flanges, pipe openings, nozzles, bearings, and couplings from damage during shipping and storage.
2. Comply with manufacturer's written rigging instructions.
3. Deliver deaerators as factory-assembled units with protective crating and covering.



1.2 PRODUCTS

A. Manufactured Units

1. Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, single-compartment deaerator, and a separate packaged surge tank with transfer and feedwater pumps and controls to supply feedwater to deaerator, **as directed**.
OR
Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, two-compartment deaerator. One compartment for deaeration and one for surge volume, each with its own transfer and feedwater pumps and controls.
OR
Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, single-compartment deaerator and separate surge tank, both mounted on same factory-fabricated stand with necessary transfer and feedwater pumps and controls.
2. Material for Wetted Components: Components in contact with water that has not been deaerated shall be made of Type 304 **OR** 316, **as directed**, stainless steel.
3. Adjustable Spray Valves: Type 316 stainless steel. Arrange spray valves for counterflow of steam and condensate and so corrosive gases being vented do not contact deaerator's head or shell.
4. Vent Condenser: Stainless steel, with automatic and manual vent valves.
5. Deaerator and Storage Tank:
 - a. Material: Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
 - b. Additional Corrosion Protection:
 - 1) 0.07-inch (1.8-mm) **OR** 0.13-inch (3.3-mm) **OR** 0.19-inch (4.8-mm), **as directed**, thickness allowance.
 - 2) Electrolytic corrosion-inhibitor anode.
 - c. Access: Manhole in deaerator and storage tank for access to internal components for inspection and service.
 - d. Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm), **as directed**, for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
 - e. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
 - 1) Cast-Iron Threaded Fittings: ASME B16.4, Class 125 **OR** 250, **as directed**.
 - 2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
 - 3) Forged-Steel Fittings: ASME B16.11, Class 3000.
 - 4) Malleable-Iron Unions: ASME B16.39, Class 150 **OR** 300, **as directed**.
 - 5) Forged-Steel Unions: MSS SP-83, Class 3000.
 - f. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
 - 1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 - 2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
6. Accessories:
 - a. Lifting eyes.
 - b. Companion flanges.
 - c. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
 - d. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**.
 - e. Pump-discharge bypass relief valve **OR** orifice plate **OR** relief valve with orifice plate, **as directed**.



- f. Makeup Water Assembly:
 - 1) Factory-mounted modulating valve with mechanical level control, external float cage, and stainless-steel float.
OR
Factory **OR** Field, **as directed**, -mounted, electric, pilot-operated, solenoid **OR** modulating, **as directed**, valve with factory-mounted, probe-type, **as directed**, water-level controller.
OR
Factory **OR** Field, **as directed**, -mounted, pneumatic modulating valve with factory-mounted water-level controller.
 - 2) Factory **OR** Field, **as directed**, -mounted, three-valve bypass and inlet strainer.
 - g. Steam Pressure-Reducing Valve(s): Steam **OR** Electric **OR** Pneumatic, **as directed**, operated with three-valve bypass, **as directed**, and sized to reduce boiler outlet pressure to the deaerator design pressure.
 - h. Tank Overflow Drain: Sized to relieve full capacity at operating pressure.
 - i. Safety Valve(s): ASME labeled and sized to relieve full capacity of pressure-reducing valve.
 - j. Vents: Manual and automatic vent valves.
 - k. Vacuum breaker.
 - l. Meters and Gages:
 - 1) Full-height, water-level gage glass, reflex flat type, **as directed**, and stop valve set.
 - 2) Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**, mounted to measure temperature in storage and steam, **as directed**, section of tank.
 - 3) Pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**, mounted to measure pressure in steam section of tank.
 - m. Provision for chemical injection quill.
 - n. Chemical injection quill.
 - o. Sampling connection with valve.
 - p. Tank drain connection with valve.
 - q. Oxygen test kit.
7. Support Frame: Structural-steel frame for supporting tank and pumps. Weld or bolt to tank.
- a. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only, **as directed**.
8. Feedwater Pump: Cast-iron, flange **OR** base, **as directed**, -mounted volute; with bronze **OR** stainless-steel, **as directed**, multistage centrifugal **OR** turbine, **as directed**, impeller, renewable bronze case ring, and stainless-steel shaft.
- a. Seals: Mechanical, suitable for 250 deg F (121 deg C).
 - b. Pump Motor: Vertical **OR** Horizontal, **as directed**, open dripproof **OR** totally enclosed **OR** totally enclosed fan-cooled, **as directed**, enclosure, close **OR** flexible, **as directed**, coupled to pump. Comply with requirements in Division 15 Section "Motors."
9. Feedwater Pump Control Panel: Factory mounted and wired and including the following:
- a. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
 - b. Single-point, field power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - 1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
 - c. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor.
 - 1) Alternating control as indicated by control sequence for each pump.
 - d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 - e. Metal raceway **OR** Raceway, **as directed**, for factory-installed wiring outside of enclosures. Make connections to motor with liquidtight conduit.
 - f. Removable control mounting plate.



- g. Visual indication of status and alarm with momentary test push button, **as directed**.
 - h. Audible alarm and silence switch.
 - i. Visual indication of elapsed run time, graduated in hours.
 - j. Fusible, control-circuit transformer.
 - k. Microprocessor-based controller.
10. Feedwater Pump Start-Stop Control Sequence (for intermittent pump operation):
- a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
 - b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
 - c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
 - d. Visual indication of pump on **OR** on and off, **as directed**, status.
 - e. Visual indication of pump lead/lag status.
 - f. Visual **OR** Visual and audible, **as directed**, alarm indication of pump failure.
11. Feedwater Pump Continuous Control Sequence (for continuous pump operation and modulating control valve):
- a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
 - b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
 - c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
 - d. Lead pump failure automatically starts lag pump.
OR
Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
 - e. Visual indication of pump on **OR** on and off, **as directed**, status.
 - f. Visual indication of pump lead/lag status.
 - g. Visual **OR** Visual and audible, **as directed**, alarm indication of pump failure.
12. Makeup Water Control Sequence:
- a. Electric level controller operates electric control valve to maintain tank water-level set point.
OR
Pneumatic level controller operates pneumatic control valve to maintain tank water-level set point.
OR
Mechanical float operates valve to maintain water-level set point.
 - b. Visual **OR** Visual and audible, **as directed**, alarm indication of low **OR** low and high, **as directed**, tank water level.
13. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
- a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, low-water level alarm, high-water level alarm, feedwater temperature, **as directed**.

B. Surge Tank

- 1. Description: Factory-assembled and -tested unit consisting of a condensate receiver, transfer pumps, and controls.
- 2. Accessories:
 - a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.
 - b. Level gage glass, reflex flat type, **as directed**, with stops at top and bottom.
 - c. Lifting eyes.
 - d. Companion flanges.
 - e. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
 - f. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**.



- g. Pump-discharge bypass relief valve **OR** orifice plate **OR** relief valve with orifice plate, **as directed**.
3. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
- Cast-Iron Threaded Fittings: ASME B16.4, Class 125 **OR** 250, **as directed**.
 - Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
 - Forged-Steel Fittings: ASME B16.11, Class 3000.
 - Malleable-Iron Unions: ASME B16.39, Class 150 **OR** 300, **as directed**.
 - Forged-Steel Unions: MSS SP-83, Class 3000.
4. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
- Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
 - Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
5. Tank:
- Material: Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
 - Additional Corrosion Protection:
 - 0.07-inch (1.8-mm) **OR** 0.13-inch (3.3-mm) **OR** 0.19-inch (4.8-mm), **as directed**, thickness allowance.
 - Electrolytic corrosion-inhibitor anode.
 - Access: Manhole in tank for access to internal components for inspection and service.
 - Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
6. Support Frame: Structural-steel frame for supporting tank. Weld or bolt to tank.
- Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.
7. Transfer Pump: Vertical, flange-mounted, close-coupled, single-stage **OR** multistage, **as directed**, radially split-case centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C); with the following features:
- Impeller: Bronze **OR** Stainless steel, **as directed**.
 - Seals: Mechanical.
 - Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
8. Transfer Pump: Horizontal, base-mounted, single-stage **OR** multistage, **as directed**, radially split-case centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C); with the following features:
- Impeller: Bronze **OR** Stainless steel, **as directed**.
 - Coupling: Close **OR** Flexible, **as directed**.
 - Seals: Mechanical.
 - Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
9. Transfer Pump Control Panel: Factory mounted and wired and including the following:
- NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
 - Single-point, field power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
 - Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
 - NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor.



- 1) Alternating control indicated by control sequence for each pump.
- d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
- e. Metal raceway **OR** Raceway, **as directed**, for factory-installed wiring outside of enclosures. Make connections to motor with liquidtight conduit.
- f. Removable control mounting plate.
- g. Visual indication of on/off status and pump failure alarm with momentary test push button, **as directed**.
- h. Audible alarm and silence switch.
- i. Visual indication of elapsed run time, graduated in hours.
- j. Fusible, control-circuit transformer.
- k. Microprocessor-based controller.
10. Transfer Pump Start-Stop Control Sequence: Deaerator water-level controller controls lead pump; alternator switches lead and lag pump(s) after each start **OR** to equalize run time, **as directed**; failure of lead pump switches to lag pump and sounds audible alarm, **as directed**.
11. Transfer Pump Continuous-Run Control Sequence: Lead pump runs continuously while deaerator is operating; deaerator water-level controller modulates water-level-control valve; lead and lag pump(s) switch to equalize run time; lag pump operates if lead pump fails; pump failure sounds audible alarm, **as directed**.
12. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
 - a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, low-water level alarm, high-water level alarm, **as directed**.

C. Factory Finishes

1. Manufacturer's standard prime-coat finish ready for field painting.
2. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.
3. Do not paint aluminum, galvanized-steel, and stainless-steel surfaces.

D. Source Quality Control

1. Fabricate and label deaerator tanks according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
2. Factory install and test piping that connects pumps to tanks according to ASME B31.1, "Power Piping" **OR** ASME B31.9, "Building Services Piping," **as directed**.
3. Factory test performance and certify test results on packaged deaerator units, according to ASME PTC 12.3, before shipping to Project.

1.3 EXECUTION

A. Examination

1. Before deaerator installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance, maintenance, and operations.
 - a. Final deaerator locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
 - b. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Install deaerators level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are



specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

3. Install deaerators to permit access for service and maintenance.
 4. Support piping independent of pumps.
 5. Install base-mounted pumps on concrete base with grouted base frame.
 6. Install all parts and materials not factory installed.
 7. Extend overflow drains to floor drains.
 8. Extend vent piping to outside and terminate with manufacturer-approved cap furnished with deaerator.
 9. Install piping adjacent to machine to allow service and maintenance.
- C. Connections
1. Steam and condensate piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Connect steam and condensate piping to tank tapplings with shutoff valves and unions or flanges at each connection.
 3. Connect condensate drains, pump-discharge piping, vents, overflow drains, makeup water, steam supply, and cooling water piping.
- D. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 2. Tests and Inspections:
 - a. Inspect field-assembled components and equipment installation, including piping and electrical connections, for compliance with requirements.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - c. Verify bearing lubrication.
 - d. Verify proper motor rotation.
 - e. Test Reports: Prepare a written report to record the following:
 - 1) Test procedures used.
 - 2) Test results that comply with requirements.
 - 3) Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
 3. Remove and replace malfunctioning equipment and retest as specified above.
- E. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
 2. Complete installation and startup checks according to manufacturer's written instructions and do the following:
 - a. Set deaerator makeup water-level controls.
 - b. Verify bearing lubrication.
 - c. Verify proper motor rotation.
 - d. Start pumps according to manufacturer's written instructions.
- F. Adjusting And Cleaning
1. Adjust initial temperature and pressure set points.
 2. Set field-adjustable switches and circuit-breaker trip ranges.
 3. Clean strainers.
- G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain deaerators.

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SECTION 23 54 16 13 - FURNACES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for furnaces. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Gas-fired, noncondensing, Gas-fired, condensing, Oil-fired, and Electric furnaces and accessories complete with controls.
 - b. Air filters.
 - c. Air cleaners.
 - d. Ultraviolet germicidal lights.
 - e. Humidifiers.
 - f. Ventilation heat exchangers.
 - g. Refrigeration components.

C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each of the following:
 - a. Furnace.
 - b. Thermostat.
 - c. Humidistat.
 - d. Air filter.
 - e. Air cleaner.
 - f. Ultraviolet germicidal light.
 - g. Humidifier.
 - h. Ventilation heat exchanger.
 - i. Refrigeration components.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and maintenance data.
4. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - c. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
5. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."



3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. Comply with NFPA 70.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:
 - a. Warranty Period, Commencing on Date of Final Completion:
 - 1) Furnace Heat Exchanger: 10 years **OR** 20 years **OR** Lifetime, **as directed**.
 - 2) Integrated Ignition and Blower Control Circuit Board: Five years.
 - 3) Draft-Inducer Motor: Five years.
 - 4) High-Efficiency Oil Furnace Burner: Three years.
 - 5) Refrigeration Compressors: 10 years **OR** Lifetime, **as directed**.
 - 6) Evaporator and Condenser Coils: Five years.

1.2 PRODUCTS

A. Gas-Fired Furnaces, Noncondensing

1. General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3, "Gas-Fired Central Furnaces," and with NFPA 54.
2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
 - a. Cabinet interior around heat exchanger shall be factory-installed insulation.
 - b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
 - c. Factory paint external cabinets in manufacturer's standard color.
 - d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive **OR** belt drive **OR** direct or belt drive **OR** drive type indicated on Drawings, **as directed**.
 - a. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.

OR

 Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

OR

 Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
4. Type of Gas: Natural **OR** Propane, **as directed**.
5. Heat Exchanger: Aluminized **OR** Stainless, **as directed**, steel.
6. Burner:
 - a. Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
 - b. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
7. Gas-Burner Safety Controls:
 - a. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
 - b. Flame Rollout Switch: Installed on burner box; prevents burner operation.
 - c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.



8. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.
 9. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.
 10. Vent Materials: Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks", for Type B metal vents.
- B. Gas-Fired Furnaces, Condensing
1. General Requirements for Gas-Fired, Condensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3, "Gas-Fired Central Furnaces," and with NFPA 54.
 2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
 - a. Cabinet interior around heat exchanger shall be factory-installed insulation.
 - b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
 - c. Factory paint external cabinets in manufacturer's standard color.
 - d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.
 - a. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.

OR

Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

OR

Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
 4. Type of Gas: Natural **OR** Propane, **as directed**.
 5. Heat Exchanger:
 - a. Primary: Aluminized **OR** Stainless, **as directed**, steel.
 - b. Secondary: Polyethylene-coated **OR** Stainless, **as directed**, steel.
 6. Burner:
 - a. Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
 - b. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
 7. Gas-Burner Safety Controls:
 - a. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
 - b. Flame Rollout Switch: Installed on burner box; prevents burner operation.
 - c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
 8. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.
 9. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; terminals for connection to accessories; diagnostic light with viewport, **as directed**.
 10. Accessories:
 - a. Combination Combustion-Air Intake and Vent: PVC plastic fitting to combine combustion-air inlet and vent through outside wall **OR** roof, **as directed**.
 - b. CPVC Plastic Vent Materials.
 - 1) CPVC Plastic Pipe: Schedule 40, complying with ASTM F 441/F 441M.



- 2) CPVC Plastic Fittings: Schedule 40, complying with ASTM F 438, socket type.
- 3) CPVC Solvent Cement: ASTM F 493.
 - a) Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- c. PVC Plastic Vent Materials:
 - 1) PVC Plastic Pipe: Schedule 40, complying with ASTM D 1785.
 - 2) PVC Plastic Fittings: Schedule 40, complying with ASTM D 2466, socket type.
 - 3) PVC Solvent Cement: ASTM D 2564.
 - a) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Oil-Fired Furnaces

1. General Requirements for Oil-Fired Furnaces: Factory assembled, piped, wired, and tested; complying with UL 727 and with NFPA 31.
2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
 - a. Cabinet interior around heat exchanger shall be factory-installed insulation.
 - b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
 - c. Factory paint external cabinets in manufacturer's standard color.
 - d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive **OR** belt drive **OR** drive type indicated on Drawings, **as directed**.
 - a. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
4. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.

OR

 Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
5. Heat Exchanger: Welded steel with ceramic-fiber liner **OR** refractory insert, **as directed**, at the burner in the combustion chamber. Minimum 2-inch- (50-mm-) diameter access ports in heat exchanger to permit access for cleaning.
6. Burner: High-pressure atomizing type, with rubber-mounted, adjustable, combustion-air blower; integrated fuel pump; hinged, flame-inspection port; cadmium-sulfide flame sensor; electrodes; ignition transformer; and oil nozzle.
 - a. Time-Delay Relay: Limits time for establishing main flame.
 - b. Flame Sensor: Monitors flame and stops burner on flame failure.
 - c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
7. Barometric Draft Regulator: Match furnace; for mounting in flue.
8. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.
9. Vent Materials: Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for Type B metal vents.

D. Electric Furnaces

1. General Requirements for Electric Furnaces: Factory assembled, piped, wired, and tested.
2. Cabinet: Steel, with duct liner downstream from cooling coil, **as directed**.
 - a. Duct Liner: Fiberglass, minimum 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, thick, complying with ASTM C 1071 and having a coated surface exposed to airstream



complying with NFPA 90A or NFPA 90B and with NAIMA's "Fibrous Glass Duct Liner Standard."

- 1) Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- b. Factory paint external cabinets in manufacturer's standard color.
3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.
 - a. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.

OR

Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

OR

Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
4. Electric-Resistant Heating Elements: Helix-wound, nickel-chromium wire-heating elements in ceramic insulators mounted on steel supports.
5. Heating-Element Control: Sequencer relay with relay for each element; switches elements on and off, with delay between each increment; initiates, stops, or changes fan speed.
6. Summer Fan Switch: Connected to permit independent on-off switch of unit fan.

E. Thermostats And Humidistats

1. Solid-State Thermostat: Wall-mounting **OR** Freestanding **OR** Wireless, **as directed**, programmable, microprocessor-based unit with automatic **OR** manual, **as directed**, switching from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, **as directed**, and battery backup protection against power failure for program settings.

OR

Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounting unit with fan on-automatic selector.

OR

Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounting unit with fan on-automatic selector.

OR

Single-Stage **OR** Two-Stage, **as directed**, Heating-Only Thermostat: Wall-mounting unit with fan on-automatic selector.

OR

Solid-State, Combination Thermostat and Humidistat: Wall-mounting **OR** Freestanding **OR** Wireless, **as directed**, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, **as directed**, and battery backup protection against power failure for program settings.
2. Humidistat: Adjustable, wall-mounting **OR** duct-mounting, **as directed**, unit.
3. Control Wiring: Unshielded twisted-pair cabling.
 - a. No. 24 AWG, 100 ohm, four pair.
 - b. Cable Jacket Color: Blue.
4. Controls shall comply with requirements in ASHRAE/IESNA 90.1, "Controls."

F. Air Filters

1. Washable Filters: 1-inch- (25-mm-) thick, urethane pad.
2. Disposable Filters: 1-inch- (25-mm-) thick fiberglass media with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**, in sheet metal frame.
3. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace, generates electrostatic charge; MERV 10 rating.



4. HEPA Air Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter, high-efficiency particulate air (HEPA) disposable filter, and carbon VOC, **as directed**. HEPA shall be as follows:
 - a. Standard: UL 586, "High-Efficiency, Particulate, Air Filter Units."
 - b. Rating: ASHRAE 52.1, dust-spot efficiency of 65 percent; ASHRAE 52.2, 99.97 percent efficiency to 0.03-micrometer particle size.
- G. Air Cleaners
1. Electronic Air Cleaners: Packaged system, including sheet metal housing, prefilter, power supply, and automatic control device, arranged for mounting in return-air duct at furnace; equip with on-off and test switches and pilot light.
 - a. Standard: UL 586, "High-Efficiency, Particulate, Air Filter Units."
 - b. Rating: ASHRAE 52.2, particle size to 0.01 micrometer.
 - c. Static Pressure Drop: Maximum 0.14-inch wg (35 Pa) at 300-fpm (1.52-m/s) air velocity.
- H. Ultraviolet Germicidal Lights
1. Description: Lighting unit in metal housing arranged for installation in supply-air duct and controlled to cycle on and off with furnace fan, with one **OR** two, **as directed**, 75-W ultraviolet-light bulb(s).
- I. Humidifiers
1. Minimum capacity rating indicated according to ARI 610, "Central System Humidifiers for Residential Applications."
 2. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.

OR

Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.

OR

Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.

OR

Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.

OR

Steam type with electric heating element in stainless-steel reservoir with float-valve level control; arranged for attachment to duct or plenum and for control by humidistat.
 3. Comply with applicable requirements in ASHRAE 62.1.
- J. Ventilation Air Heat Exchanger
1. Cabinet: Steel, with factory-installed interior insulation and manufacturer's standard factory finish. Fabricate with space for piping and electrical conduits.
 2. Heat-Recovery Device: Fixed-plate, polypropylene copolymer (high-density plastic) heat-exchanger plates evenly spaced and sealed and arranged for counter airflow.
 3. Supply and Exhaust Fans: Forward curved centrifugal with direct drive. Motors comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 4. Filters: 1-inch- (25-mm-) thick disposable type with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**, in galvanized-steel frame, mounted upstream of unit in both supply and exhaust airstreams.
 5. Wiring: Wire motors and controls so only external connections are required during installation.
- K. Refrigeration Components
1. General Refrigeration Component Requirements:



- a. Refrigeration compressor, coils, and specialties shall be designed to operate with CFC-free refrigerants.
- b. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
2. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment." Match size with furnace. Include condensate drain pan with accessible drain outlet complying with ASHRAE 62.1, **as directed**.
 - a. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.
3. Refrigerant Line Kits: Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.
 - a. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I, 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
4. Refrigerant Piping: Comply with requirements in Division 23 Section "Refrigerant Piping".
5. Air-Cooled, Compressor-Condenser Unit:
 - a. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
 - b. Compressor: Hermetically sealed reciprocating **OR** scroll, **as directed**, type.
 - 1) Crankcase heater.
 - 2) Restrained vibration **OR** Vibration, **as directed**, isolation mounts for compressor.
 - 3) Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - 4) Two-speed compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - 5) Refrigerant Charge: R-407C **OR** R-410A, **as directed**.
 - c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
 - d. Heat-Pump Components: Reversing valve and low-temperature air cut-off thermostat.
 - e. Fan: Aluminum-propeller type, directly connected to motor.
 - f. Motor: Permanently lubricated, with integral thermal-overload protection.
 - g. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
 - h. Mounting Base: Polyethylene.

1.3 EXECUTION

A. Installation

1. Install gas-fired furnaces and associated fuel and vent features and systems according to NFPA 54.
2. Install oil-fired furnaces and associated fuel and vent piping according to NFPA 31.
3. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
 - a. Install seismic restraints to limit movement of furnace by resisting code-required seismic acceleration.
4. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.
 - a. Anchor furnace to substrate to resist code-required seismic acceleration.
5. Controls: Install thermostats and humidistats at mounting height of 60 inches (1500 mm) above floor.
6. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.



7. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete". Coordinate anchor installation with concrete base.
OR
Install ground-mounted, compressor-condenser components on polyethylene mounting base.
8. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories". Anchor units to supports with removable, cadmium-plated fasteners.

B. Connections

1. Gas piping installation requirements are specified in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties. Connect gas piping with union or flange and appliance connector valve.
2. Oil piping installation requirements are specified in Division 23 Section "Facility Fuel-oil Piping". Drawings indicate general arrangement of piping, fittings, and specialties. Connect oil piping with union or flange and ball **OR** gate, **as directed**, valve.
3. Install piping adjacent to equipment to allow service and maintenance.
4. Water piping installation requirements for furnaces with humidifiers are specified in Division 22 Section "Domestic Water Piping". Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.
5. Vent Connection, Noncondensing, Gas-Fired Furnaces: Connect Type B vents to furnace vent connection and extend outdoors. Type B vents and their installation requirements are specified in Division 23 Section "Breechings, Chimneys, And Stacks".
6. Vent and Outside-Air Connection, Condensing, Gas-Fired Furnaces: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a cap and in an arrangement that will protect against entry of birds, insects, and dirt.
 - a. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - b. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 - c. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1) Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2) CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3) PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 4) Requirements for Low-Emitting Materials:
 - a) Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - c) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - d. Slope pipe vent back to furnace or to outside terminal.
7. Vent Connections, Oil-Fired Furnaces: Connect Type L vents to furnace vent connection and extend outdoors. Type L vents and their installation requirements are specified in Division 23 Section "Breechings, Chimneys, And Stacks".
8. Connect ducts to furnace with flexible connector. Comply with requirements in Division 23 Section "Air Duct Accessories".
9. Connect refrigerant tubing kits to refrigerant coil in furnace and to air-cooled, compressor-condenser unit.



- a. Flared Joints: Use ASME B16.26 fitting and flared ends, following procedures in CDA's "Copper Tube Handbook."
OR
Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
OR
Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
 10. Comply with requirements in Division 23 Section "Refrigerant Piping" for installation and joint construction of refrigerant piping.
- C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
 - a. Perform electrical test and visual and mechanical inspection.
 - b. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
 - d. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
 - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- D. Startup Service
1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for physical damage to unit casings.
 - b. Verify that access doors move freely and are weathertight.
 - c. Clean units and inspect for construction debris.
 - d. Verify that all bolts and screws are tight.
 - e. Adjust vibration isolation and flexible connections.
 - f. Verify that controls are connected and operational.
 2. Adjust fan belts to proper alignment and tension.
 3. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.
 4. Measure and record airflows.
 5. Verify proper operation of capacity control device.
 6. After startup and performance test, lubricate bearings and adjust belt tension, **as directed**.
- E. Adjusting
1. Adjust initial temperature and humidity set points.
 2. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including shutters, dampers, and relays, to provide optimum heating performance and system efficiency.
- F. Cleaning
1. After completing installation, clean furnaces internally according to manufacturer's written instructions.
 2. Install new filters in each furnace within 14 days after Final Completion.
- G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units.



END OF SECTION 23 54 16 13



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 54 19 00	23 54 16 13	Furnaces



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**SECTION 23 55 23 13 - RADIANT HEATING AND COOLING UNITS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for radiant heating and cooling units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Electric radiant heaters.
 - b. Prefabricated electric radiant heating panels.
 - c. Hydronic heating and cooling panels.

C. Definitions

1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.

D. Submittals

1. Product Data: Include rated capacities, specialties, and accessories for each product indicated.
2. Manufacturer Seismic Qualification Certification.
3. Field quality-control test reports.
4. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Electric Radiant Heaters

1. Quartz Lamp Heating Elements: Coiled tungsten-wire heating element enclosed in clear quartz tube.
2. Quartz Tube Heating Elements: Nickel-chromium-wire heating element enclosed in quartz tube.
3. Metal-Sheathed Heating Elements: Nickel-chromium-wire heating element embedded in magnesium oxide powder and enclosed in metal sheath. Comply with UL 1030.
4. Comply with UL 499 and UL 2021, **as directed**.
5. Enclosures: Aluminized **OR** Stainless **OR** Painted, **as directed**,-steel housing with anodized-aluminum reflector.
 - a. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
6. Unit Controls:
 - a. Line-voltage thermostat.
 - b. Enclosed contactor for remote thermostat.
 - c. Snow and ice detector with moisture sensor and integral temperature sensor.

B. Prefabricated Electric Radiant Heating Panels

1. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**. Comply with UL 2021.



- a. Panel: Minimum 0.0276-inch- (0.7-mm-) thick, galvanized-steel sheet back panel riveted to minimum 0.0396-inch- (1.0-mm-) thick, galvanized-steel sheet front panel with fused-on crystalline surface.
 - b. Heating Element: Powdered graphite sandwiched between sheets of electric insulation **OR** Insulated resistive wires, **as directed**.
 - c. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
 - d. Exposed-Side Panel Finish:
 - 1) Apply silk-screened finish to match appearance of Architect-selected acoustical ceiling tiles.
OR
Factory prime coated, ready for field painting.
OR
Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
 - e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
2. Wall Thermostat: Bimetal, sensing elements calibrated from 55 to 90 deg F (13 to 32 deg C); with contacts suitable for low **OR** line, **as directed**, -voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.
 3. Capacities and Characteristics:
 - a. Nominal Panel Size: 24 by 24 inches (600 by 600 mm) **OR** 24 by 36 inches (600 by 900 mm) **OR** 24 by 48 inches (600 by 1200 mm) **OR** 24 by 60 inches (600 by 1500 mm), **as directed**.
 - b. Heating Capacity: 250 **OR** 375 **OR** 500 **OR** 570 **OR** 625 **OR** 750 **OR** 950, **as directed**, kW.
- C. Hydronic Heating And Cooling, **as directed**, Panels
1. Description: Modular **OR** Linear, **as directed**, sheet metal panel with serpentine water piping, suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**.
 - a. Panels: Minimum 0.0336-inch- (0.86-mm-) thick, galvanized-steel **OR** 0.0396-inch- (1.0-mm-) thick, aluminum, **as directed**, sheet.
 - b. Backing Insulation: Minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB with factory-applied jacket.
 - c. Exposed-Side Panel Finish:
 - 1) Apply silk-screened finish to match appearance of selected acoustical ceiling tiles.
OR
Factory prime coated, ready for field painting.
OR
Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
 - d. Factory Piping: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M, Type C), **as directed**, copper tube with ASME B16.22 wrought-copper fittings and brazed joints. Piping shall be mechanically bonded to panel.
 - e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
 - f. Accessories:
 - 1) 5-inch (127-mm) **OR** 6-inch (152-mm) **OR** 8-inch (203-mm), **as directed**, panel with drape track recess.
 - 2) 5-inch (127-mm) male bullnose panel.
 - 3) 5-inch (127-mm) female bullnose panel.
 - 4) 4-inch (102-mm) male corner panel.
 - 5) 4-inch (102-mm) female corner panel.



- 6) Inside corner panel.
- 7) 1/2-inch (13-mm) filler panel.
2. Capacities and Characteristics:
 - a. Nominal Panel Size: 24 by 24 inches (600 by 600 mm) **OR** 24 by 36 inches (600 by 900 mm) **OR** 24 by 48 inches (600 by 1200 mm) **OR** 24 by 60 inches (600 by 1500 mm), **as directed**.
 - b. Piping Inlet and Outlet: NPS 1/2 (DN 15).

1.3 EXECUTION

A. Installation

1. Install radiant heating and cooling units level and plumb.
2. Suspend radiant heaters from structure.
3. Support for Radiant Heating and Cooling Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - a. Install a minimum of four ceiling support system rods or wires for each panel. Locate not more than 6 inches (150 mm) from panel corners.
 - b. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
 - c. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two 3/4-inch (19-mm) metal channels spanning and secured to ceiling tees.
 - d. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of 3.
4. Verify locations of thermostats with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**, above finished floor.
5. Piping installation requirements are specified in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
6. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
7. Install piping adjacent to unit to allow service and maintenance.
8. Ground electric units according to Division 26 Section "Grounding And Bonding For Electrical Systems".
9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

B. Field Quality Control

1. Testing: Perform the following field tests and inspections and prepare test reports:
 - a. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and units.
2. Remove and replace malfunctioning units and retest as specified above.
3. After installing panels, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

END OF SECTION 23 55 23 13



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SECTION 23 55 23 13a - RADIANT-HEATING ELECTRIC PANELS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for radiant-heating electric panels. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes prefabricated radiant-heating electric panels.

C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: For electric heating panels. Include plans, sections, details, and attachments to other work.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and Maintenance Data: For electric heating panels to include in operation and maintenance manuals.
5. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Prefabricated Radiant-Heating Electric Panels

1. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**. Comply with UL 2021.
 - a. Panel: Minimum 0.0276-inch- (0.7-mm-) thick, galvanized-steel sheet back panel riveted to minimum 0.0396-inch- (1.0-mm-) thick, galvanized-steel sheet front panel with fused-on crystalline surface.
 - b. Heating Element:
 - 1) Powdered graphite sandwiched between sheets of electric insulation.
OR
Insulated resistive wires.
 - c. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
 - d. Exposed-Side Panel Finish:
 - 1) Apply silk-screened finish to match appearance of selected acoustical ceiling tiles.
 - 2) Factory prime coated, ready for field painting.
 - 3) Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
 - e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.



2. Wall Thermostat: Bimetal, sensing elements calibrated from 55 to 90 deg F (13 to 32 deg C); with contacts suitable for low **OR** line, **as directed**, -voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

1.3 EXECUTION

A. Installation

1. Install radiant-heating panels level and plumb.
2. Support for Radiant-Heating Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - a. Install a minimum of four ceiling support system rods or wires for each panel. Locate not more than 6 inches (150 mm) from panel corners.
 - b. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
 - c. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two 3/4-inch (19-mm) metal channels spanning and secured to ceiling tees.
 - d. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of 3.
3. Verify locations of thermostats with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**, above finished floor.

B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Testing: Perform the following field tests and inspections and prepare test reports:
 - a. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - b. Test and adjust controls and safeties.
2. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 23 55 23 13a



SECTION 23 55 33 00 - FUEL-FIRED UNIT HEATERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fuel-fired unit heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes gas and oil-fired unit heaters.

C. Submittals

1. Product Data: For each type of fuel-fired unit heater indicated. Include rated capacities, operating characteristics, and accessories.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that fuel-fired unit heaters, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchanger of fuel-fired unit heater that fails in materials or workmanship within Two **OR** Five, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Gas-Fired Unit Heaters

1. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
2. Fuel Type: Design burner for natural **OR** propane, **as directed**, gas having characteristics same as those of gas available at Project site.
3. Type of Venting: Gravity **OR** Powered **OR** Indoor, separated combustion, power, **as directed**, vented.
4. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
 - a. External Casings and Cabinets: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface.
 - b. Suspension Attachments: Reinforce suspension attachments at connection to fuel-fired unit heaters.



- 1) Seismic Fabrication Requirements: Fabricate suspension attachments of fuel-fired unit heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fuel-fired unit heater is anchored to building structure.
5. Heat Exchanger: Aluminized **OR** Stainless, **as directed**, steel.
6. Burner Material: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
7. Unit Fan: Formed-steel **OR** Aluminum, **as directed**, propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
 - a. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
 - b. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 3) Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
8. Unit Fan: Steel, centrifugal fan dynamically balanced and resiliently mounted.
 - a. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
 - 1) Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 2) Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 3) Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - b. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 3) Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
9. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - a. Gas Control Valve: Single stage **OR** Two stage **OR** Modulating, **as directed**.
 - b. Ignition: Standing pilot **OR** Electronically controlled electric spark with flame sensor, **as directed**.
 - c. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
 - d. Vent Flow Verification: Flame rollout switch **OR** Differential pressure switch to verify open vent, **as directed**.
 - e. Control transformer.
 - f. High Limit: Thermal switch or fuse to stop burner.
 - g. Thermostats: Devices and wiring are specified in Division 23 Section "Instrumentation And Control For Hvac".

OR

Thermostat: Single-stage, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

OR

Thermostat: 2-stage, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

OR

Thermostat: Single-stage type with duct-mounting sensor and 50 to 90 deg F (10 to 32 deg C) operating range.

OR



- Thermostat: 2-stage type with duct-mounting sensor and 50 to 90 deg F (10 to 32 deg C) operating range.
10. Discharge Louvers: Independently adjustable horizontal blades.
 11. Accessories:
 - a. Vertical discharge louvers.
 - b. Discharge Nozzle: Discharge at 25 to 65 degrees (0.44 to 1.13 radians) **OR** 50 to 90 degrees (0.87 to 1.57 radians), **as directed**, from horizontal.
 - c. Four-point suspension kit.
 - d. Summer fan switch.
 - e. Unit-mounted thermostat bracket.
 - f. Power Venter: Centrifugal aluminized-steel fan, with stainless-steel shaft; 120-V ac motor.
 - g. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.
- B. Oil-Fired Unit Heaters
1. Description: Factory assembled, piped, and wired, and complying with UL 731.
 2. Housing: Steel, with inserts for suspension mounting rods.
 - a. External Casings and Cabinets: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface.
 - b. Suspension Attachments: Reinforce suspension attachments at connection to fuel-fired unit heaters.
 - 1) Seismic Fabrication Requirements: Fabricate suspension attachments of fuel-fired unit heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fuel-fired unit heater is anchored to building structure.
 3. Heat Exchanger: Minimum 0.09-inch (2.2-mm) steel.
 4. Burners: Flame-retention, pressure-atomizing, forced-draft, gun type; with integral fuel pump and electronic spark ignition and flame safety.
 - a. Safety Device: Oil-pressure switch.
 5. Unit Fan: Propeller fan with aluminum blades dynamically balanced and resiliently mounted.
 - a. Steel fan-blade guard.
 - b. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 3) Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
 6. Unit Fan: Steel, centrifugal fan dynamically balanced and resiliently mounted.
 - a. Belt driven with adjustable-pitch motor sheave.
 - b. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 3) Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
 7. Controls: Factory piped and prewired to electrical junction box mounted on unit, including the following:
 - a. Control Transformer: Integrally mounted, 120 to 24 V ac.
 - b. Cad-cell safety system.
 - c. Manual reset safety.



- d. Thermostat: Devices and wiring are specified in Division 23 Section "Instrumentation And Control For Hvac".
OR
 Thermostat: Single-stage, 24-V ac, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.
OR
 Thermostat: 2-stage, 24-V ac, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.
OR
 Thermostat: Single-stage, 24-V ac type with duct-mounting sensor and 50 to 90 deg F (10 to 32 deg C) operating range.
OR
 Thermostat: 2-stage, 24-V ac type with duct-mounting sensor and 50 to 90 deg F (10 to 32 deg C) operating range.
8. Automatic Fan Thermal Switch: Fan operates with heat-exchanger temperature more than 135 deg F (58 deg C).
9. Discharge Louvers: Independently adjustable horizontal blades.
10. Accessories:
- Vertical discharge louvers.
 - Discharge Nozzle: Discharge at 25 to 65 degrees (0.44 to 1.13 radians) **OR** 50 to 90 degrees (0.87 to 1.57 radians), **as directed**, from horizontal.
 - Summer fan switch.
 - Unit-mounted thermostat bracket.
 - Oil Booster Pump: 30-gph (108-L/h) **OR** 70-gph (252-L/h), **as directed**, capacity; motor and 2-stage fuel unit with pressure-regulating valve and strainer.
 - Oil safety valve.
 - Outdoor Combustion-Air Adapter: Sealed to housing and fitted with quick access cover or door and fitting for terminating outdoor-air duct.

1.3 EXECUTION

A. Installation

- Install and connect gas-fired unit heaters and associated fuel and vent features and systems according to NFPA 54 **OR** CAN/CSA B149.1, **as directed**, applicable local codes and regulations, and manufacturer's written installation instructions.
- Install and connect oil-fired unit heaters and associated fuel and vent piping according to NFPA 31 **OR** CAN/CSA B139, **as directed**, applicable local codes and regulations, and manufacturer's written installation instructions.
- Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
 - Restrain the unit to resist code-required horizontal acceleration.
- Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.
 - Spring hangers and seismic restraints are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - Anchor the unit to resist code-required horizontal acceleration.

B. Connections

- Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
- Install piping adjacent to fuel-fired unit heater to allow service and maintenance.
- Gas Piping: Comply with Division 23 Section(s) "Facility Natural-gas Piping" **OR** "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.



4. Fuel Oil Piping: Comply Division 23 Section "Facility Fuel-oil Piping". Connect to fuel oil supply and return piping with shutoff valve and union at each connection.
 5. Vent Connections: Comply with Division 23 Section "Breechings, Chimneys, And Stacks".
 6. Electrical Connections: Comply with applicable requirements in Division 22.
 - a. Install electrical devices furnished with heaters but not specified to be factory mounted.
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 2. Tests and Inspections:
 - a. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - b. Verify bearing lubrication.
 - c. Verify proper motor rotation.
 - d. Test Reports: Prepare a written report to record the following:
 - 1) Test procedures used.
 - 2) Test results that comply with requirements.
 - 3) Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
 3. Remove and replace malfunctioning units and retest as specified above.
- D. Adjusting
1. Adjust initial temperature set points.
 2. Adjust burner and other unit components for optimum heating performance and efficiency.
- E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain fuel-fired unit heaters.

END OF SECTION 23 55 33 00



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SECTION 23 55 33 00a - UNIT HEATERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for unit heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Cabinet unit heaters with centrifugal fans and hot-water, steam, and electric-resistance heating coils.
 - b. Propeller unit heaters with hot-water, steam, and electric-resistance heating coils.
 - c. Wall and ceiling heaters with propeller fans and electric-resistance heating coils.

C. Definitions

1. BAS: Building automation system.
2. CWP: Cold working pressure.
3. PTFE: Polytetrafluoroethylene plastic.
4. TFE: Tetrafluoroethylene plastic.

D. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
2. LEED Submittal:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Plans, elevations, sections, and details.
 - b. Location and size of each field connection.
 - c. Details of anchorages and attachments to structure and to supported equipment.
 - d. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
 - e. Location and arrangement of piping valves and specialties.
 - f. Location and arrangement of integral controls.
 - g. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."



1.2 PRODUCTS

A. Cabinet Unit Heaters

1. Description: A factory-assembled and -tested unit complying with ARI 440.
 - a. Comply with UL 2021.
2. Coil Section Insulation (for duct-liner-type, glass-fiber insulation): ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing **OR** erosion-resistant coating, **as directed**, to prevent erosion of glass fibers.
 - a. Thickness: 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - b. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F (0.037 W/m x K at 24 deg C) mean temperature.
 - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - d. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
 - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Coil Section Insulation (for flexible elastomeric insulation): Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
 - a. Thickness: 3/8 inch (9 mm) **OR** 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F (0.034 W/m x K at 24 deg C) mean temperature.
 - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
 - d. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
4. Cabinet (for surface, semi-recessed, and fully recessed units): Steel with factory prime coating, ready for field painting **OR** baked-enamel finish with manufacturer's standard paint, in color selected by the Owner **OR** baked-enamel finish with manufacturer's custom paint, in color selected by the Owner, **as directed**.
 - a. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch- (1.35-mm-) **OR** 0.0677-inch- (1.7-mm-), **as directed**, thick, galvanized, **as directed**, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
 - b. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch- (1.35-mm-) **OR** 0.0677-inch- (1.7-mm-), **as directed**, thick, galvanized, **as directed**, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
 - c. Recessing Flanges (for units that are semirecessed or fully recessed in walls or ceilings): Steel, finished to match cabinet.
 - d. Control Access Door: Key operated.
 - e. Base (for surface, vertical, wall-mounting units): Minimum 0.0528-inch- (1.35-mm-) thick steel, finished to match cabinet, 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, high with leveling bolts.
 - f. Extended Piping Compartment: 8-inch- (200-mm-), **as directed**, wide piping end pocket.
 - g. False Back (for vertical, wall-mounting units only): Minimum 0.0428-inch- (1.1-mm-) thick steel, finished to match cabinet.
 - h. Outdoor-Air Wall Box (for vertical, wall-mounting units only): Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen. Aluminum louver with anodized **OR** baked-enamel, **as directed**, finish in color selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.
 - 1) Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with manual **OR** electronic **OR** pneumatic, **as directed**, two-position actuators.



5. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
 - a. Washable Foam: 70 percent arrestance and 3 MERV.
 - b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
 - c. Pleated: 90 percent arrestance and 7 MERV.
6. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.

OR

Steam Coil: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 75 psig (517 kPa).

OR

Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
7. Fan and Motor Board: Removable.
 - a. Fan: Forward curved, high static, **as directed**, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - b. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
8. Factory, Hot-Water Piping Package: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.
 - a. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve. Three-way valve packages shall include bypass line with manually adjustable balance device, **as directed**.
 - b. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
 - 1) Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
 - 2) Minimum Diameter: Equal to cabinet unit heater connection size.
 - c. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
 - d. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or vent, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
 - e. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig (2068-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning, piston-spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
 - f. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) threaded pipe and full-port ball valve in strainer drain connection.
 - g. Wrought-Copper Unions: ASME B16.22.
9. Control devices and operational sequences are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
10. Basic Unit Controls:
 - a. Control voltage transformer.
 - b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
 - 1) Heat-off switch.



- 2) Fan on-auto switch.
 - 3) Manual fan speed switch (for use with multispeed motors).
 - 4) Adjustable deadband.
 - 5) Concealed **OR** Exposed, **as directed**, set point.
 - 6) Concealed **OR** Exposed, **as directed**, indication.
 - 7) Deg F (Deg C) indication.
 - c. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
 - d. Unoccupied period override push button.
 - e. Data entry and access port.
 - 1) Input data includes room temperature, and occupied and unoccupied periods.
 - 2) Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.
 11. DDC, **as directed**, Terminal Controller:
 - a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 - b. Unoccupied Period Override: Two, **as directed**, hours.
 - c. Unit Supply-Air Fan Operations:
 - 1) Occupied Periods: Fan runs continuously.
 - 2) Unoccupied Periods: Fan cycles to maintain setback room temperature.
 - d. Heating Coil Operations:
 - 1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
 - 2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
 - e. Outdoor-Air Damper Operation:
 - 1) Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
 - 2) Unoccupied Periods: Close damper.
 - f. Controller shall have volatile-memory backup.
 12. BAS Interface Requirements:
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at central workstation.
 - c. Interface shall be BAC-net **OR** LonWorks, **as directed**, compatible for central BAS workstation and include the following functions:
 - 1) Adjust set points.
 - 2) Cabinet unit heater start, stop, and operating status.
 - 3) Data inquiry, including outdoor-air damper position, **as directed**, supply-air and room-air temperature.
 - 4) Occupied and unoccupied schedules.
 13. Electrical Connection: Factory wire motors and controls for a single field connection.
- B. Propeller Unit Heaters
1. Description: An assembly including casing, coil, fan, and motor in vertical **OR** horizontal **OR** vertical and horizontal, **as directed**, discharge configuration with adjustable discharge louvers.
 2. Comply with UL 2021, for electric unit heaters.
 3. Comply with UL 823, for explosion-proof electric unit heaters.
 4. Cabinet: Removable panels for maintenance access to controls.
 5. Cabinet Finish: Manufacturer's standard **OR** custom, **as directed**, baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.
 6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
 7. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.



8. General Coil Requirements: Test and rate hot-water **OR** steam, **as directed**, propeller unit heater coils according to ASHRAE 33.
9. Hot-Water Coil: Copper tube, minimum 0.025-inch (0.635-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 350 psig (2413 kPa) underwater.
OR
Hot-Water Coil: Cupronickel tube, minimum 0.031-inch (0.78-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 400 psig (2760 kPa) and a maximum entering-water temperature of 450 deg F (232 deg C), with manual air vent. Test for leaks to 600 psig (4137 kPa) underwater.
OR
Hot-Water Coil: Red brass tube, minimum 0.049-inch (1.24-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 260 psig (1793 kPa) and a maximum entering-water temperature of 390 deg F (199 deg C), with manual air vent. Test for leaks to 390 psig (2689 kPa) underwater.
OR
Hot-Water Coil: Steel tube, minimum 0.049-inch (1.24-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 400 psig (2760 kPa) and a maximum entering-water temperature of 450 deg F (232 deg C), with manual air vent. Test for leaks to 600 psig (4137 kPa) underwater.
OR
Hot-Water Coil: Vertical steel tube, minimum 0.065-inch (1.65-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 400 psig (2760 kPa) and a maximum entering-water temperature of 450 deg F (232 deg C), with steel headers at top and bottom. Test for leaks to 600 psig (4137 kPa) underwater.
OR
Steam Coil: Copper tube, minimum 0.025-inch (0.635-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 75 psig (520 kPa).
OR
Steam Coil: Red brass tube, minimum 0.049-inch (1.24-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 75 psig (520 kPa).
OR
Steam Coil: Vertical steel tube, minimum 0.065-inch (1.65-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 100 psig (690 kPa) **OR** 200 psig (1380 kPa), **as directed**, with steel headers at top and bottom.
10. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F (288 deg C) at any point during normal operation.
 - a. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
 - b. Wiring Terminations: Stainless-steel or corrosion-resistant material.
11. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
12. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Motor Type: Permanently lubricated, explosion proof **OR** multispeed **OR** variable speed, **as directed**.
13. Control Devices:
 - a. Unit-mounted **OR** Wall-mounting, **as directed**, variable, **as directed**, fan-speed switch.
 - b. Unit-mounted **OR** Wall-mounting, **as directed**, thermostat.



C. Wall And Ceiling Heaters

1. Description: An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
2. Cabinet:
 - a. Front Panel: Stamped-steel louver **OR** Extruded-aluminum bar grille, **as directed**, with removable panels fastened with tamperproof fasteners.
 - b. Finish: Baked enamel over baked-on primer with manufacturer's standard **OR** custom, **as directed**, color selected by the Owner, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
 - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Surface-Mounting Cabinet Enclosure: Steel with finish to match cabinet.
4. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high temperature protection. Provide integral circuit breaker for overcurrent protection, **as directed**.
5. Fan: Aluminum propeller directly connected to motor.
 - a. Motor: Permanently lubricated, multispeed, **as directed**. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
6. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit, **as directed**.
7. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch, **as directed**.

1.3 EXECUTION

A. Installation

1. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants".
2. Install cabinet unit heaters to comply with NFPA 90A.
3. Install propeller unit heaters level and plumb.
4. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints, **as directed**. Vibration isolators and seismic restraints, **as directed**, are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment". Vibration hangers are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
7. Install new filters in each fan-coil unit within two weeks of Final Completion.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
4. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 Section "Air Duct Accessories".
5. Comply with safety requirements in UL 1995.



6. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping".
 7. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of unit heater. Steam specialties are specified in Division 23 Section "Steam And Condensate Heating Piping".
 8. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
 - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
 2. Remove and replace malfunctioning units and retest as specified above.
- D. Adjusting
1. Adjust initial temperature set points.
 2. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION 23 55 33 00a



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 55 33 00	01 22 16 00	No Specification Required



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SECTION 23 57 13 00 - HEAT EXCHANGERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for hydronic and steam heat exchangers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes shell-and-tube and plate heat exchangers.

C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - a. Tube-removal space.
 - b. Structural members to which heat exchangers will be attached.
3. Manufacturer Seismic Qualification Certification: Submit certification that heat exchanger, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

D. Quality Assurance

1. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

1.2 PRODUCTS

A. Shell-And-Tube Heat Exchangers

1. Configuration: U-tube with removable bundle.
2. Shell Materials: Steel.
3. Head:
 - a. Materials: Cast iron **OR** Cast stainless steel **OR** Fabricated steel **OR** Fabricated steel with removable cover **OR** Fabricated stainless steel **OR** Fabricated stainless steel with removable cover, **as directed**.
 - b. Flanged and bolted to shell.
4. Tube:
 - a. Seamless copper **OR** Steel **OR** Stainless-steel **OR** Cupronickel **OR** Admiralty-metal, **as directed**, tubes.
 - b. Tube diameter is determined by manufacturer based on service.
5. Tubesheet Materials: Steel **OR** Stainless-steel, **as directed**, tubesheets.
6. Baffles: Steel **OR** Stainless steel, **as directed**.
7. Piping Connections:
 - a. Shell: Flanged inlet and threaded **OR** Threaded inlet and **OR** Flanged inlet and, **as directed**, outlet fluid connections, threaded drain, and vent connections.
 - b. Head: Threaded **OR** Flanged, **as directed**, inlet and outlet fluid connections.
8. Support Saddles:
 - a. Fabricated of material similar to shell.
 - b. Foot mount with provision for anchoring to support.



- c. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during a seismic event when heat-exchanger saddles are anchored to building structure.

B. Gasketed Plate Heat Exchangers

1. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.
2. Frame:
 - a. Capacity to accommodate 20 percent additional plates.
 - b. Painted carbon steel with provisions for anchoring to support.
3. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.
 - a. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during a seismic event when heat-exchanger carrying and guide bars are anchored to building structure.
4. End-Plate Material: Painted carbon steel.
5. Tie Rods and Nuts: Steel or stainless steel.
6. Plate Material: 0.024 inch (0.6 mm) **OR** 0.031 inch (0.8 mm) **OR** 0.039 inch (1 mm), **as directed**, thick before stamping; Type 304 **OR** 304L **OR** 316 **OR** 316L, **as directed**, stainless steel.
7. Gasket Material: Nitrile rubber **OR** EPDM, **as directed**.
8. Piping Connections:
 - a. Threaded port for NPS 2 (DN 50) and smaller. For larger sizes, furnish end-plate port with threaded studs suitable for flanged connection.
 - b. End plate with welded carbon-steel nozzles. Threaded pipe connection for NPS 2 (DN 50) and smaller; carbon-steel flanged pipe connection for larger sizes.
 - c. Line wetted surfaces with same material as plates.
9. Enclose plates in a solid aluminum **OR** stainless-steel, **as directed**, removable shroud.

C. Brazed Plate Heat Exchangers

1. Configuration: Brazed assembly consisting of two end plates, one with threaded nozzles and pattern-embossed plates.
2. End-Plate Material: Type 316 stainless steel.
3. Threaded Nozzles: Type 316 stainless steel.
4. Plate Material: Type 316 stainless steel.
5. Brazing Material: Copper or nickel.

1.3 EXECUTION

A. Heat-Exchanger Installation

1. Install shell-and-tube heat exchangers on saddle supports.
2. Install shell-and-tube heat exchangers on, and anchor to, concrete base.

B. Connections

1. Install shutoff valves at heat-exchanger inlet and outlet connections.
2. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.
3. Install vacuum breaker at heat-exchanger steam inlet connection.
4. Install hose end valve to drain shell.

END OF SECTION 23 57 13 00



Task	Specification	Specification Description
23 57 16 00	23 57 13 00	Heat Exchangers
23 57 19 13	23 57 13 00	Heat Exchangers
23 57 19 19	23 57 13 00	Heat Exchangers
23 57 19 23	23 57 13 00	Heat Exchangers



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**SECTION 23 61 16 00 - CENTRIFUGAL WATER CHILLERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for centrifugal water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Packaged, water-cooled, electric-motor-driven centrifugal chillers.
 - b. Packaged, portable refrigerant recovery units.
 - c. Heat-exchanger, brush-cleaning system.

C. Definitions

1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
4. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
5. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW) at any given set of rating conditions.
6. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements

1. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
 - a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) **OR** 55 deg F (13 deg C) **OR** 40 deg F (4 deg C), **as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
 - b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C) **OR** 60 deg F (16 deg C) **OR** 55 deg F (13 deg C), **as directed**.
 - c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 550/590, **as directed**:
 - a. Allowable Capacity Tolerance: Zero percent.
 - b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

E. Submittals



1. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Startup service reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

F. Quality Assurance

1. ARI Certification: Certify chiller according to ARI 550 certification program.
2. ARI Rating: Rate chiller performance according to requirements in ARI 550/590.
3. ASHRAE Compliance:
 - a. ASHRAE 15 for safety code for mechanical refrigeration.
 - b. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
4. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
5. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.
6. Comply with NFPA 70.
7. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.
8. Green Seal Compliance: Signed by manufacturer **OR** Green Seal, **as directed**, certifying compliance with GS-31.

G. Delivery, Storage, And Handling

1. Ship chillers from the factory fully charged with refrigerant.
OR
Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
2. Ship each oil-lubricated chiller with a full charge of oil.
 - a. Ship oil factory installed in chiller **OR** in containers separate from chiller, **as directed**.
3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
 - a. Extended warranties include, but are not limited to, the following:
 - 1) Complete chiller including refrigerant and oil charge.
- OR**



- Complete compressor and drive assembly including refrigerant and oil charge.
- OR**
- Refrigerant **OR** Refrigerant and oil, **as directed**, charge.
- 2) Parts only **OR** Parts and labor, **as directed**.
- 3) Loss of refrigerant charge for any reason.
- b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Unit

1. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor motor controller, evaporator **OR** lubrication system evaporator, **as directed**, condenser, heat-reclaim condenser as indicated, controls, interconnecting unit piping and wiring, and indicated accessories.
 - a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
 - b. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced.
2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

B. Compressor-Drive Assembly

1. Description: Single-stage or multistage, variable-displacement, centrifugal-type compressor driven by an electric motor.
 - a. Where indicated, provide oil-free compressor technology using a permanent magnet synchronous motor, magnetic bearings, integral variable frequency controller, and digital electronic controls.
2. Compressor:
 - a. Casing: Cast iron, precision ground.
 - b. Impeller: High-strength cast aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.
3. Drive: Direct-drive, hermetic **OR** Gear-drive, hermetic **OR** Gear-drive, open **OR** Direct- or gear-drive, hermetic **OR** Direct- or gear-drive, open or hermetic, **as directed**, design using an electric motor as the driver.
 - a. Gear Drives: For chillers with gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating. Gears shall comply with American Gear Manufacturer Association standards.
 - b. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
 - c. Seals: Seal drive assembly to prevent refrigerant leakage.
4. Compressor Motor:
 - a. Continuous-duty, squirrel-cage, induction-type, two-pole motor with energy efficiency required to suit chiller energy efficiency indicated.
 - b. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
 - c. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
 - d. For chillers with open drives, provide motor with open-dripproof **OR** weather-protected, Type I **OR** weather-protected, Type II **OR** totally enclosed, **as directed**, enclosure.
 - e. Provide motor with thermistor or RTD in single motor winding **OR** each of three-phase motor windings, **as directed**, to monitor temperature and report information to chiller control panel.



- f. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
- g. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
5. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
 - a. Overspeed Test: 25 percent above design operating speed.
6. Service: Easily accessible for inspection and service.
 - a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
 - b. Provide lifting lugs or eyebolts attached to casing.
7. Economizers: For multistage chillers, provide interstage economizers.
8. Capacity Control: Modulating, variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve performance indicated.
 - a. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
 - b. Operating Range: From 100 to 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
 - c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) for each 10 percent in capacity reduction, **as directed**.
 - d. Chillers with variable frequency controllers shall modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.
9. Oil Lubrication System: Consisting of pump, filtration, heater, **as directed**, cooler, factory-wired power connection, and controls.
 - a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, coastdown, and standby conditions including power failure.
 - b. Manufacturer's standard method **OR** Thermostatically controlled oil heater properly sized, **as directed**, to remove refrigerant from oil.
 - c. Oil filter **OR** Dual oil filters, one redundant, **as directed**, shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
 - d. Refrigerant **OR** Water, **as directed**, -cooled oil cooler.
 - e. Factory-installed and pressure-tested piping with isolation valves and accessories.
 - f. Oil compatible with refrigerant and chiller components.
 - g. Positive visual indication of oil level.

C. Refrigeration

1. Refrigerant:
 - a. Type: R-123; ASHRAE 34, Class B1 **OR** R-134a; ASHRAE 34, Class A1, as directed.
 - b. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
2. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
3. Pressure Relief Device:
 - a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. For Chillers Using R-123: Rupture disc constructed of frangible carbon **OR** Spring-loaded, pressure relief valve; single- or multiple-reseating type, **as directed**.
 - c. For Chillers Using R-134a: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.



4. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.
 5. Refrigerant Isolation for Chillers Using R-134a: Factory install positive shutoff, manual, **as directed**, isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell, **as directed**.
 6. Purge System:
 - a. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of noncondensables including, but not limited to, water, water vapor, and noncondensable gases.
 - b. System shall be a thermal purge design, refrigerant or air cooled, equipped with a carbon filter that includes an automatic regeneration cycle.
 - c. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.
 - d. Construct components of noncorrodible materials.
 - e. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
 - f. Efficiency of not more than 0.02 lb of refrigerant per pound of air (9 g of refrigerant per gram of air) when rated according to ARI 580.
 - g. Operation independent of chiller per ASHRAE 147.
 7. Positive-Pressure System:
 - a. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic positive-pressure system.
 - b. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant pressure vessel of not less than 0.5 psig (3 kPa) (adjustable) up to a pressure that remains within the vessel design pressure limits.
 - c. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.
- D. Evaporator
1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
 2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
 3. Designed to prevent liquid refrigerant carryover from entering compressor.
 4. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
 5. Tubes:
 - a. Individually replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
 - d. Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
 - e. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: Enhanced **OR** Smooth, **as directed**.
 6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.



8. Water Box:
 - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
 - c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
 - d. Hinged **OR** Davited, **as directed**, water boxes.
OR
Hinged **OR** Davited, **as directed**, marine water-box covers.
 - e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - f. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - g. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
9. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

E. Condenser

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
4. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
5. Tubes:
 - a. Individually replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
 - d. Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**
 - e. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: Enhanced **OR** Smooth, **as directed**.
6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
8. Water Box:
 - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
 - c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
 - d. Hinged **OR** Davited, **as directed**, water boxes.
OR



- Hinged **OR** Davited, **as directed**, marine water-box covers.
 - e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - f. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - g. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
 - 9. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
- F. Heat-Reclaim Condenser
 - 1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.
 - 2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
 - 3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
 - 4. Tubes:
 - a. Individually replaceable from either end and without damage to tube sheets and other tubes.
 - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
 - d. Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
 - e. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - f. External Finish: Manufacturer's standard.
 - g. Internal Finish: Enhanced **OR** Smooth, **as directed**.
 - 5. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - 6. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
 - 7. Water Box:
 - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
 - c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
 - d. Hinged **OR** Davited, **as directed**, water boxes.
OR
Hinged **OR** Davited, **as directed**, marine water-box covers.
 - e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - f. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - g. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
 - 8. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR



Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

G. Insulation

1. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - a. Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
2. Adhesive: As recommended by insulation manufacturer.
3. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
 - a. Apply adhesive to 100 percent of insulation contact surface.
 - b. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 - c. Seal seams and joints to provide a vapor barrier.
 - d. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

H. Electrical

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
 - a. Branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
 - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
 - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
 - b. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
 - c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight **OR** flexible metallic, **as directed**, conduit.
5. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at all operating conditions.
 - a. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
 - b. Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAR ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
 - c. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
 - d. Provide a ground terminal and a terminal block or individual connectors for phase connection.

I. Motor Controller



1. Enclosure: Factory installed, unit mounted **OR** Factory furnished, field mounted, **as directed**, NEMA 250 **OR** NEMA ICS 6, **as directed**, Type 1 **OR** Type 4 **OR** Type 4X **OR** Type 12, **as directed**, with hinged full-front access door with lock and key or padlock and key, **as directed**.
2. Control Circuit: Obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected control devices.
3. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.
4. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
5. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
6. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.
7. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
 - a. Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - b. Visual indication of motor and control status, including the following conditions:
 - 1) Controller on.
 - 2) Overload trip.
 - 3) Loss of phase.
 - 4) Starter fault.
8. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
 - a. Externally Operated, Door-Interlocked, **as directed**, Disconnect: Fused disconnect switch **OR** Nonfused disconnect switch **OR** Circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
 - b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
 - d. Control Relays: Time-delay relays.
 - e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
 - f. Number-of-Starts Counter: Numerical readout on face of enclosure.
 - g. Meters: Panel type, 2-1/2 inches (64 mm) **OR** 4-1/4 inches (108 mm), **as directed**, with 90 **OR** 120 **OR** 270, **as directed**,-degree scale and 1 **OR** 2, **as directed**, percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
 - 1) Ammeter: Output current for each phase, with current sensors rated to suit application.
 - 2) Voltmeter: Output voltage for each phase.
 - 3) Frequency Meter, **as directed**: Output frequency.
 - 4) Real-time clock with current time and date.
 - 5) Total run time.

OR

Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

 - 1) Selectable, digital display of the following:
 - a) Phase Currents, Each Phase: Plus or minus 1 percent.
 - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d) Three-Phase Real Power: Plus or minus 2 percent.
 - e) Three-Phase Reactive Power: Plus or minus 2 percent.
 - f) Power Factor: Plus or minus 2 percent.
 - g) Frequency: Plus or minus 0.5 percent.
 - h) Integrated Demand with Demand Interval Selectable from Five to 60 Minutes: Plus or minus 2 percent.



- i) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 - 2) Mounting: Display and control unit flush or semirecessed in instrument compartment door.
 - h. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
 - i. Power Protection: Chiller shall shut down within six cycles of power interruption.
- J. Variable Frequency Controller
 - 1. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
 - 2. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
 - 3. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, with hinged full-front access door with lock and key.
 - 4. Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
 - 5. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
 - 6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
 - a. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.
 - b. Regulator shall provide full digital control of frequency and voltage.
 - c. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage, for application to a squirrel-cage motor. Inverter shall produce a sine-coded, pulse width modulated (PWM) output wave form and shall conduct no radio-frequency interference back to the input power supply.
 - 7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
 - 8. Operating Requirements:
 - a. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum, **as directed**.
 - b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - c. Capable of driving full load, without derating, under the following conditions:
 - 1) Ambient Temperature: 0 to 50 deg C.
 - 2) Relative Humidity: Up to 90 **OR** 95, **as directed**, percent (noncondensing).
 - 3) Altitude: 3300 feet (1005 m) **OR** 6600 feet (2010 m), **as directed**.
 - d. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter, 98 percent with harmonic filter.
 - f. Overload Capability: 1.05 times the full-load current for 7 seconds.
 - g. Starting Torque: As required by compressor-drive assembly.
 - h. Speed Regulation: Plus or minus 1 percent.
 - i. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
 - j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
 - 9. Internal Adjustability Capabilities:
 - a. Minimum Output Frequency: 6 Hz.
 - b. Maximum Output Frequency: 60 Hz.
 - c. Acceleration: 2 seconds to a minimum of 60 seconds.



- d. Deceleration: 2 seconds to a minimum of 60 seconds.
- e. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.
10. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
 - a. Overtemperature.
 - b. Short circuit at controller output.
 - c. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
 - d. Open circuit at controller output.
 - e. Input undervoltage.
 - f. Input overvoltage.
 - g. Loss of input phase.
 - h. Reverse phase.
 - i. AC line switching transients.
 - j. Instantaneous overload, line to line or line to ground.
 - k. Sustained overload exceeding 100 percent of controller rated current.
 - l. Starting a rotating motor.
11. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
12. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
13. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:
 - a. Power on.
 - b. Run.
 - c. Overvoltage.
 - d. Line fault.
 - e. Overcurrent.
 - f. External fault.
 - g. Motor speed (percent).
 - h. Fault or alarm status (code).
 - i. DC-link voltage.
 - j. Motor output voltage.
 - k. Input kilovolt amperes.
 - l. Total power factor.
 - m. Input kilowatts.
 - n. Input kilowatt-hours.
 - o. Three-phase input voltage.
 - p. Three-phase output voltage.
 - q. Three-phase input current.
 - r. Three-phase output current.
 - s. Three-phase input voltage total harmonic distortion.
 - t. Three-phase input current total harmonic distortion.
 - u. Output frequency (Hertz).
 - v. Elapsed operating time (hours).
 - w. Diagnostic and service parameters.
14. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
15. Control Signal Interface:
 - a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
16. Active Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.

OR

Input Line Conditioning: <Insert requirements>.



17. Cooling: Air **OR** Refrigerant **OR** Water, **as directed**, cooled.
18. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
 - a. Control Relays: Auxiliary and adjustable time-delay relays.
19. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

K. Controls

1. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Fault history with not less than last 10 faults displayed.
 - d. Set points of controllable parameters.
 - e. Trend data.
 - f. Operating hours.
 - g. Number of chiller starts.
 - h. Outdoor-air temperature or space temperature if required for chilled-water reset.
 - i. Entering- and leaving-fluid temperatures of evaporator and condenser.
 - j. Difference in fluid temperatures of evaporator and condenser.
 - k. Fluid flow of evaporator and condenser.
 - l. Fluid pressure drop of evaporator and condenser.
 - m. Refrigerant pressures in evaporator and condenser.
 - n. Refrigerant saturation temperature in evaporator and condenser shell.
 - o. Compressor refrigerant suction and discharge temperature.
 - p. Compressor bearing temperature.
 - q. Motor bearing temperature.
 - r. Motor winding temperature.
 - s. Oil temperature.
 - t. Oil discharge pressure.
 - u. Phase current.
 - v. Percent of motor rated load amperage.
 - w. Phase voltage.
 - x. Demand power (kilowatts).
 - y. Energy use (kilowatt-hours).
 - z. Power factor.
 - aa. For chillers equipped with variable frequency controllers and harmonic filters, include the following:
 - 1) Output voltage and frequency.
 - 2) Voltage total harmonic distortion for each phase.
 - 3) Supply current total demand distortion for each phase.
 - 4) Inlet vane position.
 - 5) Controller internal ambient temperature.
 - 6) Heatsink temperature.
 - bb. Purge suction temperature if purge system is provided.
 - cc. Purge elapsed time if purge system is provided.
4. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.



- b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
 - c. Current limit and demand limit.
 - d. Condenser-fluid temperature.
 - e. External chiller emergency stop.
 - f. Variable evaporator flow.
 - g. Thermal storage.
 - h. Heat reclaim.
5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
- a. Low evaporator pressure **OR** temperature, **as directed**; high condenser pressure.
 - b. Low evaporator fluid temperature.
 - c. Low oil differential pressure.
 - d. High or low oil pressure.
 - e. High oil temperature.
 - f. High compressor-discharge temperature.
 - g. Loss of condenser-fluid flow.
 - h. Loss of evaporator fluid flow.
 - i. Motor overcurrent.
 - j. Motor overvoltage.
 - k. Motor undervoltage.
 - l. Motor phase reversal.
 - m. Motor phase failure.
 - n. Sensor- or detection-circuit fault.
 - o. Processor communication loss.
 - p. Motor controller fault.
 - q. Extended compressor surge.
 - r. Excessive air-leakage detection for chillers using R-123 refrigerant.
6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.
10. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
- a. Hardwired Points:
 - 1) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours) **OR** power factor, **as directed**.
 - 2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
 - b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

L. Finish

- 1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:



- a. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
 - b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least 4 mils (0.10 mm).
 - c. Paint surfaces that are to be insulated before applying the insulation.
 - d. Paint installed insulation to match adjacent uninsulated surfaces.
 - e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner, **as directed**.
2. Provide the Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

M. Accessories

1. Flow Switches:

- a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and verify field-mounting location before installation.
- b. Paddle Flow Switches:
 - 1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
 - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
 - 3) Pressure rating equal to pressure rating of heat exchanger.
 - 4) Construct body and wetted parts of Type 316 stainless steel.
 - 5) House switch in a NEMA 250, Type 4, **as directed**, enclosure constructed of die-cast aluminum.
 - 6) Vane length to suit installation.

OR

Pressure Differential Switches:

- 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - 2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
 - 3) Set Point: Screw type, field adjustable.
 - 4) Electrical Connections: Internally mounted screw-type terminal blocks.
 - 5) Switch Enclosure: NEMA 250, Type 4, **as directed**.
 - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
2. Vibration Isolation:
 - a. Chiller manufacturer shall furnish vibration isolation for each chiller.
 - b. Neoprene Pad:
 - 1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
 - 2) Fabricate pads from 40- to 50-durometer neoprene.
 - 3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

OR

Spring Isolator:

- 1) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed so that the Kx/Ky ratio shall be 1.0 or more for stability.
- 2) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
- 3) Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of 0.25 inch (6 mm) shall be bonded to the baseplate.



- 4) Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
 - 5) Isolators shall be selected for a nominal 1-inch (25-mm) **OR** 2-inch (50-mm), **as directed**, deflection.
3. Sound Barrier:
- a. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
 - b. Provide for repeated installation and removal without use of tape or calk.
 - c. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
 - d. Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
 - e. Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
 - f. Continuously lap all exposed seams at least 2 inches (50 mm) for better sound containment.
 - g. Permanently label each section of cover to indicate its location, description, size, and number sequence.
 - h. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.
- N. Packaged Refrigerant Recovery Units
1. Packaged portable unit consisting of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.
- O. Heat-Exchanger, Brush-Cleaning System
1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.
 2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
 3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
 4. Components:
 - a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
 - b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
 - c. Four-Way Valve:
 - 1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
 - 2) Configure valve with parallel flow connections to minimize field installation piping.
 - 3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
 - 4) Pipe connections shall be flanged.



- 5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
 - 6) Hydrostatically test to 1.5 times the design working pressure.
 - 7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
 - 8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
 - 9) Valve Actuator: Mount electric actuator to operate valve.
OR
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
 - 10) Position Switches: Factory mount microswitches on the valve to indicate the complete turn of valve in both normal and reverse flow.
- d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
- 1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
 - 2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
 - 3) Manual override of preset cleaning cycle.
 - 4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
 - 5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
 - 6) Flow switch bypass.
 - 7) Unloading signal to chiller.

P. Source Quality Control

1. Perform functional **OR** functional run, **as directed**, tests of chillers before shipping.
2. Factory performance test chillers, before shipping, according to ARI 550/590.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.
OR
Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
OR
At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
 - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
 - c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
3. Factory sound test chillers, before shipping, according to ARI 575, **s directed**.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Chiller operating at calculated worst-case sound condition.
 - 3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
 - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
 - c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.



4. For chillers using R-134a refrigerant, factory test and inspect evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
5. For chillers using R-123 refrigerant, factory test and inspect evaporator and condenser **OR** condenser and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers to a minimum of 45 psig (310 kPa). Vacuum and pressure test for leaks.
6. For chillers located indoors, rate sound power level according to ARI 575.

1.3 EXECUTION

A. Chiller Installation

1. Install chillers on support structure indicated.
2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install chiller using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Maintain manufacturer's recommended clearances for service and maintenance.
6. Charge chiller with refrigerant and fill with oil if not factory installed.
7. Install separate devices furnished by manufacturer and not factory installed.

B. Heat-Exchanger, Brush-Cleaning System Installation

1. Install brush-cleaning system control panel adjacent to chiller control panel.
2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
3. Provide field electric power, as required, to each system control panel and electric actuated valve.
4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.



5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

C. Connections

1. Comply with requirements for piping specified in Division 23 Section(s) "Hydronic Piping" AND "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to chiller to allow service and maintenance.
3. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
4. Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
5. Heat-Reclaim Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping **OR** separate vent piping for each chiller, **as directed** to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
7. For chillers equipped with a purge system, extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.
8. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Verify that refrigerant charge is sufficient and chiller has been leak tested.
 - c. Verify that pumps are installed and functional.
 - d. Verify that thermometers and gages are installed.
 - e. Operate chiller for run-in period.
 - f. Check bearing lubrication and oil levels.
 - g. Verify that refrigerant pressure relief device is vented outside.
 - h. Verify proper motor rotation.
 - i. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
 - j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**.
 - k. Verify and record performance of chiller protection devices.
 - l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.



3. Prepare test and inspection startup reports.

END OF SECTION 23 61 16 00



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**SECTION 23 61 16 00a - ROTARY-SCREW WATER CHILLERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for rotary screw water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Packaged, water-cooled, single-compressor chillers.
 - b. Packaged, water-cooled, multiple-compressor chillers.
 - c. Packaged, air-cooled chillers.
 - d. Packaged, portable refrigerant recovery units.
 - e. Heat-exchanger, brush-cleaning system.

C. Definitions

1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
4. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
5. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW) at any given set of rating conditions.
6. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than ARI standard rating conditions.

D. Performance Requirements

1. Seismic Performance: Chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
 - a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) **OR** 55 deg F (13 deg C) **OR** 40 deg F (4 deg C), **as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
 - b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C) **OR** 60 deg F (16 deg C) **OR** 55 deg F (13 deg C), **as directed**.
 - c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 550/590, **as directed**:
 - a. Allowable Capacity Tolerance: Zero percent.
 - b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.



- E. Submittals
1. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
 2. LEED Submittal:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
 4. Certificates: For certification required in "Quality Assurance" Article.
 5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
 6. Startup service reports.
 7. Operation and maintenance data.
 8. Warranty: Sample of special warranty.
- F. Quality Assurance
1. ARI Certification: Certify chiller according to ARI 550 and ARI 590, **as directed**, certification program(s).
 2. ARI Rating: Rate chiller performance according to requirements in ARI 550/590.
 3. ASHRAE Compliance:
 - a. ASHRAE 15 for safety code for mechanical refrigeration.
 - b. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
 4. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
 5. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.
 6. Comply with NFPA 70.
 7. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.
- G. Delivery, Storage, And Handling
1. Ship chillers from the factory fully charged with refrigerant.
OR
Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
 2. Ship each oil-lubricated chiller with a full charge of oil.
 - a. Ship oil factory installed in chiller **OR** in containers separate from chiller, **as directed**.
 3. Package chiller for export shipping in totally enclosed crate and bagging, **as directed**.
- H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
 - a. Extended warranties include, but are not limited to, the following:
 - 1) Complete chiller including refrigerant and oil charge.
OR
Complete compressor and drive assembly including refrigerant and oil charge.
OR
Refrigerant **OR** Refrigerant and oil charge, **as directed**.
 - 2) Parts only **OR** Parts and labor, **as directed**.
 - 3) Loss of refrigerant charge for any reason.
 - b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Final Completion.



1.2 PRODUCTS

A. Packaged, Water-Cooled, Single-Compressor Chillers

1. Description: Factory-assembled and factory-tested **OR** run-tested, **as directed**, chiller with compressor, compressor motor, compressor motor controller, lubrication system, evaporator, condenser, heat-reclaim condenser as indicated, controls, interconnecting unit piping and wiring, and indicated accessories.
 - a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
3. Compressor:
 - a. Description: Hermetic **OR** Open, **as directed**, positive displacement, and oil lubricated.
 - b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
 - c. Rotors: Manufacturer's standard one-, two-, or three-rotor design.
 - d. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
 - e. Seals: Seal drive assembly to prevent refrigerant leakage.
4. Compressor Motor:
 - a. Continuous-duty, squirrel-cage, induction-type motor with energy efficiency required to suit chiller energy efficiency indicated.
 - b. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
 - c. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
 - d. For chillers with open drives, provide motor with open-dripproof **OR** weather-protected, Type I **OR** weather-protected, Type II **OR** totally enclosed, **as directed**, enclosure.
 - e. Provide motor with thermistor or RTD in single motor winding **OR** each of three-phase motor windings, **as directed**, to monitor temperature and report information to chiller control panel.
 - f. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
 - g. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
5. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
 - a. Overspeed Test: 25 percent above design operating speed.
6. Service: Easily accessible for inspection and service.
 - a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
 - b. Provide lifting lugs or eyebolts attached to casing.
7. Capacity Control: Modulating slide-valve assembly or port unloaders combined with a variable frequency controller, if applicable, and hot-gas bypass, if necessary, to achieve performance indicated.
 - a. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
 - b. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
 - c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of 2.5 deg F/1.4 deg C drop for each 10 percent in capacity reduction, **as directed**.
8. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
 - a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
 - b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.



- c. Oil filter **OR** Dual oil filters, one redundant, **as directed**, shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
 - d. Refrigerant **OR** Water, **as directed**, -cooled oil cooler.
 - e. Factory-installed and pressure-tested piping with isolation valves and accessories.
 - f. Oil compatible with refrigerant and chiller components.
 - g. Positive visual indication of oil level.
9. Refrigerant Circuit:
- a. Refrigerant: Type as indicated on Drawings.
OR
Refrigerant Type: R-134a **OR** HFC, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
 - b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 - c. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
 - d. Pressure Relief Device:
 - 1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.
 - e. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.
 - f. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell, **as directed**.
10. Evaporator:
- a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
 - b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
 - c. Designed to prevent liquid refrigerant carryover from entering compressor.
 - d. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
 - e. Tubes:
 - 1) Individually replaceable from either end and without damage to tube sheets and other tubes.
 - 2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - 3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
 - 4) Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
 - 5) Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - 6) External Finish: Manufacturer's standard.
 - 7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
 - f. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - g. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.



- h. Water Box:
 - 1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - 2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
 - 3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
 - 4) Hinged **OR** Davited, **as directed**, water boxes.
OR
Hinged **OR** Davited, **as directed**, marine water-box covers.
 - 5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - 6) Thermistor or RTD temperature sensor factory installed in each nozzle.
 - 7) Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
 - i. Additional Corrosion Protection:
 - 1) Electrolytic corrosion-inhibitor anode.
 - 2) Coat wetted surfaces with a corrosion-resistant finish.
11. Condenser:
- a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.
 - b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
 - c. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
 - d. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
 - e. Tubes:
 - 1) Individually replaceable from either end and without damage to tube sheets and other tubes.
 - 2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - 3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
 - 4) Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
 - 5) Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - 6) External Finish: Manufacturer's standard.
 - 7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
 - f. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - g. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
 - h. Water Box:
 - 1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - 2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
 - 3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
 - 4) Hinged **OR** Davited, **as directed**, water boxes.
OR
Hinged **OR** Davited, **as directed**, marine water-box covers.



- 5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - 6) Thermistor or RTD temperature sensor factory installed in each nozzle.
 - 7) Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
 - i. Additional Corrosion Protection:
 - 1) Electrolytic corrosion-inhibitor anode.
 - 2) Coat wetted surfaces with a corrosion-resistant finish.
12. Heat-Reclaim Condenser:
- a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.
 - b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
 - c. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
 - d. Tubes:
 - 1) Individually replaceable from either end and without damage to tube sheets and other tubes.
 - 2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
 - 3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
 - 4) Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
 - 5) Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - 6) External Finish: Manufacturer's standard.
 - 7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
 - e. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 - f. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
 - g. Water Box:
 - 1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - 2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
 - 3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
 - 4) Hinged **OR** Davited, **as directed**, water boxes.
OR
Hinged **OR** Davited, **as directed**, marine water-box covers.
 - 5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - 6) Thermistor or RTD temperature sensor factory installed in each nozzle.
 - 7) Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
 - h. Additional Corrosion Protection:
 - 1) Electrolytic corrosion-inhibitor anode.
 - 2) Coat wetted surfaces with a corrosion-resistant finish.
13. Electrical Power:
- a. Factory installed and wired, and functionally tested at factory before shipment.



- b. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
 - 1) Provide branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
 - 2) NEMA- and ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
 - 3) Control-circuit transformer with primary and secondary side fuses.
- c. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
- d. Factory-installed wiring outside of enclosures shall be in metal raceway except make connections to each motor and heater with not more than a 24-inch (610-mm) length of liquidtight conduit.
- e. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at all operating conditions.
 - 1) If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
 - 2) Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAr ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
 - 3) Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within 1 minute after de-energizing.
 - 4) Provide a ground terminal and a terminal block or individual connectors for phase connection.
- 14. Motor Controller:
 - a. Enclosure: Factory installed, unit mounted **OR** Factory furnished, field mounted, **as directed**, NEMA 250 **OR** NEMA ICS 6, **as directed**, Type 1 **OR** Type 4 **OR** Type 4X **OR** Type 12, **as directed**, with hinged full-front access door with lock and key or padlock and key, **as directed**.
 - b. Control Circuit: Obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected control devices.
 - c. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.
 - d. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
 - e. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
 - f. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.
 - g. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
 - 1) Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - 2) Visual indication of motor and control status, including the following conditions:
 - a) Controller on.
 - b) Overload trip.
 - c) Loss of phase.
 - d) Starter fault.
 - h. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
 - 1) Externally Operated, Door-Interlocked, **as directed**, Disconnect: Fused disconnect switch **OR** Nonfused disconnect switch **OR** Circuit breaker, **as directed**. Minimum



- withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
- 2) Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - 3) Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
 - 4) Control Relays: Time-delay relays.
 - 5) Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
 - 6) Number-of-Starts Counter: Numerical readout on face of enclosure.
 - 7) Meters: Panel type, 2-1/2 inches (64 mm) **OR** 4-1/4 inches (108 mm), **as directed**, with 90 **OR** 120 **OR** 270, **as directed**,-degree scale and 1 **OR** 2, **as directed**, percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
 - a) Ammeter: Output current for each phase, with current sensors rated to suit application.
 - b) Voltmeter: Output voltage for each phase.
 - c) Frequency Meter: Output frequency.
 - d) Real-time clock with current time and date.
 - e) Total run time.

OR

Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

 - a) Selectable, digital display of the following:
 - i. Phase Currents, Each Phase: Plus or minus 1 percent.
 - ii. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - iii. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - iv. Three-Phase Real Power: Plus or minus 2 percent.
 - v. Three-Phase Reactive Power: Plus or minus 2 percent.
 - vi. Power Factor: Plus or minus 2 percent.
 - vii. Frequency: Plus or minus 0.5 percent.
 - viii. Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - ix. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 - b) Mounting: Display and control unit flush or semirecessed in instrument compartment door.
 - 8) Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
 - 9) Power Protection: Chiller shall shut down within six cycles of power interruption.
15. Variable Frequency Controller:
- a. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
 - b. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
 - c. Enclosure: Unit mounted, NEMA 250, Type 1, **as directed**, with hinged full-front access door with lock and key.
 - d. Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
 - e. Technology: Pulse width modulated (PWM) output suitable for constant or variable torque loads.



- f. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
- g. Operating Requirements:
 - 1) Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum, **as directed**.
 - 2) Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - 3) Capable of driving full load, without derating, under the following conditions:
 - a) Ambient Temperature: 0 to 40 deg C.
 - b) Relative Humidity: Up to 90 **OR** 95, **as directed**, percent (noncondensing).
 - c) Altitude: 3300 feet (1005 m) **OR** 6600 feet (2010 m), **as directed**.
 - 4) Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 5) Minimum Displacement Primary-Side Power Factor: 98 percent.
 - 6) Overload Capability: 1.05 times the full-load current for 7 seconds.
 - 7) Starting Torque: As required by compressor-drive assembly.
 - 8) Speed Regulation: Plus or minus 1 percent.
 - 9) Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
 - 10) To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - 11) Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
- h. Internal Adjustability Capabilities:
 - 1) Minimum Output Frequency: 6 Hz.
 - 2) Maximum Output Frequency: 60 Hz.
 - 3) Acceleration: 2 seconds to 60 seconds.
 - 4) Deceleration: Zero seconds to 60 seconds.
 - 5) Current Limit: 30 to a minimum of 100 percent of maximum rating.
- i. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
 - 1) Overtemperature.
 - 2) Short circuit at controller output.
 - 3) Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
 - 4) Open circuit at controller output.
 - 5) Input undervoltage.
 - 6) Input overvoltage.
 - 7) Loss of input-phase.
 - 8) Reverse phase.
 - 9) AC line switching transients.
 - 10) Instantaneous overload, line to line or line to ground.
 - 11) Sustained overload exceeding 100 percent of controller rated current.
 - 12) Starting a rotating motor.
- j. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
- k. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss, and overvoltage and undervoltage trips.
- l. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:
 - 1) Power on.
 - 2) Run.
 - 3) Overvoltage.
 - 4) Line fault.
 - 5) Overcurrent.



- 6) External fault.
 - 7) Motor speed (percent).
 - 8) Fault or alarm status (code).
 - 9) Motor output voltage.
 - 10) Input kilovolt amperes.
 - 11) Total power factor.
 - 12) Input kilowatts.
 - 13) Input kilowatt-hours.
 - 14) Three-phase input voltage.
 - 15) Three-phase output voltage.
 - 16) Three-phase input current.
 - 17) Three-phase output current.
 - 18) Output frequency (Hertz).
 - 19) Elapsed operating time (hours).
 - 20) Diagnostic and service parameters.
- m. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
- n. Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.
16. Controls:
- a. Standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
 - b. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.
 - c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
 - 1) Date and time.
 - 2) Operating or alarm status.
 - 3) Fault history with not less than last 10 faults displayed.
 - 4) Set points of controllable parameters.
 - 5) Trend data.
 - 6) Operating hours.
 - 7) Number of chiller starts.
 - 8) Outdoor-air temperature or space temperature if required for chilled-water reset.
 - 9) Temperature and pressure of operating set points.
 - 10) Entering- and leaving-fluid temperatures of evaporator and condenser.
 - 11) Difference in fluid temperatures of evaporator and condenser.
 - 12) Fluid flow of evaporator and condenser.
 - 13) Fluid pressure drop of evaporator and condenser.
 - 14) Refrigerant pressures in evaporator and condenser.
 - 15) Refrigerant saturation temperature in evaporator and condenser.
 - 16) Pump status.
 - 17) Antirecycling timer status.
 - 18) Percent of maximum motor amperage.
 - 19) Current-limit set point.
 - 20) Compressor bearing temperature.
 - 21) Motor bearing temperature.
 - 22) Motor winding temperature.
 - 23) Oil temperature.
 - 24) Oil discharge pressure.
 - 25) Phase current.
 - 26) Percent of motor rated load amperes.
 - 27) Phase voltage.



- 28) Demand power (kilowatts).
- 29) Energy use (kilowatt-hours).
- 30) Power factor.
- d. Control Functions:
 - 1) Manual or automatic startup and shutdown time schedule.
 - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
 - 3) Current limit and demand limit.
 - 4) Condenser-fluid temperature.
 - 5) External chiller emergency stop.
 - 6) Antirecycling timer.
 - 7) Variable evaporator flow.
 - 8) Thermal storage.
 - 9) Heat reclaim.
- e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
 - 1) Low evaporator pressure or temperature; high condenser pressure.
 - 2) Low evaporator fluid temperature.
 - 3) Low oil differential pressure.
 - 4) High or low oil pressure.
 - 5) High oil temperature.
 - 6) High compressor-discharge temperature.
 - 7) Loss of condenser-fluid flow.
 - 8) Loss of evaporator-fluid flow.
 - 9) Motor overcurrent.
 - 10) Motor overvoltage.
 - 11) Motor undervoltage.
 - 12) Motor phase reversal.
 - 13) Motor phase failure.
 - 14) Sensor- or detection-circuit fault.
 - 15) Processor communication loss.
 - 16) Motor controller fault.
 - 17) Extended compressor surge.
- f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
- g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
- h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
- i. Communication Port: RS-232 port or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.
- j. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
 - 1) Hardwired Points:
 - a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours) **OR** power factor, **as directed**.
 - b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
 - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.



17. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - b. Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - c. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 - d. Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
 - 1) Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 - 2) Seal seams and joints to provide a vapor barrier.
 - 3) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
18. Finish:
- a. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
 - 1) Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
 - 2) Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least 4 mils (0.10 mm).
 - 3) Paint surfaces that are to be insulated before applying the insulation.
 - 4) Paint installed insulation to match adjacent uninsulated surfaces.
 - 5) Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner, **as directed**.
 - b. Provide the Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.
19. Accessories:
- a. Flow Switches:
 - 1) If required and not factory installed, chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and verify field-mounting location before installation.
 - 2) Paddle Flow Switches:
 - a) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
 - b) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
 - c) Pressure rating equal to pressure rating of heat exchanger.
 - d) Construct body and wetted parts of Type 316 stainless steel.
 - e) House switch in a NEMA 250, Type 4, **as directed**, enclosure constructed of die-cast aluminum.
 - f) Vane length to suit installation.
 - OR**
 - Pressure Differential Switches:
 - g) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - h) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
 - i) Set Point: Screw type, field adjustable.
 - j) Electrical Connections: Internally mounted screw-type terminal blocks.
 - k) Switch Enclosure: NEMA 250, Type 4, **as directed**.



- l) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
 - b. Vibration Isolation:
 - c. Chiller manufacturer shall furnish vibration isolation for each chiller.
 - 1) Neoprene Pad:
 - a) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
 - b) Fabricate pads from 40- to 50-durometer neoprene.
 - c) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.
 - OR**
 - Spring Isolator:
 - d) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed such that the Kx/Ky ratio shall be 1.0 or more for stability.
 - e) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
 - f) Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of 0.25 inch (6 mm) shall be bonded to the baseplate.
 - g) Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
 - h) Isolators shall be selected for a nominal 1-inch (25-mm) **OR** 2-inch (50-mm), **as directed**, deflection.
 - d. Sound Barrier:
 - 1) Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
 - 2) Provide for repeated installation and removal without use of tape or caulk.
 - 3) Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
 - 4) Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
 - 5) Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
 - 6) Continuously lap all exposed seams at least 2 inches (50 mm) for better sound containment.
 - 7) Permanently label each section of cover to indicate its location, description, size, and number sequence.
 - 8) Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.
- B. Packaged, Water-Cooled, Multiple-Compressor Chillers
- 1. Description: Factory-assembled and -tested **OR** run-tested, **as directed**, chiller with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
 - a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.



2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
3. Compressors:
 - a. Description: Positive displacement, hermetically sealed.
 - b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
 - c. Rotors: Manufacturer's standard one- or two-rotor design.
4. Service: Easily accessible for inspection and service.
 - a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
 - b. Provide lifting lugs or eyebolts attached to casing.
5. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.
 - a. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
 - b. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
 - c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) drop for each 10 percent in capacity reduction, **as directed**.
6. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
 - a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
 - b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
 - c. Factory-installed and pressure-tested piping with isolation valves and accessories.
 - d. Oil compatible with refrigerant and chiller components.
 - e. Positive visual indication of oil level.
7. Vibration Control:
 - a. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
 - 1) Overspeed Test: 25 percent above design operating speed.
 - b. Isolation: Mount individual compressors on vibration isolators.
8. Sound Control: Sound-reduction package shall consist of removable acoustic enclosures around the compressors and drive assemblies that are designed to reduce sound levels without affecting performance.
9. Compressor Motors:
 - a. Hermetically sealed and cooled by refrigerant suction gas.
 - b. High-torque, induction type with inherent thermal-overload protection on each phase.
10. Refrigerant Circuits:
 - a. Refrigerant: Type as indicated on Drawings.
OR
Refrigerant Type: R-134a **OR** HFC, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
 - b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 - c. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction, **as directed**, and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core, **as directed**, filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 - d. Pressure Relief Device:
 - 1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.



- e. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid-line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.
11. Evaporator:
- a. Description: Shell-and-tube design.
- 1) Direct-expansion (DX) type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
 - 2) Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
- b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- c. Shell Material: Carbon steel.
- d. Shell Heads: Removable carbon-steel heads with multipass baffles, and located at each end of the tube bundle.
- e. Fluid Nozzles: Terminated with mechanical-coupling or flanged end connections for connection to field piping.
- f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
12. Condenser:
- a. Shell and tube, or without integral condenser; as indicated.
OR
Shell and Tube:
- 1) Description: Shell-and-tube design with refrigerant flowing through shell, and fluid flowing through tubes within shell.
 - 2) Provides positive subcooling of liquid refrigerant.
 - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 4) Shell Material: Carbon steel.
 - 5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
 - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - 7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.
- b. Provide chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 23 Section "Air-cooled Refrigerant Condensers".
13. Electrical Power:
- a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a multipoint **OR** single-point, **as directed**, field-power connection to chiller.
- b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key, **as directed**.
- c. Wiring shall be numbered and color-coded, **as directed**, to match wiring diagram.
- d. Install factory wiring outside of an enclosure in a raceway.
- e. Field-power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch **OR** NEMA AB 1, instantaneous-trip circuit breaker with lockable handle, **as directed**.
- 1) Disconnect means shall be interlocked with door operation.
 - 2) Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
- f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
- 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.



- 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
- g. Provide each motor with overcurrent protection.
- h. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
- i. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.
- j. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- k. Control Relays: Auxiliary and adjustable time-delay relays.
- l. For chiller electrical power supply, indicate the following:
 - 1) Current and phase to phase for all three phases.
 - 2) Voltage, phase to phase, and phase to neutral for all three phases.
 - 3) Three-phase real power (kilowatts).
 - 4) Three-phase reactive power (kilovolt amperes reactive).
 - 5) Power factor.
 - 6) Running log of total power versus time (kilowatt-hours).
 - 7) Fault log, with time and date of each.
14. Compressor Motor Controllers:
 - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing, or solid state, **as directed**.
 - b. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed or open transition, or solid state, **as directed**.
15. Controls:
 - a. Standalone and microprocessor based.
 - b. Enclosure: Share enclosure with electrical-power devices or provide a separate enclosure of matching construction.
 - c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
 - 1) Date and time.
 - 2) Operating or alarm status.
 - 3) Fault history with not less than last 10 faults displayed.
 - 4) Set points of controllable parameters.
 - 5) Trend data.
 - 6) Operating hours.
 - 7) Number of chiller starts.
 - 8) Outdoor-air temperature or space temperature if required for chilled-water reset.
 - 9) Temperature and pressure of operating set points.
 - 10) Entering- and leaving-fluid temperatures of evaporator and condenser.
 - 11) Difference in fluid temperatures of evaporator and condenser.
 - 12) Refrigerant pressures in evaporator and condenser.
 - 13) Refrigerant saturation temperature in evaporator and condenser.
 - 14) No cooling load condition.
 - 15) Elapsed time meter (compressor run status).
 - 16) Pump status.
 - 17) Antirecycling timer status.
 - 18) Percent of maximum motor amperage.
 - 19) Current-limit set point.
 - 20) Number of compressor starts.
 - 21) Compressor refrigerant suction and discharge temperature.
 - 22) Oil temperature.
 - 23) Oil discharge pressure.
 - 24) Phase current.
 - 25) Percent of motor rated load amperes.
 - 26) Phase voltage.



- d. Control Functions:
 - 1) Manual or automatic startup and shutdown time schedule.
 - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
 - 3) Current limit and demand limit.
 - 4) Condenser-fluid temperature.
 - 5) External chiller emergency stop.
 - 6) Antirecycling timer.
 - 7) Automatic lead-lag switching.
 - 8) Variable evaporator flow.
 - 9) Thermal storage.
 - e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
 - 1) Low evaporator pressure, or high condenser pressure.
 - 2) Low chilled-water temperature.
 - 3) Refrigerant high pressure.
 - 4) High or low oil pressure.
 - 5) High oil temperature.
 - 6) Loss of chilled-water flow.
 - 7) Loss of condenser-fluid flow.
 - 8) Control device failure.
 - f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
 - g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
 - h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
 - i. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
 - 1) Hardwired Points:
 - a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours), **as directed**.
 - b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
 - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.
16. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - b. Thickness: 3/4 inch (19 mm).
 - c. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 - d. Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
 - 1) Before insulating steel surfaces, prepare surfaces for paint, prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 - 2) Seal seams and joints to provide a vapor barrier.



- 3) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
17. Finish:
 - a. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
 - 1) Provide at least one coat of primer.
 - 2) Provide finish coat of alkyd-modified, vinyl enamel, **as directed**.
 - 3) Paint surfaces that are to be insulated before applying the insulation.
 - 4) Paint installed insulation to match adjacent uninsulated surfaces.
 18. Accessories:
 - a. Factory-furnished, chilled- and condenser-, **as directed**, water flow switches for field installation.
 - b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
 - c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.
- C. Packaged, Air-Cooled Chillers
1. Description: Factory-assembled and run-tested chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
 2. Fabricate base, frame, and attachment to chiller components strong enough to resist chiller movement during a seismic event when chiller base is anchored to field support structure.
 3. Cabinet:
 - a. Base: Galvanized-steel base extending the perimeter of chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
 - b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported by base.
 - c. Casing: Galvanized steel.
 - d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500 **OR** 1000, **as directed**,-hour salt-spray test according to ASTM B 117.
 - e. Sound-reduction package designed to reduce sound level without affecting performance and consisting of the following:
 - 1) Acoustic enclosure around compressors.
 - 2) Reduced-speed fans with acoustic treatment.
 - f. Security Package: Provide removable grilles **OR** louvered panels, **as directed**, with fasteners for additional protection of compressors, evaporator, and condenser coils without inhibiting service access. Finish to match cabinet.
 4. Compressors:
 - a. Description: Positive displacement, hermetically sealed.
 - b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
 - c. Rotors: Manufacturer's standard one- or two-rotor design.
 - d. Each compressor provided with suction and, **as directed**, discharge shutoff valves, crankcase oil heater, and suction strainer.
 5. Service: Easily accessible for inspection and service.
 6. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.
 7. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
 - a. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
 - b. Condenser-Air Unloading Requirements over Operating Range: Constant-design entering condenser-air temperature **OR** Drop-in entering condenser-air temperature of 5 deg F (3 deg C) drop for each 10 percent in capacity reduction, **as directed**.



- c. For units equipped with a variable frequency controller, capacity control shall be both "valveless" and "stepless," requiring no slide valve or capacity-control valve(s) to operate at reduced capacity.
8. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
 - a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
 - b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
 - c. Factory-installed and pressure-tested piping with isolation valves and accessories.
 - d. Oil compatible with refrigerant and chiller components.
 - e. Positive visual indication of oil level.
9. Vibration Control:
 - a. Vibration Balance: Balance chiller compressors and drive assemblies to provide a precision balance that is free of noticeable vibration over the entire operating range.
 - 1) Overspeed Test: 25 percent above design operating speed.
 - b. Isolation: Mount individual compressors on vibration isolators.
10. Compressor Motors:
 - a. Hermetically sealed and cooled by refrigerant suction gas.
 - b. High-torque, induction type with inherent thermal-overload protection on each phase.
11. Compressor Motor Controllers:
 - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing, or solid state, **as directed**.
 - b. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition, or solid state, **as directed**.
 - c. Variable Frequency Controller:
 - 1) Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
 - 2) Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
 - 3) Enclosure: Unit mounted, NEMA 250, Type 3R, **as directed**, with hinged full-front access door with lock and key.
 - 4) Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR 65,000 OR 100,000, as directed**, A.
 - 5) Technology: Pulse width modulated (PWM) output suitable for constant or variable torque loads.
 - 6) Motor current at start shall not exceed the rated load amperes, providing no electrical inrush.
12. Refrigerant Circuits:
 - a. Refrigerant: Type as indicated on Drawings.
OR
Refrigerant Type: R-134a **OR** R-407c **OR** HFC, **as directed**: Classified as Safety Group A1 according to ASHRAE 34.
 - b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 - c. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction, **as directed**, and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core, **as directed**, filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 - d. Pressure Relief Device:
 - 1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.
13. Evaporator:



- a. Description: Shell-and-tube design.
 - 1) Direct-expansion (DX) type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
 - 2) Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
 - b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - c. Shell Material: Carbon steel.
 - d. Shell Heads: Removable carbon-steel heads located at each end of the tube bundle.
 - e. Fluid Nozzles: Terminated with mechanical-coupling **OR** flanged, **as directed**, end connections for connection to field piping.
 - f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - g. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
 - h. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.
14. Air-Cooled Condenser:
- a. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).
 - 1) Construct coil casing of galvanized **OR** stainless, **as directed**, steel.
 - 2) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.
 - 3) Coat coils with a baked-epoxy, corrosion-resistant coating after fabrication.
 - 4) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
 - b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
 - c. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings. Equip each motor with overload protection integral to either the motor or chiller controls.
 - d. Fan Guards: Steel safety guards with corrosion-resistant coating.
15. Electrical Power:
- a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a multipoint **OR** single-point, **as directed**, field-power connection to chiller.
 - b. House in a unit-mounted, NEMA 250, Type 3R, **as directed**, enclosure with hinged access door with lock and key or padlock and key, **as directed**.
 - c. Wiring shall be numbered and color-coded, **as directed**, to match wiring diagram.
 - d. Install factory wiring outside of an enclosure in a raceway.
 - e. Field-power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch **OR** NEMA AB 1, instantaneous-trip circuit breaker with lockable handle, **as directed**.
 - 1) Disconnect means shall be interlocked with door operation.
 - 2) Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
 - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
 - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
 - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
 - g. Provide each motor with overcurrent protection.
 - h. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
 - i. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.



- j. Provide power factor correction capacitors to correct power factor to 0.90 **OR** 0.95, **as directed**, at full load.
 - k. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
 - 1) Power unit-mounted controls where indicated.
 - 2) Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.
 - l. Control Relays: Auxiliary and adjustable time-delay relays.
 - m. For chiller electrical power supply, indicate the following:
 - 1) Current and phase to phase for all three phases.
 - 2) Voltage, phase to phase, and phase to neutral for all three phases.
 - 3) Three-phase real power (kilowatts).
 - 4) Three-phase reactive power (kilovolt amperes reactive).
 - 5) Power factor.
 - 6) Running log of total power versus time (kilowatt-hours).
 - 7) Fault log, with time and date of each.
16. Controls:
- a. Standalone and microprocessor based.
 - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure for remote mounting in the field, **as directed**.
 - c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
 - 1) Date and time.
 - 2) Operating or alarm status.
 - 3) Operating hours.
 - 4) Outdoor-air temperature if required for chilled-water reset.
 - 5) Temperature and pressure of operating set points.
 - 6) Entering and leaving temperatures of chilled water.
 - 7) Refrigerant pressures in evaporator and condenser.
 - 8) Saturation temperature in evaporator and condenser.
 - 9) No cooling load condition.
 - 10) Elapsed time meter (compressor run status).
 - 11) Pump status.
 - 12) Antirecycling timer status.
 - 13) Percent of maximum motor amperage.
 - 14) Current-limit set point.
 - 15) Number of compressor starts.
 - d. Control Functions:
 - 1) Manual or automatic startup and shutdown time schedule.
 - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
 - 3) Current limit and demand limit.
 - 4) External chiller emergency stop.
 - 5) Antirecycling timer.
 - 6) Automatic lead-lag switching.
 - 7) Variable evaporator flow.
 - 8) Thermal storage.
 - e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
 - 1) Low evaporator pressure or high condenser pressure.
 - 2) Low chilled-water temperature.
 - 3) Refrigerant high pressure.
 - 4) High or low oil pressure.
 - 5) High oil temperature.
 - 6) Loss of chilled-water flow.



- 7) Control device failure.
 - f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
 - g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
 - h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
 - i. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
 - 1) Hardwired Points:
 - a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours), **as directed**.
 - b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
 - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.
17. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - b. Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - c. Factory-applied insulation over cold surfaces of chiller components.
 - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 - d. Apply protective coating to exposed surfaces of insulation to protect insulation from weather.
18. Accessories:
- a. Factory-furnished, chilled-water flow switches for field installation.
 - b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
 - c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.
- D. Packaged Refrigerant Recovery Units
1. Packaged portable unit consisting of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.
- E. Heat-Exchanger, Brush-Cleaning System
1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.
 2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
 3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
 4. Components:



- a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
- b. Basket: Single-piece polypropylene basket with neck OD to press fit ID of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
- c. Four-Way Valve:
 - 1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
 - 2) Configure valve with parallel flow connections to minimize field installation piping.
 - 3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
 - 4) Pipe connections shall be flanged.
 - 5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
 - 6) Hydrostatically test to 1.5 times the design working pressure.
 - 7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
 - 8) Provide valve with valve-mounted indicating/warning light, which shall light before valve begins rotation.
 - 9) Valve Actuator: Mount electric actuator to operate valve.
OR
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
 - 10) Position Switches: Factory mount microswitches on valve to indicate the complete turn of valve in both normal and reverse flow.
- d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
 - 1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
 - 2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
 - 3) Manual override of preset cleaning cycle.
 - 4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
 - 5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
 - 6) Flow switch bypass.
 - 7) Unloading signal to chiller.

F. Source Quality Control

1. Perform functional tests of chillers before shipping.
2. Factory run test each air-cooled chiller with water flowing through evaporator.
3. Factory performance test water-cooled chillers, before shipping, according to ARI 550/590.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.
OR
Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
OR
At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
 - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.



- c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
 4. Factory performance test air-cooled chillers, **as directed**, before shipping, according to ARI 550/590.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser air at design conditions.

OR

At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
 - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
 - c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
5. Factory sound test water-cooled chillers, **as directed**, before shipping, according to ARI 575 **OR** air-cooled chillers, before shipping, according to ARI 370, **as directed**.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Chiller operating at calculated worst-case sound condition.

OR

At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
- b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
- c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
6. Factory test and inspect evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
7. For chillers located indoors, rate sound power level according to ARI 575.
8. For chillers located outdoors, rate sound power level according to ARI 370.

1.3 EXECUTION

A. Chiller Installation

1. Install chillers on support structure indicated.
2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install chiller using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".



- a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 5. Maintain manufacturer's recommended clearances for service and maintenance.
 6. Charge chiller with refrigerant and fill with oil if not factory installed.
 7. Install separate devices furnished by manufacturer and not factory installed.
- B. Heat-Exchanger, Brush-Cleaning System Installation
1. Install brush-cleaning system control panel adjacent to chiller control panel.
 2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
 3. Provide field electric power, as required, to each system control panel and electric actuated valve.
 4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
 5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
 6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.
- C. Connections
1. Comply with requirements for piping specified in Division 23 Section(s) "Hydronic Piping" AND "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to chiller to allow service and maintenance.
 3. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
 4. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
 5. Heat-Reclaim Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
 6. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.
 7. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.



D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Verify that refrigerant charge is sufficient and chiller has been leak tested.
 - c. Verify that pumps are installed and functional.
 - d. Verify that thermometers and gages are installed.
 - e. Operate chiller for run-in period.
 - f. Check bearing lubrication and oil levels.
 - g. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
 - h. Verify proper motor rotation.
 - i. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
 - j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**.
 - k. Verify and record performance of chiller protection devices.
 - l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
3. Prepare test and inspection startup reports.

END OF SECTION 23 61 16 00a



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 61 23 00	23 61 16 00a	Rotary-Screw Water Chillers



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**SECTION 23 62 13 00 - INDIRECT-FIRED ABSORPTION WATER CHILLERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for indirect-fired absorption water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Packaged, water-cooled, single-effect and double-effect absorption chillers.
 - b. Heat-exchanger, brush-cleaning system.

C. Definitions

1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 560 and referenced to ARI standard rating conditions.
4. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 560 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements

1. Seismic Performance: Indirect-fired absorption chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
 - a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) **OR** 55 deg F (13 deg C) **OR** 40 deg F (4.4 deg C), **as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
 - b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C) **OR** 60 deg F (16 deg C) **OR** 55 deg F (13 deg C), **as directed**.
 - c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 560, **as directed**:
 - a. Allowable Capacity Tolerance: Zero percent.
 - b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

E. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties and accessories.
2. LEED Submittals:
 - a. Product Data for LEED-NC Prerequisite EA 2: Documentation indicating that units comply with ASHRAE 90.1.



- b. Product Data for LEED-NC Prerequisite EA 3: Documentation indicating that refrigerants comply.
- c. Product Data for LEED-NC Credit EA 4: Documentation indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Startup service reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

F. Quality Assurance

1. ARI Rating: Rate chiller performance according to requirements in ARI 560.
2. ASHRAE Compliance:
 - a. ASHRAE 15 for safety code for mechanical refrigeration.
 - b. ASHRAE/IESNA 90.1.
3. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.
4. Comply with NFPA 70.
5. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.

G. Delivery, Storage, And Handling

1. Ship chillers factory charged with nitrogen.
2. Ship absorbent and refrigerant in chillers or in containers separate from chillers.
OR
Ship absorbent and refrigerant, **as directed**, in containers separate from chillers.
3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
 - a. Extended warranties include, but are not limited to, the following:
 - 1) Complete chiller.
OR
Pumps and motors **OR** Purge unit, **as directed**.
OR
Absorbent **OR** Absorbent and refrigerant, **as directed**, only.
 - 2) Parts only **OR** Parts and labor, **as directed**.
 - 3) Loss of absorbent and refrigerant for any reason.
2. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Unit



1. Description: Factory-assembled and -tested, hermetic-design chiller complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.
 - a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
 2. Absorbent and Refrigerant:
 - a. Absorbent: Lithium bromide solution with corrosion inhibitor.
 - b. Refrigerant: Deionized or distilled, **as directed**, water.
 - c. Performance Enhancer: Heat and mass transfer enhancer to improve performance.
 3. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- B. Pumps
1. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating tapered carbon bearings.
 2. Pump motor assembly shall be designed to operate for not less than 25,000 **OR** 50,000, **as directed**, hours between inspections.
 3. Pump motors cooled, and bearings lubricated, either by fluid being pumped or by a filtered supply of liquid refrigerant.
 4. Pump suction and discharge equipped with isolation valves.
 5. Separate and dedicated pumps for absorbent solution and refrigerant.
 - a. Absorbent solution and refrigerant flow-control method shall be manufacturer's choice to comply with operating requirements indicated.
 6. Purge System: Unit mounted and factory wired, equipped with controls and a pump to automatically remove noncondensable vapors.
 - a. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Enclosure: Open dripproof **OR** Totally enclosed, **as directed**.
- C. Heat-Exchanger Shells
1. Configuration for Single-Effect Chillers: Two shells; one shell consists of the absorber/evaporator and the other shell consists of the condenser/generator.
 2. Configuration for Double-Effect Chillers: Two shells; one shell consists of the absorber/evaporator, low-stage generator/condenser and the other shell consists of the high-stage generator.
 3. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.
 4. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.
 5. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
 6. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
 7. Generator/Condenser Shell Pressure Relief Device: Manufacturers standard rupture disk complying with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. Absorber
1. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes. Constructed of brass, stainless steel, or another material that will not corrode.
 2. Tubes:



- a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
3. Water Boxes:
- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine, **as directed**, type for water box with piping connections.
 - 1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.
 - OR**
Standard type for water box without piping connections.
 - 1) Water boxes shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.
 - c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - d. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - e. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm) **OR** 3/4- or 1-inch (19- or 25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
- a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
5. Absorber/Condenser Crossover Piping: Factory furnished **OR** installed, **as directed**, piping connecting fluid connection of absorber discharge to condenser inlet.
- E. Evaporator
1. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes. Constructed of brass, stainless steel, or another material that will not corrode.
 2. Refrigerant Holding Pan: Steel **OR** Stainless steel, **as directed**.
 3. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
 4. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine, **as directed**, type for water box with piping connections.



- 1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.
- OR**
Standard type for water box without piping connections.
- 1) Water boxes shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.
- c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - d. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - e. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm) **OR** 3/4- or 1-inch (19- or 25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

F. Condenser

1. Refrigerant Holding Pan: Steel **OR** Stainless steel, **as directed**.
2. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
3. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine, **as directed**, type for water box with piping connections.
 - 1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.

OR
Standard type for water box without piping connections.

 - 1) Water boxes shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.
 - c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - d. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - e. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.



G. Generator For Single-Effect Chillers

1. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
 - b. Material: 90/10 copper-nickel alloy **OR** Stainless steel **OR** Titanium, as directed.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Smooth **OR** Enhanced, **as directed**
2. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard type water box.
 - c. Water boxes shall have lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

H. First-Stage Generator For Double-Effect Chillers

1. Tubes:
 - a. Replaceable, straight, or U tubes expanded into tube sheets.
 - b. Material: Manufacturer's standard **OR** 70/30 copper-nickel alloy **OR** Type 409 stainless steel **OR** Titanium, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Smooth **OR** Enhanced, **as directed**.
2. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard type water box.
 - c. Water boxes shall have lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

I. Second-Stage Generator For Double-Effect Chillers

1. Tubes:



- a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Smooth **OR** Enhanced, **as directed**.
2. Water Boxes:
- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard type water box.
 - c. Water boxes shall have lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
- a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
- J. Solution Heat Exchanger
1. Description: Shell-and-tube or brazed-plate heat exchanger; integral part of chiller to increase cycle efficiency by preheating the weak solution on its way to the generator while precooling the strong solution returning from the generator.
- K. Steam Condensate Drain Cooler
1. Description: Shell-and-tube heat exchanger constructed of carbon-steel shell and copper-nickel-alloy or stainless-steel tubes.
- L. Factory-Applied Insulation
1. Factory-Applied Insulation on Cold Surfaces:
 - a. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tube and Type II for sheet materials.
 - 1) Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - b. Adhesive: As recommended by insulation manufacturer.
 - c. Factory apply insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets; evaporator water boxes including nozzles; refrigerant pump; cold surfaces of motor; and cold piping.
 - 1) Apply adhesive to 100 percent of insulation contact surface.
 - 2) Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 - 3) Seal seams and joints to provide a vapor barrier.
 - 4) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
 2. Factory-Applied Insulation on Hot Surfaces:
 - a. Mineral-fiber board, pipe or tank insulation complying with one of following:
 - 1) ASTM C 547, Type I or Type II, Grade A.
 - 2) ASTM C 612, Type IB.
 - 3) ASTM C 1393, Type II or Type IIIA, Category 2.
 - 4) Thickness: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**.



- b. Adhesive: As recommended by insulation manufacturer.
- c. Factory apply materials over all hot surfaces to provide smooth, straight, and even surfaces; free of voids.
 - 1) Apply adhesive to insulation contact surface as recommended by insulation manufacturer.
 - 2) Install insulation anchor pins and washers if required by insulation manufacturer to secure insulation to surfaces to be insulated.
 - 3) Completely encapsulate insulation with metal jacket, leaving no exposed insulation. Provide removable jacket on components requiring access for service and inspection.
 - 4) Paint exposed surfaces of metal jacket to match other painted parts unless jacket material is aluminum or stainless steel.

M. Electrical

- 1. Factory installed and wired, and functionally tested at factory before shipment.
- 2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
 - a. Branch power circuit to each motor, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
 - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
 - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
 - b. NEMA ICS 2, Class A, full-voltage, nonreversing motor controller, hand-off-auto switch, and overcurrent protection for each motor.
 - c. Control-circuit transformer with primary and secondary side fuses.
- 3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
- 4. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight **OR** flexible metallic, **as directed**, conduit.

N. Controls

- 1. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
- 2. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x, **as directed**, hinged or lockable.
- 3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Operating hours.
 - d. Outdoor-air temperature if required for chilled-water reset.
 - e. Temperature and pressure of operating set points.
 - f. Entering and leaving temperatures of chilled and condenser water.
 - g. Refrigerant temperature.
 - h. Solution concentration and temperature.
 - i. Indication of solution and purge-pump operation.
 - j. Generator shell pressure.
 - k. Number of starts.
 - l. Number of purge cycles.
 - m. Hot-water valve actuator potentiometer position (percentage).
 - n. Entering and leaving hot-water temperatures.



- o. Steam demand limit.
- p. Inlet steam pressure and temperature.
- q. Steam valve actuator potentiometer position (percentage).
- r. First-stage generator pressure and temperature.
4. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Automatic cycle to prevent crystallization.
 - c. Entering and leaving chilled-water temperatures and control set points. Chilled-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
 - d. Condenser-fluid temperature.
 - e. Cooling provided and heating energy used within programmable time periods, minimum monthly.
5. Capacity Control: Automatically controls input flow rate of heat source to maintain chilled-water temperature set point for cooling loads ranging from 10 to 100 percent.
6. Control Valve Package: Factory-furnished, for field installation, **OR** Factory-installed, **as directed**, control valve package suitable for energy source indicated.
 - a. Body: Cast-iron, carbon-steel, or stainless-steel body with flanged connections.
 - b. Type: Manufacturer's choice **OR** V-notch ball **OR** Butterfly **OR** Globe style with cage-guide plug, **as directed**, constructed of stainless steel.
 - c. Rating: Pressure and temperature rating to match heat exchanger.
 - d. Shutoff: Capable of bubble-tight shutoff against maximum system pressure.
 - e. Size: Determined by chiller manufacturer.
 - f. Modulation: Two-way **OR** Three-way, **as directed**.
 - g. Turndown: As required to achieve stable control through the indicated operating range.
 - h. Actuator: Electric powered from chiller control panel and installed on valve.
7. Safety Shutdowns:
 - a. Crystallization.
 - b. Low refrigerant temperature.
 - c. Loss of chilled- or condenser-water flow.
 - d. Low leaving chilled-water temperature, 2 deg F (1 deg C) below set point, **as directed**.
 - e. First-stage generator low-solution level.
 - f. First-stage generator high temperature or pressure.
 - g. Power failure.
 - h. Solution pump overloads.
 - i. External auxiliary safety shutdown.
 - j. High solution concentration.
 - k. Incomplete dilution cycle.
 - l. High entering-water temperature.
 - m. High inlet steam pressure and temperature.
8. Warning Conditions: Control panel shall close warning contacts and generate a message when one of the following operating conditions is detected:
 - a. Low refrigerant temperature.
 - b. High generator temperature or pressure.
 - c. High entering generator-water temperature (single-stage generator only).
 - d. High or low entering condenser-water temperature.
 - e. Solution temperature sensor failure.
 - f. Low chilled-water flow.
9. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
10. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
11. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.



12. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.
13. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On-off status, common trouble alarm.
 - 2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** generator heat source capacity limiting, **as directed**.
 - b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

O. Finish

1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
 - a. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
 - b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least 4 mils (0.10 mm).
 - c. Paint surfaces that are to be insulated before applying the insulation.
 - d. Paint installed insulation to match adjacent uninsulated surfaces.
 - e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner.
2. Provide the Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

P. Accessories

1. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.
2. Flow Switches:
 - a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and verify field-mounting location before installation.
 - b. Paddle Flow Switches:
 - 1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
 - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
 - 3) Pressure rating equal to pressure rating of heat exchanger.
 - 4) Construct body and wetted parts of Type 316 stainless steel.
 - 5) House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
 - 6) Vane length to suit installation.

OR

Pressure Differential Switches:

 - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - 2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
 - 3) Set Point: Screw type, field adjustable.
 - 4) Electrical Connections: Internally mounted screw-type terminal blocks.
 - 5) Switch Enclosure: NEMA 250, Type 4.
 - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
3. Vibration Isolation:
 - a. Chiller manufacturer shall furnish neoprene-pad vibration isolation for each chiller.



- 1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
 - 2) Fabricate pads from 40- to 50-durometer neoprene.
 - 3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.
4. Lithium Bromide Filter, **as directed**:
- a. Factory install a filter, isolation valves, and associated piping.
 - b. Filter shall consist of a stainless-steel body, with removable and cleanable 150-micron, stainless-steel element.
 - c. Isolation valves shall provide isolation for filter servicing without disturbing operation of chiller.
- Q. Heat-Exchanger, Brush-Cleaning System
1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.
 2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
 3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
 4. Components:
 - a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
 - b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
 - c. Four-Way Valve:
 - 1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
 - 2) Configure valve with parallel flow connections to minimize field installation piping.
 - 3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
 - 4) Pipe connections shall be flanged.
 - 5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
 - 6) Hydrostatically test to 1.5 times the design working pressure.
 - 7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
 - 8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
 - 9) Valve Actuator: Mount electric actuator to operate valve.
OR
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
 - 10) Position Switches: Factory mount microswitches on the valve to indicate the complete turn of valve in both normal and reverse flow.
 - d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
 - 1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
 - 2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
 - 3) Manual override of preset cleaning cycle.
 - 4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.



- 5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
- 6) Flow-switch bypass.
- 7) Unloading signal to chiller.

R. Source Quality Control

1. Perform functional tests **OR** run tests, **as directed**, of chillers before shipping.
2. Factory test and inspect absorber, generator, evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Vacuum and pressure test shells for leaks.
3. Rate sound power level according to ARI 575.
4. Factory performance test chillers, before shipping, according to ARI 560, **as directed**.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.
OR
Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
OR
At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
5. Factory sound test chillers, before shipping, according to ARI 575, **as directed**.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Chiller operating at calculated worst-case sound condition.
 - 3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
6. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
7. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

1.3 EXECUTION

A. Chiller Installation

1. Install chillers on support structure indicated.
2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install chiller using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".



- a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.
 4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 5. Install chillers with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 6. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 7. Maintain manufacturer's recommended clearances for service and maintenance.
 8. Charge chiller with absorbent and refrigerant if not factory charged.
 9. Install separate devices furnished by manufacturer and not factory installed.
 10. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated, and are not factory insulated. Comply with requirements in Division 23 Section "Hvac Insulation".
- B. Heat-Exchanger, Brush-Cleaning System Installation
1. Install brush-cleaning system control panel adjacent to chiller control panel.
 2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
 3. Provide field electric power, as required, to each system control panel and electric actuated valve.
 4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
 5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
 6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.
- C. Connections
1. Comply with requirements in Division 23 Section "Hydronic Piping" for hydronic piping. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Comply with requirements in Division 23 Section "Steam And Condensate Heating Piping" for steam and condensate piping. Drawings indicate general arrangement of piping, fittings, and specialties.
 3. Install piping adjacent to chiller to allow service and maintenance.
 4. Generator Steam Piping Connections:
 - a. Connect steam piping with trapped drip leg, gate valve, strainer, control valve, and pressure gage. Install pressure reducing valve and safety relief valve upstream from steam-control valve to protect control valve from excessive steam pressure. Make connections to chiller with a flange **OR** union, **as directed**.
 - b. Connect steam condensate piping with vacuum breaker, trapped drip leg, gate valve, strainer, float and thermostatic trap(s), condensate cooler, **as directed**, condensate receiver, **as directed**, condensate receiver and pump, **as directed**, and check valve. Make connections to chiller with a flange **OR** union, **as directed**.
 5. Generator Hot-Water Connections: Connect to generator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, control valve, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to generator outlet with shutoff valve, check valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with



shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.

6. Evaporator-Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
7. Absorber/Condenser-Fluid Connections: Connect to inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
 - a. If not factory furnished or installed, provide pipe connecting fluid connection of absorber discharge and condenser inlet.
8. Refrigerant Pressure Relief Device Connections: Extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
9. Extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15.
10. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Operate chiller for run-in period.
 - c. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
 - d. Verify that pumps are installed and functional.
 - e. Verify that thermometers and gages are installed.
 - f. Operate chiller for run-in period.
 - g. Verify that refrigerant pressure relief device is vented outside.
 - h. Verify proper motor rotation.
 - i. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
 - j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
 - k. Verify and record performance of chiller protection devices.
 - l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
3. Prepare test and inspection startup reports.

E. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain chillers.

END OF SECTION 23 62 13 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 62 23 00	23 01 60 71	Condensing Units



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SECTION 23 63 13 00 - AIR-COOLED CONDENSERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for air-cooled condensers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged, air-cooled condensers for outdoor and indoor installation.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.
 - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
 - c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that air-cooled condensers, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. LEED Submittal:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Code for Mechanical Refrigeration."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.2 PRODUCTS

A. Manufactured Units

1. Description: Factory assembled and tested; consisting of casing, condenser coils, condenser fans and motors, and unit controls.
2. Condenser Coil: Seamless copper-tube, finned coil; factory tested at 425 psig (2930 kPa).
 - a. Coil Fin: Aluminum **OR** Copper, **as directed**.
 - b. Coil Coating: **As directed**.
 - c. Circuit: To match compressors with liquid subcooling coil, **as directed**.
 - d. Refrigerant Accessories, **as directed**: Provide receiver, pressure control, and solenoid valve for each circuit.



3. Condenser Fans and Drives: Propeller fans with aluminum or galvanized-steel **OR** galvanized-steel **OR** stainless-steel, **as directed**, fan blades, for vertical **OR** horizontal, **as directed**, air discharge; directly driven with permanently lubricated ballbearing motors with integral current- and thermal-overload protection.
OR
Condenser Fans and Drives: Forward-curved centrifugal fans for vertical **OR** horizontal, **as directed**, air discharge.
 - a. Fan on steel shaft with self-aligning ball bearings.
 - b. V-belt drive with minimum of two belts; variable pitch drive pulley.
 - c. Motor mounted on adjustable slide base.
4. Operating and Safety Controls: Include condenser fan motor thermal and overload cutouts; 115-V control transformer, if required; magnetic contactors for condenser fan motors and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
5. Unit Casings: Galvanized or zinc-coated steel treated and finished with manufacturer's standard paint coating **OR** Stainless steel, **as directed**, designed for outdoor installation with weather protection for components and controls **OR** indoor installation, **as directed**, and with the following:
 - a. Removable panels for access to controls, condenser fans, motors, and drives.
 - b. Plated-steel **OR** Stainless-steel, **as directed**, fan guards.
 - c. Lifting eyes.
 - d. Removable legs.
 - e. 1-inch- (25-mm-) thick inlet filter.

B. Motors

1. General requirements for motors are specified in Division 14 Section "Facility Chutes".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.

C. Source Quality Control

1. Verification of Performance: Rate air-cooled condensers according to ARI 460.
2. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

1.3 EXECUTION

A. Installation

1. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
2. Install air-cooled condensers on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac" and concrete materials and installation requirements are specified in Division 31.
3. Concrete Bases:
 - a. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of the base.
 - b. For equipment supported on structural slab, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
4. Install roof-mounting units on equipment supports specified in Division 07.



5. Vibration Isolation: Mount air-cooled condensers on rubber pads with a minimum deflection of 1/4 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
OR
Vibration Isolation: Mount air-cooled condensers on restrained spring isolators with a minimum deflection of <Insert measurement>. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 6. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Secure vibration and seismic controls, and suspended units to structure.**OR**
Support suspended units from structure using threaded steel rods.
 7. Maintain manufacturer's recommended clearances for service and maintenance.
 8. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.
- B. Connections
1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to machine to allow service and maintenance.
 3. Refrigerant Piping: Connect piping to unit with pressure relief, service valve, filter-dryer, and moisture indicator on each refrigerant-circuit liquid line. Refrigerant piping and specialties are specified in Division 23 Section "Refrigerant Piping".
- C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
 - a. Perform electrical test and visual and mechanical inspection.
 - b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Complete manufacturer's starting checklist.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - e. Verify proper airflow over coils.
 2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
 3. Remove and replace malfunctioning air-cooled condensers and retest as specified above.
- D. Startup Service
1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for physical damage to unit casing.
 - b. Verify that access doors move freely and are weathertight.
 - c. Clean units and inspect for construction debris.
 - d. Verify that all bolts and screws are tight.
 - e. Adjust vibration isolation and flexible connections.
 - f. Verify that controls are connected and operational.
 2. Lubricate bearings on fans.
 3. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
 4. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
 5. Measure and record airflow over coils.
 6. Verify proper operation of capacity control device.



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7. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
 8. After startup and performance test, lubricate bearings.

E. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain air-cooled condensers.

END OF SECTION 23 63 13 00



SECTION 23 63 13 00a - SPLIT-SYSTEM AIR-CONDITIONING UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for split-system air-conditioning units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

C. Submittals

1. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within five years from date of Final Completion.

1.2 PRODUCTS

A. Concealed Evaporator-Fan Components

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
 - a. Insulation: Faced, glass-fiber duct liner.
 - b. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1, **as directed**.
 - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.



2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
 3. Water **OR** Steam, **as directed**, Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a two-position control valve.
OR
Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
 4. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
 5. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
 6. Disposable Filters: 1 inch (25 mm) thick, in fiberboard frames with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
 7. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- B. Floor-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner.
 - a. Discharge Grille: Steel with surface-mounted frame **OR** Welded steel bars forming a linear grille and welded into supporting panel, **as directed**.
 - b. Insulation: Faced, glass-fiber, duct liner.
 - c. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1, **as directed**.
 - d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
 3. Water **OR** Steam, **as directed**, Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a 2-position control valve.
OR
Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
 4. Fan: Direct drive, centrifugal, with power-induced outside air, **as directed**.
 5. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
 6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
- C. Wall-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner, and discharge drain pans with drain connection.
 - a. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - b. Drain Pan and Drain Connection: Comply with ASHRAE 62.1.
 2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.



3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
 4. Fan: Direct drive, centrifugal fan.
 5. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
 6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
- D. Ceiling-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner, and discharge drain pans with drain connection.
 - a. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - b. Drain Pan and Drain Connection: Comply with ASHRAE 62.1.
 2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
 3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
 4. Fan: Direct drive, centrifugal fan, with power-induced outside air, **as directed**, and integral condensate pump.
 5. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
 6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
- E. Air-Cooled, Compressor-Condenser Components
1. Casing: Steel, finished with baked enamel in color selected by the Owner, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
 2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
 - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
 3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
 4. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.
 5. Fan: Aluminum-propeller type, directly connected to motor.
 6. Motor: Permanently lubricated, with integral thermal-overload protection.
 7. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
 8. Mounting Base: Polyethylene.
 9. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
- F. Water-Cooled, Compressor-Condenser Components



1. Casing: Steel, with baked-enamel finish in color selected by the Owner, removable panels for access to controls, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
 - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
3. Heat Pump Components: Reversing valve.
4. Heat Exchanger: Copper tubes in copper tube or in steel shell, with water-temperature-actuated, water-regulating valve.
5. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."

G. Accessories

1. Control equipment and sequence of operation are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
2. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
3. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
 - a. Compressor time delay.
 - b. 24-hour time control of system stop and start.
 - c. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 - d. Fan-speed selection, including auto setting.
4. Automatic-reset timer to prevent rapid cycling of compressor.
5. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
 - a. Minimum Insulation Thickness: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.

1.3 EXECUTION

A. Installation

1. Install units level and plumb.
2. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
3. Install ground-mounting, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete". Coordinate anchor installation with concrete base.
OR
Install ground-mounting, compressor-condenser components on polyethylene mounting base.
4. Install roof-mounting compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories". Anchor units to supports with removable, cadmium-plated fasteners.
5. Install seismic restraints.
6. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch (25 mm). Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
7. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.



B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 - a. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
 - b. Remote Water-Cooled Condenser Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
 - c. Steam Coil Connections: Comply with requirements in Division 23 Section "Steam And Condensate Heating Piping". Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.
2. Install piping adjacent to unit to allow service and maintenance.
3. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".
4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
5. Electrical Connections: Comply with requirements in Division 22 for power wiring, switches, and motor controls.

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
 - a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace malfunctioning units and retest as specified above.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.

E. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 63 13 00a



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 63 13 00	23 01 60 71	Condensing Units



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SECTION 23 64 13 16 - DIRECT-FIRED ABSORPTION WATER CHILLERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for direct-fired absorption water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Packaged, water-cooled, direct-fired absorption chillers.
 - b. Heat-exchanger, brush-cleaning system.

C. Definitions

1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. IPLV: Integrated part-load value. A single-number, part-load efficiency figure of merit calculated per the method defined by ARI 560 and referenced to ARI standard rating conditions.
4. NPLV: Nonstandard part-load value. A single-number, part-load efficiency figure of merit calculated per the method defined by ARI 560 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements

1. Seismic Performance: Direct-fired absorption chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
 - a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
 - b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 70 deg F (21 deg C).
 - c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which it is installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 560:
 - a. Allowable Capacity Tolerance: Zero percent.
 - b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

E. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties and accessories, and the following:
 - a. Performance at ARI standard conditions and at conditions indicated.
 - b. Performance at ARI standard unloading conditions.
 - c. Minimum evaporator flow rate.



- d. Absorbent capacity of chiller.
- e. Refrigerant capacity of chiller.
- f. Fluid capacity of evaporator and condenser.
- g. Fluid capacity of generator.
- h. Characteristics of safety relief devices.
- i. Minimum entering condenser-fluid temperature.
- j. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in 5 deg F (3 deg C) increments.
- k. If equipped, fluid capacity of dedicated hot-water heater exchanger.
- l. Combustion-air flow.
- m. Exhaust gas airflow.
- n. Exhaust gas minimum and maximum operating temperature.
2. LEED Submittals:
 - a. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1.
 - b. Product Data for Prerequisite EA 3: Documentation indicating that refrigerants comply.
 - c. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
 - c. Insulated Surface Diagrams: Indicating cold and hot surfaces requiring field-applied insulation with area tabulated for each.
4. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Structural supports.
 - b. Piping roughing-in requirements.
 - c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
 - d. Access requirements, including working clearances for mechanical controls and electrical equipment, and clearances for tube pull and service.
5. Certificates: For certification required in "Quality Assurance" Article.
6. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Source quality-control reports.
8. Startup service reports.
9. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.
10. Warranty: Sample of special warranty.

F. Quality Assurance

1. ARI Rating: Rate chiller performance according to requirements in ARI 560.
2. ASHRAE Compliance:
 - a. ASHRAE 15 for safety code for mechanical refrigeration.
 - b. ASHRAE/IESNA 90.1.
3. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.
4. Comply with NFPA 70.



5. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.
 - a. UL Compliance: UL 726, "Oil-Fired Boiler Assemblies" **OR** UL 726, "Oil-Fired Boiler Assemblies"; and UL 795, "Commercial-Industrial Gas Heating Equipment" **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**.

G. Delivery, Storage, And Handling

1. Ship chillers factory charged with nitrogen.
2. Ship absorbent and refrigerant in chillers or in containers separate from chillers.
OR
Ship absorbent and refrigerant in containers separate from chillers.
3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.

H. Coordination

1. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
2. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

I. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
 - a. Extended warranties include, but are not limited to, the following:
 - 1) Complete chiller.
OR
Pumps and motors **OR** Purge unit **OR** Burner assembly, **as directed**.
OR
Absorbent **OR** Absorbent and refrigerant, **as directed**, only.
 - 2) Parts only **OR** only and labor, **as directed**.
 - 3) Loss of absorbent and refrigerant for any reason.
 - b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Unit

1. Description: Factory-assembled and -tested, hermetic-design chiller complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, burner assembly, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.
 - a. Disassemble chiller into major assemblies, as required by the installation, after factory testing and before packaging for shipment.
2. Absorbent and Refrigerant:
 - a. Absorbent: Lithium bromide solution with corrosion inhibitor.
 - b. Refrigerant: Deionized or distilled, **as directed**, water.
 - c. Performance Enhancer: Heat and mass transfer enhancer to improve performance.
3. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

B. Pumps



1. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating, tapered carbon bearings.
2. Pump motor assembly shall be designed to operate for not less than 50,000 hours between inspections.
3. Pump motors shall be cooled and bearings lubricated, either by fluid being pumped or by a filtered supply of liquid refrigerant.
4. Pump suction and discharge shall be equipped with isolation valves.
5. Absorbent solution and refrigerant shall have separate and dedicated pumps.
 - a. Absorbent solution and refrigerant flow-control method shall be manufacturer's choice to comply with operating requirements indicated.
6. Purge System: Unit mounted and factory wired, equipped with controls and a pump to automatically remove noncondensable vapors.
 - a. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Enclosure: Open dripproof **OR** Totally enclosed, **as directed**.

C. Heat-Exchanger Shells

1. Configuration: Two shells; one shell consists of the absorber/evaporator, low-stage generator/condenser and the other shell consists of the high-stage generator. Where indicated, equip chiller with a dedicated hot-water heat exchanger.
2. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.
3. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.
4. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.
5. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid tube contact resulting in abrasion and wear.
6. Generator/Condenser Shell Pressure Relief Device: Manufacturer's standard rupture disk complying with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code.

D. Absorber

1. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes; constructed of brass, stainless steel, or another material that will not corrode.
2. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
3. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine-type, **as directed**, water box with piping connections.
 - 1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** Davited, **as directed**, water boxes.
OR
Hinged **OR** Davited, **as directed**, marine-type water-box covers.
 - c. Standard water box without piping connections.



- 1) Water boxes shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** Davited, **as directed**, water boxes.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
 4. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
 5. Absorber/Condenser Crossover Piping: Factory-furnished and -installed piping connecting fluid connection of absorber discharge to condenser inlet.
- E. Evaporator
1. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes; constructed of brass, stainless steel, or another material that will not corrode.
 2. Refrigerant Holding Pan: Steel or stainless steel.
 3. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
 4. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine-type, **as directed**, water box with piping connections.
 - 1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** Davited, **as directed**, water boxes.
OR
Hinged **OR** Davited, **as directed**, marine-type water-box covers.
 - c. Standard water box without piping connections.
 - 1) Water boxes shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** Davited, **as directed**, water boxes.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- F. Condenser
1. Refrigerant Holding Pan: Steel or stainless steel.
 2. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.



- d. External Finish: Manufacturer's standard.
- e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
- 3. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard **OR** Marine-type, **as directed**, water box with piping connections.
 - 1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** Davited, **as directed**, water boxes.
 - OR**
 - Hinged **OR** Davited, **as directed**, marine-type water-box covers.
 - c. Standard water box without piping connections.
 - 1) Water boxes shall have lifting lugs or eyebolts.
 - 2) Hinged **OR** Davited, **as directed**, water boxes.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- 4. Additional Corrosion Protection:
 - a. Electrolytic corrosion-inhibitor anode.
 - b. Coat wetted surfaces with a corrosion-resistant finish.
 - OR**
 - Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

G. First-Stage Generator

- 1. Tubes:
 - a. Replaceable, **as directed**, straight, or U tubes expanded into tube sheets.
 - b. Material: Manufacturer's standard **OR** Steel, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Manufacturer's choice; enhanced or smooth.
- 2. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard water box.
 - c. Water boxes shall have lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

H. Second-Stage Generator

- 1. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Manufacturer's standard.



2. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard type.
 - c. Water boxes shall have lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

- I. Dedicated Hot-Water Heat Exchanger
 1. Tubes:
 - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
 - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
 - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
 - d. External Finish: Manufacturer's standard.
 - e. Internal Finish: Manufacturer's standard.
 2. Water Boxes:
 - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
 - b. Standard type.
 - c. Water boxes shall have lifting lugs or eyebolts.
 - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
 - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
 - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

- J. Solution Heat Exchanger
 1. Description: Shell-and-tube or brazed-plate heat exchanger, an integral part of chiller, increases cycle efficiency by preheating the weak solution on its way to the generator while precooling the strong solution returning from the generator.

- K. Burner Assembly
 1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser suitable for natural gas **OR** propane **OR** fuel oil, **as directed**. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
 2. Blower: Centrifugal fan integral to burner, directly driven by motor; with adjustable damper assembly and locking quadrant to set air-fuel ratio.
 - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 3. Oil Supply: Control devices and modulating control sequence shall comply with requirements of ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
 - a. Oil Pump: Two-stage, gear-type oil pump shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-in. Hg (50.7-kPa) vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.



- 3) 0- to 30-in. Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
- 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
- 5) Nozzle-line, solenoid-safety-shutoff oil valve.
4. Oil Pilot: Intermittent-electric-spark **OR** Interrupted-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
5. Gas Train: Control devices and modulating control sequence shall comply with requirements of ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
6. Gas Pilot: Intermittent-electric-spark **OR** Interrupted-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
7. Burner assembly shall be equipped to limit nitrogen oxide emissions to 20 **OR** 30, **as directed**, ppm.

L. Electrical

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
 - a. Branch power circuit to each motor, dedicated electrical load, and to controls with disconnect switch or circuit breaker, **as directed**.
 - 1) NEMA KS 1, heavy-duty fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
 - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
 - b. NEMA ICS 2, Class A, full-voltage, nonreversing motor controller, hand-off-auto switch, and overcurrent protection for each motor.
 - c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight **OR** flexible metallic, **as directed**, conduit.

M. Controls

1. Chiller control panel shall be separate from burner control panel.
2. Burner Control Panel: Factory or field, **as directed**, mounted. Maintains safe operating conditions, burner safety limits, burner operation, and interface with chiller controls; include the following components:
 - a. On-off switch.
 - b. Flame safeguard.
 - c. Contacts for remote monitoring of flame failure.
 - d. Contacts for proof of combustion air.
 - e. Exhaust gas temperature limit switch.
 - f. Control-circuit transformer.
 - g. Burner motor controls.
 - h. Fuel-oil pump controls, if chiller is equipped with fuel-oil pump.
 - i. Visual indication of on/off status of ignition, blower, and main fuel.
 - j. Alarm bell.
3. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
4. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x, **as directed**, hinged or lockable.



5. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. Display the following information in either imperial or metric units selectable through the interface:
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Operating hours.
 - d. Outdoor-air temperature if required for chilled-water reset.
 - e. Temperature and pressure of operating set points.
 - f. Entering and leaving temperatures of chilled and condenser water.
 - g. Refrigerant temperature.
 - h. Solution concentration and temperature.
 - i. Indication of solution and purge-pump operation.
 - j. Generator shell pressure.
 - k. Number of starts.
 - l. Number of purge cycles.
 - m. Entering and leaving hot-water temperatures.
 - n. Burner firing rate displayed in percent.
6. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Automatic cycle to prevent crystallization.
 - c. Entering and leaving chilled-water temperatures and control set points. Chilled-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
 - d. Entering and leaving hot-water temperatures and control set points. Hot-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
 - e. Condenser-fluid temperature.
 - f. Cooling provided and heating energy used within programmable time periods, minimum monthly.
 - g. Heating provided and heating energy used within programmable time periods, minimum monthly.
7. Capacity Control: Automatically controls burner firing rate to maintain chilled-water temperature set point for cooling loads and heating-water temperature set point for heating loads ranging from 30 to 100 percent.
8. Safety Shutdowns: Chiller shall automatically shut down and require manual restart. Display a message following each safety shutdown.
 - a. Crystallization.
 - b. Low refrigerant temperature.
 - c. Loss of chilled- or condenser-water flow.
 - d. Low leaving chilled-water temperature, 2 deg F (1 deg C) below set point.
 - e. First-stage generator low-solution level.
 - f. First-stage generator high temperature or pressure.
 - g. Burner alarm or control malfunction.
 - h. Power failure.
 - i. Solution pump overloads.
 - j. External auxiliary safety shutdown.
 - k. High solution concentration.
 - l. Incomplete dilution cycle.
9. Warning Conditions: Chiller shall remain operational but inhibit burner firing rate to prevent safety shutdown. Control panel shall close warning contacts and generate a message when one of the following operating conditions is detected:
 - a. Low refrigerant temperature.
 - b. High generator temperature or pressure.
 - c. High or low entering condenser-water temperature.
 - d. Solution temperature sensor failure.
 - e. Low chilled-water flow.



- f. Purge-pump current overload.
 10. Cycling Shutdowns: Permit automatic restart when preprogrammed limits are reached. Display a message following each cycle shutdown.
 - a. Cooling Mode:
 - 1) Loss of condenser-water flow.
 - 2) Low leaving chilled-water temperature.
 - 3) Power failure.
 - b. Heating Mode:
 - 1) Loss of hot-water flow.
 - 2) High leaving hot-water temperature.
 - 3) Power failure.
 11. Trending: Capability to trend analog data up to five parameters simultaneously over an adjustable period and frequency of polling.
 12. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
 13. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
 14. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.
 15. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
 - a. Hardwired Points:
 - 1) Monitoring: On-off status, common trouble alarm.
 - 2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** hot-water, discharge temperature set-point adjustment, **as directed**.
 - b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.
- N. Finish
1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
 - a. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
 - b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least 4 mils (0.10 mm).
 - c. Paint surfaces that are to be insulated before applying the insulation.
 - d. Paint installed insulation to match adjacent uninsulated surfaces.
 - e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner.
- O. Accessories
1. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.
 2. Flow Switches:
 - a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and shall verify field-mounting location before installation.
 - b. Paddle Flow Switches:
 - 1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
 - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
 - 3) Pressure rating equal to pressure rating of heat exchanger.



- 4) Construct body and wetted parts of Type 316 stainless steel.
- 5) House switch in an NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
- 6) Vane length to suit installation.
- c. Pressure Differential Switches:
 - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
 - 2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set point shift due to variation in working pressure.
 - 3) Set Point: Screw type, field adjustable.
 - 4) Electrical Connections: Internally mounted, screw-type terminal blocks.
 - 5) Switch Enclosure: NEMA 250, Type 4.
 - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
3. Vibration Isolation:
 - a. Chiller manufacturer shall furnish neoprene-pad vibration isolation for each chiller.
 - 1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
 - 2) Fabricate pads from 40- to 50-durometer neoprene.
 - 3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.
- P. Heat-Exchanger, Brush-Cleaning System
 1. Furnish for field installation a brush-cleaning system on each chiller condenser for tube cleaning and improved heat transfer.
 2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
 3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
 4. Components:
 - a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
 - b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
 - c. Four-Way Valve:
 - 1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
 - 2) Configure valve with parallel flow connections to minimize field installation piping.
 - 3) Construct valve to comply with ASME Boiler and Pressure Vessel Code , at a system working pressure equal to condenser.
 - 4) Pipe connections shall be flanged.
 - 5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
 - 6) Hydrostatically test valve to 1.5 times the design working pressure.
 - 7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
 - 8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
 - 9) Valve Actuator: Mount electric actuator to operate valve.
OR
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.



- 10) Position Switches: Factory mount microswitches on valve to indicate the complete turn of valve in both normal and reverse flow.
- d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
 - 1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
 - 2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
 - 3) Manual override of preset cleaning cycle.
 - 4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow or incomplete valve turn.
 - 5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
 - 6) Flow-switch bypass.
 - 7) Unloading signal to chiller.

Q. Source Quality Control

1. Perform functional run tests of chillers before shipping.
2. Factory test and inspect absorber, generator, evaporator, and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Vacuum and pressure test shells for leaks.
3. Rate sound power level according to ARI 575.
4. Burner Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion requirements indicated.
5. Factory performance test chillers, before shipping, according to ARI 560.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.
OR
Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
OR
At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
6. Factory sound test chillers, before shipping, according to ARI 575.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) Chiller operating at calculated worst-case sound condition.
 - 3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
7. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
8. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

1.3 EXECUTION

A. Examination

1. Examine chillers before installation. Reject chillers that are damaged.
2. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.



- a. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
 3. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Chiller Installation
1. Install chillers on support structure indicated.
 2. Equipment Mounting (for equipment supported on concrete bases and vibration isolation devices): Install chiller on concrete bases using elastomeric pads. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Equipment Mounting (for equipment supported on vibration isolation devices without a concrete base): Install chiller using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.
 4. Equipment Mounting (for equipment installed on concrete bases without vibration isolation devices): Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 5. Install chillers with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 6. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 7. Maintain manufacturer's recommended clearances for service and maintenance.
 8. Charge chiller with absorbent and refrigerant if not factory charged.
 9. Install separate devices furnished by manufacturer and not factory installed.
 10. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated. Comply with requirements in Division 23 Section "Hvac Insulation".
 11. Install electrical devices furnished with chiller but not specified to be factory mounted.
 12. Install control wiring to field-mounted electrical devices.
- C. Heat-Exchanger, Brush-Cleaning System Installation
1. Install brush-cleaning system control panel adjacent to chiller control panel.
 2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
 3. Provide field electric power, as required, to each system control panel and electric-actuated valve.



4. Provide pneumatic piping with pressure regulator and an isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

D. Connections

1. Comply with requirements for hydronic piping in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements for gas piping in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Connect gas piping full size to gas-train inlet with shutoff valve and union.
4. Install gas-fired boilers according to NFPA 54.
5. Comply with requirements for fuel-oil piping in Division 23 Section "Facility Fuel-oil Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
6. Connect oil piping full size to burner inlet with shutoff valve and union.
7. Install oil-fired boilers according to NFPA 31.
8. Install piping adjacent to chiller to allow service and maintenance.
9. Hot-Water Heat-Exchanger Connections: Connect to heat-exchanger inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to heat-exchanger outlet with shutoff valve, check valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
10. Evaporator-Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
11. Absorber/Condenser-Fluid Connections: Connect to inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
 - a. If not factory furnished or installed, provide pipe connecting fluid connection of absorber discharge and condenser inlet.
12. Refrigerant Pressure Relief Device Connections: Extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
13. Extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15.
14. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.
15. Comply with requirements for chimney system in Division 23 Section "Breechings, Chimneys, And Stacks". Drawings indicate general arrangement of pipe, fittings, and specialties. Connect chimney system to chiller burner outlet and extend to the outdoors.
16. Connect fuel-fired burner assembly and blower and associated damper for combustion air.

E. Startup Service

1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.



- b. Operate chiller for run-in period.
 - c. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
 - d. Verify that pumps are installed and functional.
 - e. Verify that thermometers and gages are installed.
 - f. Operate chiller for run-in period.
 - g. Verify that refrigerant pressure relief device is vented to the outdoors.
 - h. Verify proper motor rotation.
 - i. Verify proper fuel supply. Adjust air-fuel ratio and combustion.
 - j. Verify proper combustion-air source.
 - k. Verify proper exhaust emissions.
 - l. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
 - m. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
 - n. Verify and record performance of chiller protection devices.
 - o. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
 - p. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
 3. Prepare test and inspection startup reports.
- F. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain chillers. Video record the training sessions, **as directed**.

END OF SECTION 23 64 13 16



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 64 13 16	23 62 13 00	Indirect-Fired Absorption Water Chillers



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SECTION 23 64 16 16 - FAN-COIL UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fan-coil units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes fan-coil units and accessories.

C. Definitions

1. BAS: Building automation system.

D. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Compressor failure.
 - 2) Condenser coil leak.
 - b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Final Completion.
 - c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Final Completion.



- d. Warranty Period (Condenser Coil Only): Five years from date of Final Completion.

1.2 PRODUCTS

A. Fan-Coil Units

1. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
2. Coil Section Insulation: 1/2-inch (13-mm) **OR** 1-inch (25-mm), **as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 - a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Main and Auxiliary Drain Pans: Plastic **OR** Stainless steel **OR** Insulated galvanized steel with plastic liner, **as directed**. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable, **as directed**.
4. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.
5. Cabinet: Steel with factory prime coating, ready for field painting **OR** baked-enamel finish in manufacturer's standard paint color as selected by the Owner **OR** baked-enamel finish in manufacturer's custom paint color as selected by the Owner, **as directed**.
 - a. Vertical Unit Front Panels: Removable, steel, with integral stamped **OR** polyethylene **OR** steel, **as directed**, discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
 - b. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped **OR** cast-aluminum, **as directed**, discharge grilles.
 - c. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors. Return grille shall provide maintenance access to fan-coil unit.
 - d. Steel recessing flanges for recessing fan-coil units into ceiling or wall.
6. Outdoor-Air Wall Box: Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
 - a. Louver Configuration: Horizontal **OR** Vertical, **as directed**, rain-resistant louver.
 - b. Louver Material: Aluminum **OR** Steel, **as directed**.
 - c. Bird Screen: 1/2-inch (13-mm) mesh screen on interior side of louver.
 - d. Decorative Grille: On outside of intake.
 - e. Finish: Anodized aluminum **OR** Baked enamel, **as directed**, color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.
7. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with electronic **OR** pneumatic, **as directed**, two-position **OR** modulating, **as directed**, actuators.
8. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
 - a. Washable Foam: 70 percent arrestance and 3 MERV.
 - b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
 - c. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
9. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.



10. Steam Coils: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).
11. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
12. Fan and Motor Board: Removable.
 - a. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - b. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - c. Wiring Termination: Connect motor to chassis wiring with plug connection.
13. Factory, Hydronic Piping Package: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
 - a. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for dual-temperature coil.
 - b. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
 - c. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for heating coil.
 - d. Two **OR** Three, **as directed**, -way two-position **OR** modulating, **as directed**, control valve for hot-water reheat coil.
 - e. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
 - 1) Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
 - 2) Minimum Diameter: Equal to fan-coil-unit connection size.
 - f. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
 - g. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250-deg F (121-deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
 - h. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
 - i. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
 - j. Wrought-Copper Unions: ASME B16.22.
 - k. Risers: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper pipe with hose and ball valve for system flushing.
14. Control devices and operational sequences are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
15. Basic Unit Controls:
 - a. Control voltage transformer.
 - b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features:
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) Fan-speed switch.



- 4) Manual **OR** Automatic, **as directed**, changeover.
 - 5) Adjustable deadband.
 - 6) Concealed **OR** Exposed, **as directed**, set point.
 - 7) Concealed **OR** Exposed, **as directed**, indication.
 - 8) Degree F **OR** Degree C, **as directed**, indication.
 - c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
 - 1) Concealed **OR** Exposed, **as directed**, set point.
 - 2) Concealed **OR** Exposed, **as directed**, indication.
 - d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
 - e. Unoccupied-period-override push button.
 - f. Data entry and access port.
 - 1) Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
 - 2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
16. DDC, **as directed**, Terminal Controller:
- a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 - b. Unoccupied Period Override Operation: Two, **as directed**, hours.
 - c. Unit Supply-Air Fan Operation:
 - 1) Occupied Periods: Fan runs continuously.
 - 2) Unoccupied Periods: Fan cycles to maintain room setback temperature.
 - d. Hydronic-Cooling-Coil Operation:
 - 1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to maintain room temperature.
 - 2) Unoccupied Periods: Close control valve.
 - e. Heating-Coil Operation:
 - 1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
 - 2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
 - f. Dual-Temperature Hydronic-Coil Operation:
 - 1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open control valve if temperature falls below thermostat set point.
 - 2) Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.
 - g. Reheat-Coil Operation:
 - 1) Humidity Control for Occupied Periods:
 - a) Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As space temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
 - 2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
 - 3) Occupied Periods:
 - a) Heating Operations: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
 - b) Humidity-Control Operations: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide



- heating. As space temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
- 4) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature. Humidity control is not available.
 - h. Outdoor-Air Damper Operation:
 - 1) Occupied Periods: Open damper to fixed position for 25 percent outdoor air.
 - 2) Unoccupied periods: Close damper.
 - i. Outdoor-Air Damper Operation:
 - 1) Occupied Periods:
 - a) Outdoor-Air Temperature below Room Temperature: If room temperature is above thermostat set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below thermostat set point, position damper to fixed minimum position.
 - b) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for 25 percent outdoor air.
 - 2) Unoccupied Periods: Close damper.
 - j. Controller shall have volatile-memory backup.
17. BAS Interface Requirements:
- a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at the central workstation.
 - c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
 - 1) Adjust set points.
 - 2) Fan-coil-unit start, stop, and operating status.
 - 3) Data inquiry, including outdoor-air damper position, **as directed**, supply- and room-air temperature and humidity, **as directed**.
 - 4) Occupied and unoccupied schedules.
18. Electrical Connection: Factory wire motors and controls for a single electrical connection.

B. Ducted Fan-Coil Units

1. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
2. Coil Section Insulation: 1/2-inch (13-mm) **OR** 1-inch (25-mm), **as directed**, thick coated **OR** foil-faced, **as directed**, glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 - a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Drain Pans: Plastic **OR** Stainless steel **OR** Insulated galvanized steel with plastic liner, **as directed**. Fabricate pans and drain connections to comply with ASHRAE 62.1.
4. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.
5. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
 - a. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille, **as directed**.
 - b. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
 - c. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
 - d. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.
6. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
 - a. Washable Foam: 70 percent arrestance and 3 MERV.



- b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
- c. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
- 7. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.
- 8. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum 450 psig (3105 kPa) for a minimum 300-psig (2070-kPa) working pressure. Include thermal expansion valve.
- 9. Steam Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).
- 10. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
- 11. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

OR

Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

- a. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- 12. Factory, Hydronic Piping Package: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
 - a. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
 - b. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for heating coil.
 - c. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for dual-temperature coil.
 - d. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for reheat coil.
 - e. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
 - 1) Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
 - 2) Minimum Diameter: Equal to fan-coil-unit connection size.
 - f. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
 - g. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
 - h. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
 - i. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure, with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
 - j. Wrought-Copper Unions: ASME B16.22.



13. Remote condensing units are specified in Division 23 Section "Packaged Compressor And Condenser Units".
14. Remote Condensing Units: Factory assembled and tested, consisting of compressors, condenser coils, fans, motors, refrigerant receiver, and operating controls. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
 - a. Casing: Steel with baked-enamel finish, removable panels for access to controls, weep holes for water drainage, and mounting holes in base.
 - b. Compressor: Hermetic, scroll **OR** reciprocating, **as directed**, type; internally isolated for vibration with factory-installed safety devices as follows:
 - 1) Antirecycle timer.
 - 2) High-pressure cutout.
 - 3) Low-pressure cutout or loss-of-charge switch.
 - 4) Internal thermal-overload protection.
 - 5) Current and voltage sensitive safety devices.
 - c. Compressor Motor: Start capacitor, relay, and contactor. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - d. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
 - e. Refrigerant Piping Materials: ASTM B 743 copper tube with wrought-copper fittings and brazed joints.
 - f. Refrigerant: R-407C **OR** R-410A, **as directed**.
 - g. Low ambient controls to permit operation down to 45 deg F (7 deg C).
 - h. Crankcase heater.
 - i. Charging and service fittings on exterior of casing.
 - j. Filter dryer.
 - k. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat operation.
 - l. Hot-gas-bypass, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
 - m. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
 - n. Condenser Fan: Direct-drive, aluminum propeller fan.
 - 1) Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - o. Accessories: Polyethylene mounting base to provide a permanent foundation.
15. Control devices and operational sequence are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
16. Basic Unit Controls:
 - a. Control voltage transformer.
 - b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) Fan-speed switch.
 - 4) Manual **OR** Automatic, **as directed**, changeover.
 - 5) Adjustable deadband.
 - 6) Concealed **OR** Exposed, **as directed**, set point.
 - 7) Concealed **OR** Exposed, **as directed**, indication.
 - 8) Degree F **OR** Degree C, **as directed**, indication.
 - c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
 - 1) Concealed **OR** Exposed, **as directed**, set point.
 - 2) Concealed **OR** Exposed, **as directed**, indication.
 - d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
 - e. Unoccupied-period-override push button.
 - f. Data entry and access port.
 - 1) Input data includes room temperature, and humidity set points and occupied and unoccupied periods.



- 2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
17. DDC, **as directed**, Terminal Controller:
- a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 - b. Unoccupied Period Override Operation: Two, **as directed**, hours.
 - c. Unit Supply-Air Fan Operation:
 - 1) Occupied Periods: Fan runs continuously.
 - 2) Unoccupied Periods: Fan cycles to maintain room setback temperature.
 - d. Hydronic-Cooling-Coil Operation:
 - 1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to maintain room temperature.
 - 2) Unoccupied Periods: Close control valve.
 - e. Refrigerant-Coil Operation:
 - 1) Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
 - 2) Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.
 - f. Supplemental, **as directed**, Heating-Coil Operation:
 - 1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
 - 2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
 - 3) Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below 25 deg F (4 deg C).
 - g. Dual-Temperature Hydronic-Coil Operation:
 - 1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open **OR** modulate, **as directed**, control valve if temperature falls below thermostat set point.
 - 2) Unoccupied Periods: When chilled water is available, close valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.
 - h. Reheat-Coil Operation:
 - 1) Humidity Control for Occupied Periods: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
 - 2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
 - 3) Occupied Periods:
 - a) Heating Operations: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
 - b) Humidity-Control Operations: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
 - 4) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature. Humidity control is not available.
 - i. Outdoor-Air Damper Operation (for fixed, minimum outdoor-air intake):
 - 1) Occupied Periods: Open damper to fixed position for 25 percent outdoor air.



- 2) Unoccupied Periods: Close damper.
 - j. Outdoor-Air Damper Operation (for outdoor-air economizer cycle based on temperature):
 - 1) Occupied Periods:
 - a) Outdoor-Air Temperature below Room Temperature: If room temperature is above room-temperature set point, modulate outdoor- and return-air dampers to maintain room-temperature set point (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum setting.
 - b) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for 25 percent outdoor air.
 - 2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
 - k. Outdoor-Air Damper Operation (for outdoor-air economizer cycle based on enthalpy):
 - 1) Occupied Periods:
 - a) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for 25 percent outdoor air.
 - b) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum position for 25 percent outdoor air.
 - 2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
 - l. Controller shall have volatile-memory backup.
18. BAS Interface Requirements:
- a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at the central workstation.
 - c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
 - 1) Adjust set points.
 - 2) Fan-coil-unit start, stop, and operating status.
 - 3) Data inquiry including outdoor-air damper position,, **as directed** supply- and room-air temperature and humidity, **as directed**.
 - 4) Occupied and unoccupied schedules.
19. Electrical Connection: Factory wire motors and controls for a single electrical connection.

1.3 EXECUTION

A. Installation

- 1. Install fan-coil units level and plumb.
- 2. Install fan-coil units to comply with NFPA 90A.
- 3. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- 4. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**, above finished floor.
- 5. Install new filters in each fan-coil unit within two weeks after Final Completion.

B. Connections

- 1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - a. Install piping adjacent to machine to allow service and maintenance.
 - b. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
 - c. Connect condensate drain to indirect waste.
 - 1) Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.



2. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories". Comply with safety requirements in UL 1995 for duct connections.
3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
 - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace malfunctioning units and retest as specified above.

D. Adjusting

1. Adjust initial temperature and humidity set points.
2. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units.

END OF SECTION 23 64 16 16



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 64 16 16	23 61 16 00	Centrifugal Water Chillers



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SECTION 23 64 19 00 - RECIPROCATING WATER CHILLERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for reciprocating water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Packaged, water-cooled, electric-motor-driven, reciprocating water chillers.
 - b. Packaged, air-cooled, electric-motor-driven, reciprocating water chillers.
 - c. Packaged refrigerant recovery units.

C. Definitions

1. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
2. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
3. IPLV: Integrated part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
4. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
5. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements

1. Seismic Performance: Reciprocating water chillers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. Seismic Qualification Certificates: For water chillers, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
3. Source quality-control test reports.
4. Startup service reports.
5. Operation and maintenance data.
6. Warranty: Sample of special warranty.

F. Quality Assurance

1. ARI Certification: Certify chiller according to ARI 590 certification program.



2. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
3. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
5. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
6. Comply with NFPA 70.

G. Delivery, Storage, And Handling

1. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
2. Package water chiller for export shipping.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within five years from date of Final Completion.

1.2 PRODUCTS

A. Packaged Water-Cooled Water Chillers

1. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
2. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
3. Compressors:
 - a. Description: Positive-displacement direct drive with semihermetically sealed and accessible bolted casings.
 - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - c. Operating Speed: 1750 rpm for 60-Hz applications.
 - d. Capacity Control: Combinations of cylinder unloading and on-off compressor cycling of multiple compressors, **as directed**, plus hot-gas bypass, **as directed**. Compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
 - e. Oil Lubrication System: Automatically reversible, positive-displacement pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
 - f. Vibration Isolation: Mount individual compressors on either neoprene or spring isolators.
 - g. Sound-reduction package shall consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.
4. Compressor Motors:
 - a. Hermetically sealed and cooled by refrigerant suction gas.
 - b. High-torque, four-pole induction type with inherent thermal-overload protection on each phase.
5. Compressor Motor Controllers:
 - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
OR
Part-Wind Start: NEMA ICS 2, Class A, reduced voltage, nonreversing.
6. Refrigeration:
 - a. Refrigerant: R-407C **OR** R-410A, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.



- b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 - c. Refrigerant Circuit: Each circuit shall include a thermal **OR** an electronic, **as directed**, expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 - d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
7. Evaporator:
- a. Brazed-plate or shell-and-tube design, as indicated.
 - b. Shell and Tube:
 - 1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
 - 2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 3) Shell Material: Carbon steel.
 - 4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
 - 5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
 - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - c. Brazed Plate:
 - 1) Direct-expansion, single-pass, brazed-plate design.
 - 2) Type 316 stainless-steel construction.
 - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
8. Condenser:
- a. Shell and tube, brazed plate, or without integral condenser; as indicated.
 - b. Shell and Tube:
 - 1) Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
 - 2) Provides positive subcooling of liquid refrigerant.
 - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 4) Shell Material: Carbon steel.
 - 5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
 - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - 7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.
 - c. Brazed Plate:
 - 1) Single-pass, brazed-plate design provides positive subcooling of liquid refrigerant.
 - 2) Type 316 stainless-steel construction.
 - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
 - 5) Provide each condenser with a liquid-line shutoff valve.



- d. Provide water chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 23 Section "Air-cooled Refrigerant Condensers".
9. Electrical Power:
- a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
 - b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
 - c. Wiring shall be numbered and color-coded to match wiring diagram.
 - d. Install factory wiring outside of an enclosure in a raceway.
 - e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
 - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
 - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
 - 2) NEMA KS 1, heavy-duty, nonfusible switch.
 - 3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - g. Provide each motor with overcurrent protection.
 - h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
 - i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
 - j. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
 - k. Control Relays: Auxiliary and adjustable time-delay relays.
 - l. Indicate the following for water chiller electrical power supply:
 - 1) Current, phase to phase, for all three phases.
 - 2) Voltage, phase to phase and phase to neutral for all three phases.
 - 3) Three-phase real power (kilowatts).
 - 4) Three-phase reactive power (kilovolt amperes reactive).
 - 5) Power factor.
 - 6) Running log of total power versus time (kilowatt hours).
 - 7) Fault log, with time and date of each.
10. Controls:
- a. Stand-alone, microprocessor based.
 - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
 - c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
 - 1) Date and time.
 - 2) Operating or alarm status.
 - 3) Operating hours.
 - 4) Outside-air temperature if required for chilled-water reset.
 - 5) Temperature and pressure of operating set points.
 - 6) Entering and leaving temperatures of chilled water.
 - 7) Entering and leaving temperatures of condenser water.
 - 8) Refrigerant pressures in evaporator and condenser.
 - 9) Saturation temperature in evaporator and condenser.
 - 10) No cooling load condition.
 - 11) Elapsed time meter (compressor run status).
 - 12) Pump status.
 - 13) Antirecycling timer status.
 - 14) Percent of maximum motor amperage.
 - 15) Current-limit set point.



- 16) Number of compressor starts.
 - d. Control Functions:
 - 1) Manual or automatic startup and shutdown time schedule.
 - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
 - 3) Current limit and demand limit.
 - 4) Condenser-water temperature.
 - 5) External water chiller emergency stop.
 - 6) Antirecycling timer.
 - 7) Automatic lead-lag switching.
 - e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
 - 1) Low evaporator pressure or high condenser pressure.
 - 2) Low chilled-water temperature.
 - 3) Refrigerant high pressure.
 - 4) High or low oil pressure.
 - 5) High oil temperature.
 - 6) Loss of chilled-water flow.
 - 7) Loss of condenser-water flow.
 - 8) Control device failure.
 - f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
 - 1) Hardwired Points:
 - a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
 - b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
 - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to control and monitor the water chiller from a remote operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.
11. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
 - b. Thickness: 3/4 inch (19 mm).
 - c. Factory-applied insulation over cold surfaces of water chiller components.
 - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 - d. Apply protective coating to exposed surfaces of insulation.
12. Accessories:
- a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
 - b. Individual compressor suction and discharge pressure gages with shutoff valves.
 - c. Factory-furnished spring isolators for field installation.
- B. Packaged Air-Cooled Water Chillers
1. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
 2. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.
 3. Cabinet:



- a. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit. Base shall be designed to limit deflection to L/200 and shall be a minimum of 4 inches (100 mm) high.
 - b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
 - c. Casing: Galvanized steel.
 - d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.
 - e. Sound-reduction package consisting of the following:
 - 1) Acoustic enclosure around compressors.
 - 2) Reduced-speed fans with acoustic treatment.
 - 3) Designed to reduce sound level without affecting performance.
 - f. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.
4. Compressors:
- a. Description: Positive-displacement direct drive with semihermetically sealed and accessible bolted casings.
 - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - c. Operating Speed: 1750 rpm for 60-Hz applications.
 - d. Capacity Control: Combinations of cylinder unloading and on-off compressor cycling of multiple compressors, plus hot-gas bypass, **as directed**. Compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
 - e. Oil Lubrication System: Automatically reversible, positive-displacement pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
 - f. Vibration Isolation: Mount individual compressors on spring isolators with an isolation efficiency of 95 percent.
5. Compressor Motors:
- a. Hermetically sealed and cooled by refrigerant suction gas.
 - b. High-torque, four-pole induction type with inherent thermal-overload protection on each phase.
6. Compressor Motor Controllers:
- a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
OR
Part-Wind Start: NEMA ICS 2, Class A, reduced voltage, nonreversing.
7. Refrigeration:
- a. Refrigerant: R-407C **OR** R-410A, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
 - b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 - c. Refrigerant Circuit: Each circuit shall include a thermal **OR** an electronic, **as directed**, expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 - d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
8. Evaporator:
- a. Description: Direct-expansion shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
 - b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.



- c. Shell Material: Carbon steel.
 - d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
 - e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
 - f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - g. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
 - h. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.
9. Air-Cooled Condenser:
- a. Plate-fin coil with integral subcooling circuit, leak tested at 150 psig (1034 kPa).
 - 1) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.
 - 2) Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
 - 3) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
 - b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
 - c. Fan Motors: Totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
 - d. Fan Guards: Steel safety guards with corrosion-resistant coating.
10. Electrical Power:
- a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
 - b. House in a unit-mounted, NEMA 250, Type 3R **OR** Type 4, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
 - c. Wiring shall be numbered and color-coded to match wiring diagram.
 - d. Install factory wiring outside of an enclosure in a raceway.
 - e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
 - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
 - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
 - 2) NEMA KS 1, heavy-duty, nonfusible switch.
 - 3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - g. Provide each motor with overcurrent protection.
 - h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
 - i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
 - j. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
 - 1) Power unit-mounted controls where indicated.
 - 2) Power unit-mounted, ground-fault interrupt (GFI) duplex receptacle.
 - k. Control Relays: Auxiliary and adjustable time-delay relays.
 - l. Indicate the following for water chiller electrical power supply:
 - 1) Current, phase to phase, for all three phases.
 - 2) Voltage, phase to phase and phase to neutral for all three phases.
 - 3) Three-phase real power (kilowatts).
 - 4) Three-phase reactive power (kilovolt amperes reactive).
 - 5) Power factor.
 - 6) Running log of total power versus time (kilowatt hours).
 - 7) Fault log, with time and date of each.



11. Controls:
- a. Stand-alone, microprocessor based.
 - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
 - c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
 - 1) Date and time.
 - 2) Operating or alarm status.
 - 3) Operating hours.
 - 4) Outside-air temperature if required for chilled-water reset.
 - 5) Temperature and pressure of operating set points.
 - 6) Entering and leaving temperatures of chilled water.
 - 7) Refrigerant pressures in evaporator and condenser.
 - 8) Saturation temperature in evaporator and condenser.
 - 9) No cooling load condition.
 - 10) Elapsed time meter (compressor run status).
 - 11) Pump status.
 - 12) Antirecycling timer status.
 - 13) Percent of maximum motor amperage.
 - 14) Current-limit set point.
 - 15) Number of compressor starts.
 - d. Control Functions:
 - 1) Manual or automatic startup and shutdown time schedule.
 - 2) Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
 - 3) Current limit and demand limit.
 - 4) External water chiller emergency stop.
 - 5) Antirecycling timer.
 - 6) Automatic lead-lag switching.
 - e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
 - 1) Low evaporator pressure or high condenser pressure.
 - 2) Low chilled-water temperature.
 - 3) Refrigerant high pressure.
 - 4) High or low oil pressure.
 - 5) High oil temperature.
 - 6) Loss of chilled-water flow.
 - 7) Control device failure.
 - f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
 - 1) Hardwired Points:
 - a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
 - b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
 - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to control and monitor the water chiller from a remote operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

12. Insulation:



- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
 - b. Thickness: 3/4 inch (19 mm).
 - c. Factory-applied insulation over cold surfaces of water chiller components.
 - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 - d. Apply protective coating to exposed surfaces of insulation.
13. Accessories:
- a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
 - b. Individual compressor suction and discharge pressure gages with shutoff valves.
 - c. Factory-furnished spring isolators for field installation.

C. Packaged Refrigerant Recovery Units

1. Packaged portable unit shall consist of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest water chiller.

D. Source Quality Control

1. Perform functional test of water chillers before shipping.
2. Factory performance test water chillers, **as directed**, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
 - a. Allow the Owner access to place where water chillers are being tested. Notify the Owner 14 days in advance of testing.
3. Factory test and inspect evaporator and water-cooled condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
4. For water chillers located indoors, rate sound power level according to ARI 575 procedure.
5. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

1.3 EXECUTION

A. Water Chiller Installation

1. Install water chillers on support structure indicated.
2. Equipment Mounting: Install water chiller on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install water chiller using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.



4. Equipment Mounting: Install water chiller on vibration isolation inertia bases. Comply with requirements specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 5. Equipment Mounting: Install water chiller on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 6. Maintain manufacturer's recommended clearances for service and maintenance.
 7. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
 8. Install separate devices furnished by manufacturer and not factory installed.
- B. Connections
1. Comply with requirements in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Comply with requirements in Division 23 Section "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
 3. Install piping adjacent to chiller to allow service and maintenance.
 4. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
 5. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
 6. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15, **as directed**.
 7. Connect each drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.
- C. Startup Service
1. Perform startup service.
 2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
 3. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
 - b. Verify that pumps are installed and functional.
 - c. Verify that thermometers and gages are installed.
 - d. Operate water chiller for run-in period.
 - e. Check bearing lubrication and oil levels.
 - f. Verify that refrigerant pressure relief for chillers installed indoors is vented outside.
 - g. Verify proper motor rotation.
 - h. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.



- i. Verify and record performance of chilled-water and condenser-water, **as directed**, flow and low-temperature interlocks.
 - j. Verify and record performance of water chiller protection devices.
 - k. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
4. Prepare a written startup report that records results of tests and inspections.

END OF SECTION 23 64 19 00



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SECTION 23 64 23 00 - SCROLL WATER CHILLERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for scroll water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Packaged, water-cooled, electric-motor-driven, scroll water chillers.
 - b. Packaged, air-cooled, electric-motor-driven, scroll water chillers.
 - c. Packaged refrigerant recovery units.

C. Definitions

1. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
2. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
3. IPLV: Integrated part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
4. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
5. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements

1. Seismic Performance: Scroll water chillers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
3. Certificates: For certification required in "Quality Assurance" Article.
4. Seismic Qualification Certificates: For water chillers, accessories, and components from manufacturers.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Startup service reports.
6. Operation and maintenance data.
7. Warranty: Sample of special warranty.



F. Quality Assurance

1. ARI Certification: Certify chiller according to ARI 590 certification program.
2. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
3. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
5. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
6. Comply with NFPA 70.

G. Delivery, Storage, And Handling

1. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
2. Package water chiller for export shipping.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within five years from date of Final Completion.

1.2 PRODUCTS

A. Packaged Water-Cooled Water Chillers

1. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
2. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
3. Compressors:
 - a. Description: Positive-displacement direct drive with hermetically sealed casing.
 - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - c. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
 - d. Capacity Control: On-off compressor cycling, plus hot-gas bypass, **as directed**.
 - e. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
 - f. Vibration Isolation: Mount individual compressors on vibration isolators.
 - g. Sound-reduction package shall consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.
4. Compressor Motors:
 - a. Hermetically sealed and cooled by refrigerant suction gas.
 - b. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
5. Compressor Motor Controllers:
 - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
6. Refrigeration:
 - a. Refrigerant: R-407C **OR** R-410A, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
 - b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 - c. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.



- d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
- 7. Evaporator:
 - a. Brazed-plate or shell-and-tube design, as indicated.
 - b. Shell and Tube:
 - 1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
 - 2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 3) Shell Material: Carbon steel.
 - 4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
 - 5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
 - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - c. Brazed Plate:
 - 1) Direct-expansion, single-pass, brazed-plate design.
 - 2) Type 316 stainless-steel construction.
 - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
- 8. Condenser:
 - a. Shell and tube or without integral condenser; as indicated.
 - b. Shell and Tube:
 - 1) Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
 - 2) Provides positive subcooling of liquid refrigerant.
 - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 4) Shell Material: Carbon steel.
 - 5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
 - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - 7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.
 - c. Provide water chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 23 Section "Air-cooled Refrigerant Condensers".
- 9. Electrical Power:
 - a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
 - b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
 - c. Wiring shall be numbered and color-coded to match wiring diagram.
 - d. Install factory wiring outside of an enclosure in a raceway.
 - e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
 - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
 - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.



- 2) NEMA KS 1, heavy-duty, nonfusible switch.
- 3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- g. Provide each motor with overcurrent protection.
- h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
- i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
- j. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- k. Control Relays: Auxiliary and adjustable time-delay relays.
- l. Indicate the following for water chiller electrical power supply:
 - 1) Current, phase to phase, for all three phases.
 - 2) Voltage, phase to phase and phase to neutral for all three phases.
 - 3) Three-phase real power (kilowatts).
 - 4) Three-phase reactive power (kilovolt amperes reactive).
 - 5) Power factor.
 - 6) Running log of total power versus time (kilowatt hours).
 - 7) Fault log, with time and date of each.
10. Controls:
 - a. Stand-alone, microprocessor based.
 - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
 - c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
 - 1) Date and time.
 - 2) Operating or alarm status.
 - 3) Operating hours.
 - 4) Outside-air temperature if required for chilled-water reset.
 - 5) Temperature and pressure of operating set points.
 - 6) Entering and leaving temperatures of chilled water.
 - 7) Entering and leaving temperatures of condenser water.
 - 8) Refrigerant pressures in evaporator and condenser.
 - 9) Saturation temperature in evaporator and condenser.
 - 10) No cooling load condition.
 - 11) Elapsed time meter (compressor run status).
 - 12) Pump status.
 - 13) Antirecycling timer status.
 - 14) Percent of maximum motor amperage.
 - 15) Current-limit set point.
 - 16) Number of compressor starts.
 - d. Control Functions:
 - 1) Manual or automatic startup and shutdown time schedule.
 - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
 - 3) Current limit and demand limit.
 - 4) Condenser-water temperature.
 - 5) External water chiller emergency stop.
 - 6) Antirecycling timer.
 - 7) Automatic lead-lag switching.
 - e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
 - 1) Low evaporator pressure or high condenser pressure.
 - 2) Low chilled-water temperature.
 - 3) Refrigerant high pressure.



- 4) High or low oil pressure.
 - 5) High oil temperature.
 - 6) Loss of chilled-water flow.
 - 7) Loss of condenser-water flow.
 - 8) Control device failure.
 - f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
 - 1) Hardwired Points:
 - a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
 - b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
 - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.
11. Insulation:
 - a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
 - b. Thickness: 3/4 inch (19 mm).
 - c. Factory-applied insulation over cold surfaces of water chiller components.
 - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 - d. Apply protective coating to exposed surfaces of insulation.
 12. Accessories:
 - a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
 - b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
 - c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.
- B. Packaged Air-Cooled Water Chillers
1. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
 2. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.
 3. Cabinet:
 - a. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
 - b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
 - c. Casing: Galvanized steel.
 - d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.
 - e. Sound-reduction package consisting of the following:
 - 1) Acoustic enclosure around compressors.
 - 2) Reduced-speed fans with acoustic treatment.
 - 3) Designed to reduce sound level without affecting performance.
 - f. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.
 4. Compressors:



- a. Description: Positive-displacement direct drive with hermetically sealed casing.
 - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - c. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
 - d. Capacity Control: On-off compressor cycling, plus hot-gas bypass, **as directed**.
 - e. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
 - f. Vibration Isolation: Mount individual compressors on vibration isolators.
5. Compressor Motors:
- a. Hermetically sealed and cooled by refrigerant suction gas.
 - b. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
6. Compressor Motor Controllers:
- a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
7. Refrigeration:
- a. Refrigerant: R-407c **OR** R-410a, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
 - b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 - c. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 - d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
8. Evaporator:
- a. Brazed-plate or shell-and-tube design, as indicated.
 - b. Shell and Tube:
 - 1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
 - 2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 3) Shell Material: Carbon steel.
 - 4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
 - 5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
 - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
 - c. Brazed Plate:
 - 1) Direct-expansion, single-pass, brazed-plate design.
 - 2) Type 316 stainless-steel construction.
 - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - 4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
 - d. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
 - e. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.
9. Air-Cooled Condenser:
- a. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).
 - 1) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.



- 2) Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
 - 3) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
 - b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
 - c. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
 - d. Fan Guards: Steel safety guards with corrosion-resistant coating.
10. Electrical Power:
- a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
 - b. House in a unit-mounted, NEMA 250, Type 3R, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
 - c. Wiring shall be numbered and color-coded to match wiring diagram.
 - d. Install factory wiring outside of an enclosure in a raceway.
 - e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
 - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
 - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
 - 2) NEMA KS 1, heavy-duty, nonfusible switch.
 - 3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - g. Provide each motor with overcurrent protection.
 - h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
 - i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
 - j. Provide power factor correction capacitors to correct power factor to 0.90 **OR** 0.95, **as directed**, at full load.
 - k. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
 - 1) Power unit-mounted controls where indicated.
 - 2) Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.
 - l. Control Relays: Auxiliary and adjustable time-delay relays.
 - m. Indicate the following for water chiller electrical power supply:
 - 1) Current, phase to phase, for all three phases.
 - 2) Voltage, phase to phase and phase to neutral for all three phases.
 - 3) Three-phase real power (kilowatts).
 - 4) Three-phase reactive power (kilovolt amperes reactive).
 - 5) Power factor.
 - 6) Running log of total power versus time (kilowatt hours).
 - 7) Fault log, with time and date of each.
11. Controls:
- a. Stand-alone, microprocessor based.
 - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
 - c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
 - 1) Date and time.
 - 2) Operating or alarm status.
 - 3) Operating hours.
 - 4) Outside-air temperature if required for chilled-water reset.
 - 5) Temperature and pressure of operating set points.
 - 6) Entering and leaving temperatures of chilled water.



- 7) Refrigerant pressures in evaporator and condenser.
 - 8) Saturation temperature in evaporator and condenser.
 - 9) No cooling load condition.
 - 10) Elapsed time meter (compressor run status).
 - 11) Pump status.
 - 12) Antirecycling timer status.
 - 13) Percent of maximum motor amperage.
 - 14) Current-limit set point.
 - 15) Number of compressor starts.
- d. Control Functions:
- 1) Manual or automatic startup and shutdown time schedule.
 - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
 - 3) Current limit and demand limit.
 - 4) External water chiller emergency stop.
 - 5) Antirecycling timer.
 - 6) Automatic lead-lag switching.
- e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
- 1) Low evaporator pressure or high condenser pressure.
 - 2) Low chilled-water temperature.
 - 3) Refrigerant high pressure.
 - 4) High or low oil pressure.
 - 5) High oil temperature.
 - 6) Loss of chilled-water flow.
 - 7) Control device failure.
- f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
- 1) Hardwired Points:
 - a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
 - b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
 - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.
12. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
 - b. Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
 - c. Factory-applied insulation over cold surfaces of water chiller components.
 - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
 - d. Apply protective coating to exposed surfaces of insulation.
13. Accessories:
- a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
 - b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
 - c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.



- C. Packaged Refrigerant Recovery Units
 - 1. Packaged portable unit shall consist of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest water chiller.
- D. Source Quality Control
 - 1. Perform functional test of water chillers before shipping.
 - 2. Factory performance test water chillers, **as directed**, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
 - a. Allow the Owner access to place where water chillers are being tested. Notify the Owner 14 days in advance of testing.
 - 3. Factory test and inspect evaporator and water-cooled condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
 - 4. For water chillers located indoors, rate sound power level according to ARI 575 procedure.
 - 5. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

1.3 EXECUTION

- A. Water Chiller Installation
 - 1. Install water chillers on support structure indicated.
 - 2. Equipment Mounting: Install water chiller on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Equipment Mounting: Install water chiller using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - 4. Equipment Mounting: Install water chiller on vibration isolation inertia bases. Comply with requirements specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - 5. Equipment Mounting: Install water chiller on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Maintain manufacturer's recommended clearances for service and maintenance.
 - 7. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
 - 8. Install separate devices furnished by manufacturer and not factory installed.

**B. Connections**

1. Comply with requirements in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements in Division 23 Section "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to chiller to allow service and maintenance.
4. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
5. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15, **as directed**.
7. Connect each drain connection with a union and drain pipe and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

C. Startup Service

1. Perform startup service.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
3. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
 - b. Verify that pumps are installed and functional.
 - c. Verify that thermometers and gages are installed.
 - d. Operate water chiller for run-in period.
 - e. Check bearing lubrication and oil levels.
 - f. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
 - g. Verify proper motor rotation.
 - h. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
 - i. Verify and record performance of chilled-water and condenser-water, **as directed**, flow and low-temperature interlocks.
 - j. Verify and record performance of water chiller protection devices.
 - k. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
4. Prepare a written startup report that records results of tests and inspections.

END OF SECTION 23 64 23 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 64 23 00	23 64 19 00	Reciprocating Water Chillers
23 64 26 00	23 61 16 00a	Rotary-Screw Water Chillers



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**SECTION 23 65 00 00 - COOLING TOWERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for cooling towers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Closed-circuit, forced-draft, counterflow cooling towers.
 - b. Closed-circuit, induced-draft, combined-flow cooling towers.
 - c. Closed-circuit, induced-draft, counterflow cooling towers.
 - d. Open-circuit, forced-draft, counterflow cooling towers.
 - e. Open-circuit, induced-draft, counterflow cooling towers.
 - f. Open-circuit, induced-draft, crossflow cooling towers.

C. Definitions

1. BMS: Building management system.
2. FRP: Fiber-reinforced polyester.

D. Performance Requirements

1. Delegated Design: Design cooling tower support structure and seismic restraints, **as directed**, and wind restraints, **as directed**, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Cooling tower support structure shall withstand the effects of gravity loads and loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.
3. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, furnished specialties, and accessories.
 - a. Maximum flow rate.
 - b. Minimum flow rate.
 - c. Drift loss as percent of design flow rate.
 - d. Volume of water in suspension for purposes of sizing a remote storage tank.
 - e. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
 - f. Performance curves for the following:
 - 1) Varying entering-water temperatures from design to minimum.
 - 2) Varying ambient wet-bulb temperatures from design to minimum.
 - 3) Varying water flow rates from design to minimum.
 - 4) Varying fan operation (off, minimum, and design speed).
 - g. Fan airflow, brake horsepower, and drive losses.
 - h. Pump flow rate, head, brake horsepower, and efficiency.



- i. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
- j. Electrical power requirements for each cooling tower component requiring power.
2. Shop Drawings: Complete set of manufacturer's prints of cooling tower assemblies, control panels, sections and elevations, and unit isolation. Include the following:
 - a. Assembled unit dimensions.
 - b. Weight and load distribution.
 - c. Required clearances for maintenance and operation.
 - d. Sizes and locations of piping and wiring connections.
 - e. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of support structure.
 - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - c. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and wind restraints, **as directed**, and for designing vibration isolation bases.
 - d. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - e. Structural supports.
 - f. Piping roughing-in requirements.
 - g. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
 - h. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Source quality-control reports.
7. Field quality-control reports.
8. Startup service reports.
9. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.
10. Warranty: Sample of special warranty.

F. Quality Assurance

1. Testing Agency Qualifications: Certified by CTI **OR** An NRTL, **as directed**.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
5. CTI Certification: Cooling tower thermal performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."
6. FMG approval and listing in the latest edition of FMG's "Approval Guide."



- G. Coordination
 - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 - 2. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.
 - 3. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

- H. Warranty
 - 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
 - a. Fan assembly including fan, drive, and motor.
 - b. All components of cooling tower.
 - c. Warranty Period: Five years from date of Final Completion.

1.2 PRODUCTS

- A. Closed-Circuit, Forced-Draft, Counterflow Cooling Towers
 - 1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
 - 2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed.**
 - 3. Casing and Frame:
 - a. Casing **OR** Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed.**
 - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed.**
 - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
 - d. Joints and Seams: Sealed watertight.
 - e. Welded Connections: Continuous and watertight.
 - 4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
OR
Collection Basin:
 - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed.**
 - b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
 - c. Overflow and drain connections.
 - d. Makeup water connection.
 - e. Basin Sweeper Distribution Piping and Nozzles:
 - 1) Pipe Material: PVC.
 - 2) Nozzle Material: Plastic.
 - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
 - 5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
OR
Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
 - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed.**
 - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR**



- control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
- c. Electrode Probes: Stainless steel.
 - d. Water Stilling Chamber: Corrosion-resistant material **OR FRP OR Galvanized steel OR PVC pipe OR Stainless steel, as directed**.
 - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
 - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
- a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
 - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
 - c. Enclosure: NEMA 250, Type 3R **OR Type 4 OR Type 4X, as directed**.
 - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
 - e. Control-circuit transformer with primary and secondary side fuses.
 - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
 - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
- OR**
Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
7. Water Distribution Piping: Main header and lateral branch piping designed for even distribution over fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
 - a. Pipe Material: Fiberglass **OR PVC OR Galvanized steel, as directed**.
 - b. Spray Nozzle Material: Plastic **OR Polypropylene OR PVC, as directed**.
 - c. Piping Supports: Corrosion-resistant hangers and supports designed to resist movement during operation and shipment.
 8. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.
 9. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.
 - a. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
 - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
 - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
 - d. Service Factor: 1.0 **OR** 1.15, **as directed**.
 10. Heat-Exchanger Coils:
 - a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.
 - b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover



- plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.
- OR**
- ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
- c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.
11. Removable, **as directed**, Drift Eliminator:
- a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
- b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
- c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
12. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**, -steel wire mesh.
13. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.
- a. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
- b. Fan Wheel and Housing Materials: Galvanized steel.
- c. Fan Shaft: Steel, coated to resist corrosion.
- d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
- e. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
- f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
14. Belt Drive:
- a. Belt-Drive Service Factor: 1.5 based on motor nameplate horsepower.
- b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
- c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
- OR**
- Belt: One-piece, multigrooved, solid-back belt.
- d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
- e. Belt-Drive Guard: Comply with OSHA regulations.
- f. Two-Motor, Single-Fan Drive:
- 1) Two single-speed motors per fan, one sized for full speed and load, and the other sized for 67 percent of full-load speed.
- 2) Belt Drives: Each motor shall have belt drive complying with requirements for belt drives and configured for operation when other motor fails.
- 3) Motor controller and wiring same as two-speed, two-winding motor.
15. Fan Motor:
- a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
- b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
- c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
- d. Service Factor: 1.15.
- e. Insulation: Class F **OR** Class H, **as directed**.



- f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
 - g. Severe-duty rating with the following features:
 - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - 2) Double-shielded, vacuum-degassed bearings lubricated with premium moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
 - 3) Internal heater automatically energized when motor is de-energized.
 - h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
16. Discharge Hoods:
- a. Hood Configuration: Tapered **OR** Straight, **as directed**; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed insulation, **as directed**, and access doors.
 - b. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.
 - 1) Provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.
17. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
18. Vibration Switch: For each fan drive.
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Vibration Detection: Sensor with a field-adjustable acceleration sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
 - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS and, **as directed**, hardwired connection to fan motor electrical circuit.
 - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS and, **as directed**, shut down the fan.
19. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".
- OR**
- Control Package: Factory installed and wired, and functionally tested at factory before shipment.
- a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
 - b. Control-circuit transformer with primary and secondary side fuses.
 - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
 - d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
 - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
 - f. Collection basin, electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
 - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
 - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
 - i. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.
 - j. Power and controls to open discharge hood dampers when pump is energized and close dampers when pump is de-energized.
 - k. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.



- 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
 - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 - l. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
 - m. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
 - n. Audible alarm and silence switch.
 - o. Visual indication of elapsed run time, graduated in hours for each motor.
 - p. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
 - 1) Operational status of each motor.
 - 2) Position of dampers.
 - 3) Cooling tower leaving-fluid temperature.
 - 4) Fan vibration alarm.
 - 5) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
20. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both, **as directed**, cooling tower end walls. Doors shall be operable from both sides of the door, **as directed**.
 - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
 - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
 - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard at platforms and around top of cooling tower. Comply with 29 CFR 1910.23.
 - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
 - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
- B. Closed-Circuit, Induced-Draft, Combined-Flow Cooling Towers
1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
 2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
 3. Casing and Frame:
 - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
 - d. Joints and Seams: Sealed watertight.
 - e. Welded Connections: Continuous and watertight.
 4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
OR
Collection Basin:
 - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
 - c. Overflow and drain connections.



- d. Makeup water connection.
 - e. Basin Sweeper Distribution Piping and Nozzles:
 - 1) Pipe Material: PVC, **as directed**.
 - 2) Nozzle Material: Plastic, **as directed**.
 - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
- OR**
- Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
 - c. Electrode Probes: Stainless steel.
 - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
 - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
 - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
- OR**
- Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
 - c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
 - d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
 - e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
- a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
 - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
 - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
 - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
 - e. Control-circuit transformer with primary and secondary side fuses.
 - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
 - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
- OR**
- Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.



7. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.
 - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Location: Over each bank of fill with easily replaceable plastic, **as directed**, spray nozzles mounted in bottom of basin.
 - c. Joints and Seams: Sealed watertight.
 - d. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
 - e. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable corrosion-resistant **OR** stainless-steel, **as directed**, hardware.
 - f. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity water distribution basin.
8. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
 - a. Pipe Material: PVC **OR** Galvanized steel, **as directed**.
 - b. Spray Nozzle Material: Plastic **OR** Polypropylene, **as directed**.
 - c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
9. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.
10. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.
 - a. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
 - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
 - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
 - d. Service Factor: 1.0 **OR** 1.15, **as directed**.
11. Fill:
 - a. Materials: PVC, **as directed**, with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
 - b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
 - c. Fabrication: Fill-type sheets fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
 - d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
12. Heat-Exchanger Coils:
 - a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.
 - b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.
OR
ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.



- c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.
13. Drift Eliminator:
- Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 according to ASTM E 84.
 - UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 - Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
 - Fill Drift Eliminators: Integral to **OR** Separate and removable from, **as directed**, fill.
 - Heat-Exchanger Coil Drift Eliminators: Located on discharge side and removable.
14. Air-Intake Louvers:
- Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
 - UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 - Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
 - Location: Integral to **OR** Separate from, **as directed**, fill.
15. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**, -steel wire mesh.
16. Axial Fan: Balanced at the factory after assembly.
- Blade Material: Aluminum **OR** FRP, **as directed**.
 - Hub Material: Aluminum **OR** FRP, **as directed**.
 - Blade Pitch: Field adjustable.
 - Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
 - Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
 - Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
17. Belt Drive:
- Service Factor: 1.5 based on motor nameplate horsepower.
 - Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
 - Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
OR
Belt: One-piece, multigrooved, solid-back belt.
 - Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
 - Belt-Drive Guard: Comply with OSHA regulations.
 - Two-Motor, Single-Fan Drive:
 - Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
 - Each motor with belt drive and configured for operation when other motor fails.
 - Controls and wiring same as two-speed, two-winding motor.
18. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
- Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
 - Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
 - Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
 - Operation: Able to operate both forward and in reverse.



- e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
 - f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
 - g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.
19. Fan Motor:
- a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
 - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
 - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
 - d. Service Factor: 1.15.
 - e. Insulation: Class F **OR** Class H, **as directed**.
 - f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
 - g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
 - h. Severe-duty rating with the following features:
 - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
 - 3) Internal heater automatically energized when motor is de-energized.
 - i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
20. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
- a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
 - b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
21. Vibration Switch: For each fan drive.
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
 - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
 - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
22. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
- a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
23. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".
- OR**
- Control Package: Factory installed and wired, and functionally tested at factory before shipment.
- a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
 - b. Control-circuit transformer with primary and secondary side fuses.
 - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.



- d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
 - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
 - f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
 - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
 - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
 - i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
 - j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
 - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
 - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 - k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
 - l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
 - m. Audible alarm and silence switch.
 - n. Visual indication of elapsed run time, graduated in hours for each motor.
 - o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
 - 1) Operational status of each motor.
 - 2) Position of dampers.
 - 3) Cooling tower leaving-fluid temperature.
 - 4) Fan vibration alarm.
 - 5) Oil-level alarm.
 - 6) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
24. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
 - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
 - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
 - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
 - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
 - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
 - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

C. Closed-Circuit, Induced-Draft, Counterflow Cooling Towers



1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
3. Casing and Frame:
 - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
 - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
 - d. Joints and Seams: Sealed watertight.
 - e. Welded Connections: Continuous and watertight.
4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
OR
Collection Basin:
 - a. Material: Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
 - b. Overflow and drain connections.
 - c. Makeup water connection.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
OR
Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
 - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
 - c. Electrode Probes: Stainless steel.
 - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
 - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
 - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
 - a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
 - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
 - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
 - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
 - e. Control-circuit transformer with primary and secondary side fuses.
 - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
 - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
OR
Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
OR
Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
OR



- Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
7. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
 - a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
 - b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
 - c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
 8. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.
 9. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.
 10. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
 - a. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
 - b. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
 - c. Service Factor: 1.0 **OR** 1.15, **as directed**.
 11. Heat-Exchanger Coils:
 - a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.
 - b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.

OR

ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
 - c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.
 12. Removable, **as directed**, Drift Eliminator:
 - a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
 - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
 13. Air-Intake Louvers:
 - a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
 - b. UV Treatment: Treat louvers with inhibitors to protect against damage caused by UV radiation.
 - c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out during all modes of operation including operation with fans off.
 14. Axial Fan: Balanced at the factory after assembly.
 - a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
 - b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
 - c. Blade Pitch: Field adjustable.
 - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
 - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus



- 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
- f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
15. Belt Drive:
- a. Service Factor: 1.5 based on motor nameplate horsepower.
- b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
- c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
OR
Belt: One-piece, multigrooved, solid-back belt.
- d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
- e. Belt-Drive Guard: Comply with OSHA regulations.
- f. Two-Motor, Single-Fan Drive:
- 1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
- 2) Each motor with belt drive and configured for operation when other motor fails.
- 3) Controls and wiring same as two-speed, two-winding motor.
16. Fan Motor:
- a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
- b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
- c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
- d. Service Factor: 1.15.
- e. Insulation: Class F **OR** Class H, **as directed**.
- f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
- g. Severe-duty rating with the following features:
- 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
- 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
- 3) Internal heater automatically energized when motor is de-energized.
- h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
17. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
- a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
- b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
18. Vibration Switch: For each fan drive.
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
- b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
- c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
- d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
19. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".
OR
Control Package: Factory installed and wired, and functionally tested at factory before shipment.



- a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
 - b. Control-circuit transformer with primary and secondary side fuses.
 - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
 - d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
 - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
 - f. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
 - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
 - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
 - i. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker **OR** for each cooling tower cell, **as directed**.
 - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
 - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 - j. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
 - k. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
 - l. Audible alarm and silence switch.
 - m. Visual indication of elapsed run time, graduated in hours for each motor.
 - n. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
 - 1) Operational status of each motor.
 - 2) Cooling tower leaving-fluid temperature.
 - 3) Fan vibration alarm.
 - 4) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
20. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
 - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
 - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
 - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
 - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
 - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
 - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

D. Open-Circuit, Forced-Draft, Counterflow Cooling Towers



1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
3. Casing and Frame:
 - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
 - d. Joints and Seams: Sealed watertight.
 - e. Welded Connections: Continuous and watertight.
4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
OR
Collection Basin:
 - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
 - c. Overflow and drain connections.
 - d. Makeup water connection.
 - e. Basin Sweeper Distribution Piping and Nozzles:
 - 1) Pipe Material: PVC, **as directed**.
 - 2) Nozzle Material: Plastic, **as directed**.
 - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
6. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
 - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
 - c. Electrode Probes: Stainless steel.
 - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
 - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
 - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
7. Electric Basin Heater:
 - a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
 - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
 - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
 - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
 - e. Control-circuit transformer with primary and secondary side fuses.
 - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.



- h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
 - i. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
 Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
 Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
8. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
 - a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
 - b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
 - c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
 9. Fill:
 - a. Materials: PVC, **as directed**, with maximum flame-spread index of 5 according to ASTM E 84.
 - b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
 - c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
 - d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
 10. Removable, **as directed**, Drift Eliminator:
 - a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
 - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
 11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**,-steel wire mesh.
 12. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.
 - a. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
 - b. Fan Wheel and Housing Materials: Galvanized steel.
 - c. Fan Shaft: Steel, coated to resist corrosion.
 - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
 - e. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
 - f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
 13. Axial Fan: Balanced at the factory after assembly.
 - a. Blade Material: FRP, **as directed**.
 - b. Hub Material: Aluminum **OR** FRP, **as directed**.
 - c. Blade Pitch: Field adjustable.
 - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
 - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
 - f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.



14. Belt Drive:
 - a. Service Factor: 1.5 based on motor nameplate horsepower.
 - b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
 - c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
OR
Belt: One-piece, multigrooved, solid-back belt.
 - d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
 - e. Belt-Drive Guard: Comply with OSHA regulations.
 - f. Two-Motor, Single-Fan Drive:
 - 1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
 - 2) Each motor with belt drive and configured for operation when other motor fails.
 - 3) Controls and wiring same as two-speed, two-winding motor.
15. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.
16. Fan Motor:
 - a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
 - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
 - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
 - d. Service Factor: 1.15.
 - e. Insulation: Class F **OR** Class H, **as directed**.
 - f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
 - g. Severe-duty rating with the following features:
 - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and 300 deg F (minus 29 and 149 deg C).
 - 3) Internal heater automatically energized when motor is de-energized.
 - h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
17. Discharge Hoods:
 - a. Hood Configuration: Tapered **OR** Straight, **as directed**; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed insulation, **as directed**, and access doors.
 - b. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.
 - 1) Provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.
18. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
19. Vibration Switch: For each fan drive.
 - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
 - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
 - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
20. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".

**OR**

Control Package: Factory installed and wired, and functionally tested at factory before shipment.

- a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
 - b. Control-circuit transformer with primary and secondary side fuses.
 - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
 - d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
 - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
 - f. Factory-installed and -wired, collection basin electric/electronic level controller.
 - g. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
 - h. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
 - i. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
 - j. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.
 - k. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
 - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
 - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 - l. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
 - m. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
 - n. Audible alarm and silence switch.
 - o. Visual indication of elapsed run time, graduated in hours for each motor.
 - p. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
 - 1) Operational status of each motor.
 - 2) Position of dampers.
 - 3) Cooling tower leaving-fluid temperature.
 - 4) Fan vibration alarm.
 - 5) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
21. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
 - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
 - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
 - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
 - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.



- 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
 - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.
- E. Open-Circuit, Induced-Draft, Counterflow Cooling Towers
1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
 2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
 3. Casing and Frame:
 - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
 - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
 - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
 - d. Joints and Seams: Sealed watertight.
 - e. Welded Connections: Continuous and watertight.
 4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
OR
Collection Basin:
 - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
 - c. Overflow and drain connections.
 - d. Makeup water connection.
 - e. Outlet Connection: ASME B16.5, Class 150 flange.
 - f. Removable equalization flume plate between adjacent cells of multiple-cell towers.
 - g. Equalizer connection for field-installed equalizer piping.
 - h. Basin Sweeper Distribution Piping and Nozzles:
 - 1) Pipe Material: PVC, **as directed**.
 - 2) Nozzle Material: Plastic, **as directed**.
 - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
 5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
OR
Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
 - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
 - c. Electrode Probes: Stainless steel.
 - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
 - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
 - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
OR
Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:



- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
 - c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
 - d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
 - e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
- a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
 - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
 - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
 - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
 - e. Control-circuit transformer with primary and secondary side fuses.
 - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
 - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
- OR**
Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
7. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
- a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
 - b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
 - c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
8. Fill:
- a. Materials: CPVC **OR** PVC, **as directed**, resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
 - b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
 - c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
 - d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
9. Removable, **as directed**, Drift Eliminator:
- a. Material: FRP **OR** PVC, **as directed**; resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
 - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
10. Air-Intake Louvers:
- a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
 - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.



- c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
- 11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**, -steel wire mesh.
- 12. Axial Fan: Balanced at the factory after assembly.
 - a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
 - b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
 - c. Blade Pitch: Field adjustable.
 - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.
 - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
 - f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
- 13. Belt Drive:
 - a. Service Factor: 1.5 based on motor nameplate horsepower.
 - b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
 - c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
OR
Belt: One-piece, multigrooved, solid-back belt.
 - d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
 - e. Belt-Drive Guard: Comply with OSHA regulations.
- 14. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.
- 15. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
 - a. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
 - b. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
 - c. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
 - d. Operation: Able to operate both forward and in reverse.
 - e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
 - f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
 - g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.
- 16. Fan Motor:
 - a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
 - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
 - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
 - d. Service Factor: 1.15.
 - e. Insulation: Class F **OR** Class H, **as directed**.



- f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
- g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
- h. Severe-duty rating with the following features:
 - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
 - 3) Internal heater automatically energized when motor is de-energized.
- i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
- 17. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
 - a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
 - b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
- 18. Vibration Switch: For each fan drive.
 - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
 - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
 - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
- 19. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
 - a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
- 20. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".
OR
 Control Package: Factory installed and wired, and functionally tested at factory before shipment.
 - a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
 - b. Control-circuit transformer with primary and secondary side fuses.
 - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
 - d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
 - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
 - f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
 - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
 - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
 - i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
 - j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
 - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.



- 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 - k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
 - l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
 - m. Audible alarm and silence switch.
 - n. Visual indication of elapsed run time, graduated in hours for each motor.
 - o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
 - 1) Operational status of each motor.
 - 2) Position of dampers.
 - 3) Cooling tower leaving-fluid temperature.
 - 4) Fan vibration alarm.
 - 5) Oil-level alarm.
 - 6) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
21. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
 - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
 - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
 - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
 - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
 - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
 - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.
- F. Open-Circuit, Induced-Draft, Crossflow Cooling Towers
1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
 2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa), **as directed**.
 3. Casing and Frame:
 - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
 - d. Joints and Seams: Sealed watertight.
 - e. Welded Connections: Continuous and watertight.
 4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
OR
Collection Basin:
 - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
 - c. Overflow and drain connections.



- d. Makeup water connection.
 - e. Outlet Connection: ASME B16.5, Class 150 flange.
 - f. Removable equalization flume plate between adjacent cells of multiple-cell towers.
 - g. Equalizer connection for field-installed equalizer piping.
 - h. Basin Sweeper Distribution Piping and Nozzles:
 - 1) Pipe Material: PVC, **as directed**.
 - 2) Nozzle Material: Plastic, **as directed**.
 - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
- OR**
- Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
- a. Enclosures: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
 - c. Electrode Probes: Stainless steel.
 - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
 - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
 - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
- OR**
- Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
 - c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
 - d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
 - e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
- a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
 - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
 - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
 - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
 - e. Control-circuit transformer with primary and secondary side fuses.
 - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
 - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
 - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
- OR**
- Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

**OR**

Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

7. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.
 - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
 - b. Location: Over each bank of fill with easily replaceable plastic, **as directed**, spray nozzles mounted in bottom of basin.
 - c. Inlet Connection: ASME B16.5, Class 150 flange.
 - d. Joints and Seams: Sealed watertight.
 - e. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
 - f. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable corrosion-resistant **OR** stainless-steel, **as directed**, hardware.
 - g. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity distribution basin.
 - h. Single-Inlet, Field Pipe Connection: Galvanized-steel **OR** PVC, **as directed**, pipe arranged to provide balancing of flow within cooling tower cell without the need for additional balancing valves. Pipe each cooling tower cell internally to a single, field connection suitable for mating to ASME B16.5, Class 150 flange and located on the bottom **OR** side, **as directed**, unless otherwise indicated.
8. Fill:
 - a. Materials: PVC, with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
 - b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
 - c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
 - d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
9. Drift Eliminator:
 - a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
 - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
 - d. Location: Integral to **OR** Separate and removable from, **as directed**, fill.
10. Air-Intake Louvers:
 - a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
 - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 - c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
 - d. Location: Integral to **OR** Separate from, **as directed**, fill.
11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**,-steel wire mesh.
12. Axial Fan: Balanced at the factory after assembly.
 - a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
 - b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
 - c. Blade Pitch: Field adjustable.
 - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
 - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus



- 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
- f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
13. Belt Drive:
- a. Service Factor: 1.5 based on motor nameplate horsepower.
- b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
- c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
OR
Belt: One-piece, multigrooved, solid-back belt.
- d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
- e. Belt-Drive Guard: Comply with OSHA regulations.
- f. Two-Motor, Single-Fan Drive:
- 1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
 - 2) Each motor with belt drive and configured for operation when other motor fails.
 - 3) Controls and wiring same as two-speed, two-winding motor.
14. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
- a. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
- b. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
- c. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
- d. Operation: Able to operate both forward and in reverse.
- e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
- f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
- g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.
15. Fan Motor:
- a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
- b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
- c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
- d. Service Factor: 1.15.
- e. Insulation: Class F **OR** Class H, **as directed**.
- f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
- g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
- h. Severe-duty rating with the following features:
- 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
 - 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).



- 3) Internal heater automatically energized when motor is de-energized.
- i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
- 16. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
 - a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
 - b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
- 17. Vibration Switch: For each fan drive.
 - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
 - b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
 - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
 - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
- 18. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
 - a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
- 19. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
- 20. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".

OR

Control Package: Factory installed and wired, and functionally tested at factory before shipment.

- a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
- b. Control-circuit transformer with primary and secondary side fuses.
- c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
- d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
- e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
- f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
- g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
- h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
- i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
- j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
 - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
 - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
- k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
- l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
- m. Audible alarm and silence switch.
- n. Visual indication of elapsed run time, graduated in hours for each motor.



- o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
 - 1) Operational status of each motor.
 - 2) Position of dampers.
 - 3) Cooling tower leaving-fluid temperature.
 - 4) Fan vibration alarm.
 - 5) Oil-level alarm.
 - 6) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
- 21. Personnel Access Components:
 - a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
 - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
 - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
 - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
 - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
 - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
 - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

G. Source Quality Control

- 1. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."
- 2. Factory pressure test heat exchangers after fabrication and prove to be free of leaks.

1.3 EXECUTION

A. Examination

- 1. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting tower performance, maintenance, and operation.
 - a. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- 2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

- 1. Install cooling towers on support structure indicated.
- 2. Equipment Mounting: Install cooling tower on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
 - b. Provide galvanized **OR** stainless, **as directed**, -steel plate to equally distribute weight over elastomeric pad.



- c. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
- d. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
- e. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Equipment Mounting: Install cooling tower using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
 - b. Provide galvanized **OR** stainless, **as directed**, -steel plate to equally distribute weight over elastomeric pad.
4. Equipment Mounting: Install cooling tower on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Maintain manufacturer's recommended clearances for service and maintenance.
7. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

C. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to cooling towers to allow service and maintenance.
3. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.
4. Provide drain piping with valve at cooling tower drain connections and at low points in piping.
5. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.
6. Domestic Water Piping: Comply with applicable requirements in Division 22 Section "Domestic Water Piping". Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.
7. Supply and Return Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a union **OR** flange **OR** mechanical coupling, **as directed**.
8. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.
9. Hot-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Connect to supply and return basin heater with shutoff valve, strainer, control valve, and union or flange on supply connection and union or flange and balancing valve on return connection. Provide supply and return piping with pressure gage and thermometer.
10. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam And Condensate Heating Piping". Connect steam supply to basin heater with shutoff valve, strainer, control valve, and union or flange and condensate piping with union or flange, shutoff valve, strainer, and an appropriate steam trap.

D. Field Quality Control



1. Perform tests and inspections.
2. Tests and Inspections: Comply with ASME PTC 23, "ASME Performance Test Codes - Code on Atmospheric Water Cooling Equipment **OR** CTI ATC 105, "Acceptance Test Code for Water Cooling Towers", **as directed**.
3. Cooling towers will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

E. Startup Service

1. Perform startup service.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
3. Obtain performance data from manufacturer.
 - a. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1) Clean entire unit including basins.
 - 2) Verify that accessories are properly installed.
 - 3) Verify clearances for airflow and for cooling tower servicing.
 - 4) Check for vibration isolation and structural support.
 - 5) Lubricate bearings.
 - 6) Verify fan rotation for correct direction and for vibration or binding and correct problems.
 - 7) Adjust belts to proper alignment and tension.
 - 8) Verify proper oil level in gear-drive housing. Fill with oil to proper level.
 - 9) Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
 - 10) Check vibration switch setting. Verify operation.
 - 11) Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.
 - 12) Verify operation of basin heater and control.
 - 13) Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
 - 14) Replace defective and malfunctioning units.
4. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
5. Prepare a written startup report that records the results of tests and inspections.

F. Adjusting

1. Set and balance water flow to each tower inlet.
2. Adjust water-level control for proper operating level.

G. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 23 65 00 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 65 00 00	01 22 16 00	No Specification Required
23 71 13 23	22 05 23 00	Piped Utilities Basic Materials And Methods
23 71 13 23	22 12 23 26a	Facility Fuel-Oil Piping
23 71 13 23	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping



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SECTION 23 72 13 00 - AIR-TO-AIR ENERGY RECOVERY UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for air-to-air energy recovery equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Heat wheels.
 - b. Heat-pipe heat exchangers.
 - c. Fixed-plate sensible heat exchangers.
 - d. Fixed-plate total heat exchangers.
 - e. Packaged energy recovery units.

C. Performance Requirements

1. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of air-to-air energy recovery equipment.
 - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - c. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - a. Suspended ceiling components.



- b. Structural members to which equipment or suspension systems will be attached.
- 6. Seismic Qualification Certificates: For air-to-air energy recovery equipment, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 7. Field quality-control reports.
- 8. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

E. Quality Assurance

- 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2. ARI Compliance:
 - a. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
 - b. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."
- 3. ASHRAE Compliance:
 - a. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
 - b. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
- 4. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.
- 5. UL Compliance:
 - a. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
 - b. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

F. Coordination

- 1. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- 2. Coordinate sizes and locations of concrete bases with actual equipment provided.
- 3. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

G. Warranty

- 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Packaged Energy Recovery Units: Two years.
 - b. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

1.2 PRODUCTS

A. Heat Wheels

- 1. Casing:
 - a. Steel with standard factory-painted finish.



- b. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
- c. Casing seals on periphery of rotor and on duct divider and purge section.
- d. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearing.
2. Rotor: Aluminum segmented wheel strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating, **as directed**.
- a. Maximum Solid Size for Media to Pass: 500 **OR** 800 **OR** 1200, **as directed**, micrometer.
3. Rotor: Glass-fiber **OR** Polymer, **as directed**, segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
- a. Maximum Solid Size for Media to Pass: 800 **OR** 1200, **as directed**, micrometer.
4. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller, **as directed**, and self-adjusting multilink belt around outside of rotor.
- a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
5. Controls:
 - a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - b. Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.

OR

Variable frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.

OR

Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and, **as directed**, air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.
 - c. Pilot-Light Indicator: Display rotor rotation and speed.
 - d. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
6. Disposable Panel Filters:
 - a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, viscous-coated, flat-panel type.
 - d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - e. Minimum Arrestance: 80, according to ASHRAE 52.1.
 - f. Minimum Merv: 5, according to ASHRAE 52.2.
 - g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
 - h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
7. Extended-Surface, Disposable Panel Filters:
 - a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, dry, extended-surface type.
 - d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
 - e. Minimum Arrestance: 90, according to ASHRAE 52.1.
 - f. Minimum Merv: 7, according to ASHRAE 52.2.



- g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
 - h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
 - i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
8. Extended-Surface, Nonsupported-Media Filters:
- a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, dry, extended-surface, self-supporting type.
 - d. Minimum Arrestance: 95, according to ASHRAE 52.1.
 - e. Minimum Merv: 13, according to ASHRAE 52.2.
 - f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed**.
 - g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
 - h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
- B. Heat-Pipe Heat Exchangers
- 1. Casing: Galvanized-steel flanged casing, with airtight partition between airstreams.
 - 2. Refrigerant: ASHRAE 15, Group 1..
 - 3. Tubes: 5/8-inch- (16-mm-) **OR** 1-inch- (25-mm-), **as directed**, diameter, aluminum **OR** copper, **as directed**.
 - 4. Fins: Aluminum **OR** Integral aluminum **OR** Copper, **as directed**.
 - a. Fin Spacing: 0.125 inch (3.18 mm) **OR** 0.091 inch (2.31 mm) **OR** 0.071 inch (1.80 mm) **OR** 0.067 inch (1.70 mm) **OR** 0.056 inch (1.42 mm) **OR** 0.0075 inch (0.19 mm), **as directed**.
 - b. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
 - 5. Coating: Thermoplastic vinyl **OR** Epoxy **OR** Synthetic resin **OR** Phenolic **OR** Polytetrafluoroethylene **OR** Vinyl ester, **as directed**; apply to supply and exhaust.
 - 6. Control: Integral plenum containing heat-pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.

OR

Control: Pivot center of bottom of heat-pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester fabric with PVC-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.
- C. Fixed-Plate Sensible Heat Exchangers
- 1. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 2. Casing: Aluminum **OR** Galvanized steel **OR** Enameled steel, with galvanized-steel liner **OR** Enameled steel, **as directed**, with duct collars.
 - 3. Casing Insulation: 1/2-inch- (13-mm-) thick, foil-faced glass fiber **OR** 1-inch- (25-mm-) thick, foil-faced glass fiber **OR** 1 inch (25 mm) thick, ASTM C 1071 with coated surface **OR** 1 inch (25 mm) thick, fiber free, **as directed**.
 - 4. Drain Pan: Same material as casing, with drain connections on exhaust and supply side **OR** Molded ABS covering bottom of case, with drain connections on exhaust and supply side, **as directed**.
 - a. Comply with requirements in ASHRAE 62.1.
 - 5. Plates: Evenly spaced and sealed and arranged for counter airflow.
 - a. Plate Material: Embossed aluminum **OR** Stainless steel **OR** Polypropylene copolymer (high-density plastic), **as directed**.
 - b. Plate Coating: Epoxy **OR** Air-dried phenolic, **as directed**.



6. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
 7. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock, with detergent injection, **as directed**.
 8. Disposable Panel Filters:
 - a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, viscous-coated, flat-panel type.
 - d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - e. Minimum Arrestance: 80, according to ASHRAE 52.1.
 - f. Minimum Merv: 5, according to ASHRAE 52.2.
 - g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
 - h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
 9. Extended-Surface, Disposable Panel Filters:
 - a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, dry, extended-surface type.
 - d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
 - e. Minimum Arrestance: 90, according to ASHRAE 52.1.
 - f. Minimum Merv: 7, according to ASHRAE 52.2.
 - g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
 - h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
 - i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
 10. Extended-Surface, Nonsupported-Media Filters:
 - a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, dry, extended-surface, self-supporting type.
 - d. Minimum Arrestance: 95, according to ASHRAE 52.1.
 - e. Minimum Merv: 13, according to ASHRAE 52.2.
 - f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed**.
 - g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
 - h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
- D. Fixed-Plate Total Heat Exchangers
1. Casing: Galvanized steel.
 2. Plates: Evenly spaced and sealed and arranged for counter airflow.
 - a. Plate Material: Chemically treated paper with selective hydroscopicity and moisture permeability, and gas barrier properties.
 3. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
 4. Disposable Panel Filters:
 - a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.



- c. Factory-fabricated, viscous-coated, flat-panel type.
 - d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - e. Minimum Arrestance: 80, according to ASHRAE 52.1.
 - f. Minimum Merv: 5, according to ASHRAE 52.2.
 - g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
 - h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
5. Extended-Surface, Disposable Panel Filters:
- a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, dry, extended-surface type.
 - d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
 - e. Minimum Arrestance: 90, according to ASHRAE 52.1.
 - f. Minimum Merv: 7, according to ASHRAE 52.2.
 - g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
 - h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
 - i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

E. Packaged Energy Recovery Units

1. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed and calked weathertight, **as directed**, hinged access doors **OR** removable panels, **as directed**, with neoprene gaskets for inspection and access to internal parts, minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
 - a. Inlet: Weatherproof hood **OR** louver, **as directed**, with damper for exhaust and supply.
 - 1) Exhaust: Gravity backdraft damper **OR** Spring-return, two-position, motor-operated damper, **as directed**.
 - 2) Supply: Gravity backdraft damper **OR** Spring-return, two-position, motor-operated damper, **as directed**.
 - b. Roof Curb: Refer to Division 07 Section "Roof Accessories" for roof curbs and equipment supports.
3. Heat Recovery Device: Heat wheel **OR** Heat-pipe heat exchanger **OR** Fixed-plate heat exchanger, **as directed**.
4. Supply and Exhaust Fans: Forward-curved, centrifugal **OR** Propeller **OR** Backward-inclined, SWSI centrifugal **OR** Backward-inclined, plenum centrifugal, **as directed**, fan with spring isolators **OR** restrained, spring isolators **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, and insulated, **as directed**, flexible duct connections.
 - a. Motor and Drive: Direct driven **OR** Belt driven with adjustable sheaves, motor mounted on adjustable base **OR** Drive type indicated on Drawings, **as directed**.
 - b. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - c. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
 - e. Spring isolators on each fan having 1-inch (25-mm) static deflection.
5. Disposable Panel Filters:
 - a. Comply with NFPA 90A.



- b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, viscous-coated, flat-panel type.
 - d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - e. Minimum Arrestance: 80, according to ASHRAE 52.1.
 - f. Minimum Merv: 5, according to ASHRAE 52.2.
 - g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
 - h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
6. Extended-Surface, Disposable Panel Filters:
- a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, dry, extended-surface type.
 - d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
 - e. Minimum Arrestance: 90, according to ASHRAE 52.1.
 - f. Minimum Merv: 7, according to ASHRAE 52.2.
 - g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
 - h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
 - i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
7. Extended-Surface, Nonsupported-Media Filters:
- a. Comply with NFPA 90A.
 - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - c. Factory-fabricated, dry, extended-surface, self-supporting type.
 - d. Minimum Arrestance: 95, according to ASHRAE 52.1.
 - e. Minimum Merv: 13, according to ASHRAE 52.2.
 - f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed**.
 - g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
 - h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
8. Cooling Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed**.
- a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
 - b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed**.
 - c. Tubes: Copper.
 - d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed**.
 - e. Fins: Aluminum **OR** Copper, **as directed**.
 - f. Fin and Tube Joint: Mechanical bond.
 - g. Leak Test: Coils shall be leak tested with air under water.
 - h. Refrigerant Coils:
 - 1) Capacity Reduction: Circuit coils for face **OR** row **OR** interleaved, **as directed**, control.
 - 2) Suction and Distributor: Seamless copper tube with brazed joints.
 - i. Coating: Phenolic epoxy corrosion-protection coating after assembly.
9. Cooling-Coil Condensate Drain Pans:



- a. Fabricated from galvanized steel **OR** stainless-steel, **as directed**, sheet and sloped in multiple planes to collect and drain condensate from cooling coils, coil piping connections, coil headers, and return bends.
 - b. Complying with requirements in ASHRAE 62.1.
 - c. Drain Connections: At low point of pan with minimum **<Insert size>** threaded nipple.
 - d. Units with stacked coils shall have an intermediate drain pan to collect and drain condensate from top coil.
10. Hot-Water Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed**.
- a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
 - b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed**.
 - c. Tubes: Copper.
 - d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed**.
 - e. Fins: Aluminum **OR** Copper, **as directed**.
 - f. Fin and Tube Joint: Mechanical bond.
 - g. Leak Test: Coils shall be leak tested with air under water.
 - h. Coating: Phenolic epoxy corrosion-protection coating after assembly.
11. Nonfreeze Type, **as directed**, Steam Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed**.
- a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
 - b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed**.
 - c. Tubes: Copper.
 - d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed**.
 - e. Fins: Aluminum **OR** Copper, **as directed**.
 - f. Fin and Tube Joint: Mechanical bond.
 - g. Leak Test: Coils shall be leak tested with air under water.
 - h. Coating: Phenolic epoxy corrosion-protection coating after assembly.
12. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
- a. Casing Assembly: Slip-in **OR** Flanged, **as directed**, type with galvanized-steel frame.
 - b. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
 - c. Sheathed Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
OR
Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - d. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - e. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - f. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection.
 - 1) Magnetic **OR** Mercury, **as directed**, contactor.
 - 2) Solid-state, stepless pulse controller.
 - 3) Toggle switches, one per step.
 - 4) Step controller.
 - 5) Time-delay relay.



- 6) Pilot lights, one per step.
 - 7) Airflow proving switch.
13. Indirect-Fired Gas Furnaces:
- a. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
 - 1) AGA Approval: Furnace shall bear label of AGA.
 - b. Burners: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
 - 1) Ignition: Electronically controlled electric spark with flame sensor.
 - 2) High-Altitude Model **OR** Kit, **as directed**: For Project at elevations more than 2000 feet (610 m) above sea level.
 - c. Heat-Exchanger Drain Pan: Stainless steel.
 - d. Venting: Gravity vented.
OR
Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
 - e. Gas Control Valve: Single stage **OR** Two stage **OR** Electronic modulating, **as directed**.
 - f. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff. Control devices and control sequence shall comply with requirements of FMG **OR** IRI, **as directed**.
 - g. Access: Fabricate section to allow removal and replacement of furnace and to allow in-place access for service.
14. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.
- a. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
 - b. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
 - c. Include fused **OR** nonfused, **as directed**, disconnect switches.
 - d. Variable-speed controller to vary fan capacity from 100 to approximately 50 percent.
15. Accessories:
- a. Roof Curb: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**, with gasketing, and factory-installed wood nailer; complying with NRCA standards; minimum height of 14 inches (350 mm) **OR** 24 inches (600 mm), **as directed**.
 - b. Intake weather hood with 2-inch- (50-mm-) thick filters.
 - c. Louvered intake weather hood with 2-inch- (50-mm-) thick filters in V-bank configuration.
 - d. Exhaust weather hood with birdscreen.
 - e. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade **OR** parallel-blade, **as directed**, arrangement with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).
OR
Isolation Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame with operating rods connected with a common linkage, and electric damper operator factory wired. Blades shall have gaskets and edge seals, and shall be mechanically fastened to operating rod.
 - f. Duct flanges.
 - g. Rubber-in-shear isolators for ceiling-mounted units.
 - h. Hinged access doors with quarter-turn latches.
 - i. Drain pans for condensate removal complying with ASHRAE 62.1, **as directed**.



- j. Automatic, in-place, spray-wash system.
- k. Weatherproofing for tilt-control system.

F. Controls

1. Time Clock: Solid-state, programmable, microprocessor-based unit for wall mounting **OR** mounting in outdoor NEMA 250, Type 3R enclosure, **as directed**, with up to eight on/off cycles per day and battery backup protection of program settings against power failure to energize unit.
2. Motion (Occupancy) Sensor: Passive infrared sensor for wall **OR** ceiling, **as directed**, mounting with adjustable time-off delay of up to 30 minutes to energize unit.
3. Carbon Monoxide Sensor: Adjustable control from 600 to 2000 ppm for wall **OR** duct, **as directed**, mounting with digital display and computer/building management system interface to energize unit.
4. Humidistat: Adjustable, wall-mounted instrument to energize unit when space relative humidity exceeds 50 percent.
5. Chilled-Water-Cooling-Coils Controls:
 - a. For chilled-water cooling coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
 - b. For chilled-water cooling coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
6. Refrigerant-Cooling-Coils Controls:
 - a. For refrigerant cooling coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to control remote condensing unit to maintain temperature.
 - b. For refrigerant cooling coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, controls remote condensing unit to maintain temperature.
 - c. Cooling Capacity Control: On/off **OR** Multiple steps, **as directed**.
7. Hot-Water- and Steam-Coils Controls:
 - a. For hot-water or steam coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
 - b. For hot-water or steam coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
8. Electric-Coils Controls:
 - a. For electric coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to control electric coil to maintain temperature.
 - b. For electric coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to control electric coil to maintain temperature.
 - c. Coil Controls: On/off **OR** Multiple steps **OR** Modulating SCR, **as directed**.
9. Indirect-Fired-Gas-Furnaces Controls:
 - a. For indirect-fired gas furnaces with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct,



as directed, with sensor adjustment located in control panel to control gas furnace burner to maintain temperature.

- b. For indirect-fired gas furnaces with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to control gas furnace burner to maintain temperature.
- c. Burner Controls: On/off **OR** Multiple steps **OR** Modulating, **as directed**.

1.3 EXECUTION

A. Examination

- 1. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- 2. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- 3. Examine roughing-in for electrical services to verify actual locations of connections before installation.
- 4. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

- 1. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
 - a. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
 - b. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
 - c. Access doors and panels are specified in Division 23 Section "Air Duct Accessories".
- 2. Install heat-pipe heat exchangers so supply and exhaust airstreams flow in opposite directions. Install flexible connectors on ducts to enable tilt control; make connections airtight and with slack to compensate for full tilt.
 - a. Install heat exchanger with clearance space for heat-pipe coil removal.
 - b. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to both sides of heat-pipe coil. Access doors and panels are specified in Division 23 Section "Air Duct Accessories".
 - c. Install tilt-control components, including electronic controller, electric actuator and linkage, thermostats, and sensors.
- 3. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.
 - a. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Division 23 Section "Air Duct Accessories".
- 4. Install gas-fired furnaces according to NFPA 54, "National Fuel Gas Code."
- 5. Install floor-mounted units on 4-inch- (100-mm-) high concrete base designed to withstand, without damage to equipment, seismic force required by code, **as directed**.
- 6. Equipment Mounting (for equipment supported on a concrete base on grade without vibration isolation devices): Install air-to-air energy recovery equipment on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- 7. Roof Curb: Install on roof structure or concrete base, level and secure, according to The NRCA "Roofing and Waterproofing Manual - Volume 4: Construction Details - Low-Slope Roofing,"



Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install air-to-air energy recovery equipment on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Accessories". Secure air-to-air energy recovery equipment to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

8. Unit Support: Install unit level on structural curbs **OR** pilings, **as directed**. Coordinate wall penetrations and flashing with wall construction. Secure air-to-air energy recovery equipment to structural support with anchor bolts.
9. Install wind and seismic restraints according to manufacturers' written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
10. Suspended Units: Suspend and brace, **as directed**, units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
11. Install units with clearances for service and maintenance.
12. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
13. Pipe drains from units and drain pans to nearest floor drain; use ASTM B 88, Type L (ASTM B 88M, Type B), drawn-temper copper water tubing with soldered joints **OR** ASTM D 1785, Schedule 40 PVC pipe and solvent-welded fittings, **as directed**, same size as condensate drain connection.
 - a. Requirements for Low-Emitting Materials:
 - 1) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Connections

1. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to unit to allow service and maintenance.
3. Connect piping to units mounted on vibration isolators with flexible connectors.
4. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.
5. Chilled and Hot Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
6. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam And Condensate Heating Piping". Install shutoff valve at steam coil connections, float and thermostatic trap, and union or flange at each coil return connection.
7. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping".
8. Gas Piping: Comply with requirements in Division 23 Section(s) "Facility Natural-gas Piping" **OR** "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make connection with AGA-approved flexible connectors.
9. Comply with requirements for ductwork specified in Division 23 Section "Metal Ducts".
10. Indirect-Fired Furnace Vent Connections: Comply with Division 23 Section "Breechings, Chimneys, And Stacks".
11. Electrical Connections: Comply with applicable requirements in Division 22.
 - a. Install electrical devices furnished with units but not factory mounted.

D. Field Quality Control

1. Perform tests and inspections.



2. Tests and Inspections:
 - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Adjust seals and purge.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - d. Set initial temperature and humidity set points.
 - e. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 3. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.
- E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 23 72 13 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 72 16 00	23 72 13 00	Air-To-Air Energy Recovery Units



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**SECTION 23 73 13 00 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for modular indoor central-station air-handling units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Constant-air-volume, single-zone air-handling units.
 - b. Constant-air-volume, multizone air-handling units.
 - c. Constant-air-volume, dual-duct air-handling units.
 - d. Variable-air-volume, single-zone air-handling units.
 - e. Variable-air-volume, dual-duct air-handling units.

C. Performance Requirements

1. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of $L/200$ **OR** $L/100$, **as directed**, where "L" is the unsupported span length within completed casings.
3. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals

1. Product Data: For each air-handling unit indicated.
 - a. Unit dimensions and weight.
 - b. Cabinet material, metal thickness, finishes, insulation, and accessories.
 - c. Fans:
 - 1) Certified fan-performance curves with system operating conditions indicated.
 - 2) Certified fan-sound power ratings.
 - 3) Fan construction and accessories.
 - 4) Motor ratings, electrical characteristics, and motor accessories.
 - d. Certified coil-performance ratings with system operating conditions indicated.
 - e. Dampers, including housings, linkages, and operators.
 - f. Filters with performance characteristics.
2. LEED Submittal:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Delegated-Design Submittal: For vibration isolation and seismic restraints, **as directed**, indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.



4. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
3. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
4. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
5. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
6. Comply with NFPA 70.

1.2 PRODUCTS

A. Unit Casings

1. General Fabrication Requirements for Casings:
 - a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 - b. Casing Joints: Sheet metal screws or pop rivets.
 - c. Sealing: Seal all joints with water-resistant sealant.
 - d. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
OR
 Factory Finish for Steel and Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.
OR
 Casing Coating: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
 - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Casing Insulation and Adhesive:
 - a. Materials: ASTM C 1071, Type I **OR** Type II, **as directed**.
 - b. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the cooling-coil section.
 - 1) Liner Adhesive: Comply with ASTM C 916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.



- 3) Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service-air velocity.
OR
Location and Application: Encased between outside and inside casing.
3. Inspection and Access Panels and Access Doors:
 - a. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
 - b. Inspection and Access Panels:
 - 1) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
 - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 3) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
 - c. Access Doors:
 - 1) Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 3) Fabricate windows in fan section doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
 - 4) Size: At least 18 inches (450 mm) **OR** 24 inches (600 mm), **as directed**, wide by full height of unit casing up to a maximum height of 60 inches (1500 mm) **OR** 72 inches (1800 mm), **as directed**.
 - d. Locations and Applications:
 - 1) Fan Section: Inspection and access panels **OR** Doors **OR** Doors and inspection and access panels, **as directed**.
 - 2) Access Section: Doors.
 - 3) Coil Section: Inspection and access panel.
 - 4) Damper Section: Inspection and access panels **OR** Doors, **as directed**.
 - 5) Filter Section: Inspection and access panels **OR** Doors, **as directed**, large enough to allow periodic removal and installation of filters.
 - 6) Mixing Section: Doors.
 - 7) Humidifier Section: Doors.
 - e. Service Light: 100-W vaporproof fixture with switched junction box located outside **OR** inside, **as directed**, adjacent to door.
 - 1) Locations: Each section accessed with door **OR** Fan section, **as directed**.
4. Condensate Drain Pans:
 - a. Fabricated with one **OR** two, **as directed**, percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
 - 2) Depth: A minimum of 2 inches (50 mm) deep.
 - b. Formed sections **OR** Integral part of floor plating, **as directed**.
 - c. Single-wall, galvanized-steel **OR** stainless-steel, **as directed**, sheet.
OR
Double-wall, galvanized-steel **OR** stainless-steel, **as directed**, sheet with space between walls filled with foam insulation and moisture-tight seal.
 - d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end **OR** both ends, **as directed**, of pan.
 - 1) Minimum Connection Size: NPS 1 (DN 25) **OR** NPS 2 (DN 50), **as directed**.
 - e. Pan-Top Surface Coating: Asphaltic waterproofing compound, for galvanized-steel drain pans.



- f. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
5. Service Platform: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**, 42 inches (1070 mm) wide running entire length of unit and located on service access side, with angle side rails, 4-inch (100-mm) kick plates, and expanded metal floor. Provide platform with a fixed ladder that extends from the top of the side rail to the floor.
 6. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
 - a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when air-handling unit frame is anchored to building structure.
- B. Fan, Drive, And Motor Section
1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 - a. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 - 2) Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
 2. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - b. Horizontal-Flanged, Split Housing: Bolted construction.
 - c. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
 - d. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) **OR** 5-3/4 inches (146 mm), **as directed**, wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized-steel sheet or 0.032-inch- (0.8-mm-) thick aluminum sheets; select metal compatible with casing.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
 - a) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 - b) Fabric Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 - c) Fabric Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
 3. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.
 4. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

OR

Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

OR

Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

OR



- Axial Fans: Fan wheel and housing, straightening-vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
- a. Variable-Pitch Fans: Internally mounted pneumatic **OR** electric **OR** electronic, **as directed**, actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.
 - b. Housings: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**.
 - 1) Inlet and Outlet Connections: Flanges.
 - 2) Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
5. Fan Shaft Bearings:
- a. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of 50,000 **OR** 120,000, **as directed**, hours according to ABMA 9.
OR
Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and 2-piece, cast-iron housing with grease lines extended to outside unit, **as directed**, and a rated life of 50,000 **OR** 120,000, **as directed**, hours according to ABMA 11.
OR
Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit, **as directed**.
6. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**, service factor based on fan motor.
- a. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - b. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - c. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
 - d. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.
7. Variable-Inlet Vanes: Steel, with blades supported at both ends with permanently lubricated bearings. Variable mechanism terminating in single lever for connection to control actuator with connecting shaft for second set of variable inlet vanes on double-width fans.
OR
Discharge Dampers: Heavy-duty steel assembly with channel frame and sealed ball bearings, and opposed **OR** parallel, **as directed**, blades constructed of two plates formed around and welded to shaft, with blades linked out of air stream to single control lever.
8. Internal Vibration Isolation and Seismic Control, **as directed**: Fans shall be factory mounted with manufacturer's standard restrained, **as directed**, vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
- a. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.
9. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Enclosure Type: Totally enclosed, fan cooled.
 - b. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - c. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.



- d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 21.
 - e. Mount unit-mounted disconnect switches on exterior **OR** interior, **as directed**, of unit.
10. Variable Frequency Controllers:
- a. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
 - b. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range **OR** 66 Hz, with torque constant as speed changes **OR** 120 Hz, with horsepower constant throughout speed range, **as directed**.
 - c. Unit Operating Requirements:
 - 1) Input ac voltage tolerance of 208 V, plus or minus 5 **OR** 380 to 500 V, plus or minus 10 **OR** 525 to 575 V, plus or minus 10, **as directed**, percent.
 - 2) Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
 - 3) Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 4) Minimum Displacement Primary-Side Power Factor: 96 percent.
 - 5) Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
 - 6) Starting Torque: 100 percent of rated torque or as indicated.
 - 7) Speed Regulation: Plus or minus 1 percent.
 - d. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
 - e. Internal Adjustability Capabilities:
 - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3) Acceleration: 2 to a minimum of 22 seconds.
 - 4) Deceleration: 2 to a minimum of 22 seconds.
 - 5) Current Limit: 50 to a minimum of 110 percent of maximum rating.
 - f. Self-Protection and Reliability Features:
 - 1) Input transient protection by means of surge suppressors.
 - 2) Undervoltage and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 - 3) Adjustable motor overload relays capable of NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, performance.
 - 4) Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 - 5) Instantaneous line-to-line and line-to-ground overcurrent trips.
 - 6) Loss-of-phase protection.
 - 7) Reverse-phase protection.
 - 8) Short-circuit protection.
 - 9) Motor overtemperature fault.
 - g. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
 - h. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
 - i. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
 - j. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
 - k. Door-mounted LED status lights shall indicate the following conditions:
 - 1) Power on.



- 2) Run.
 - 3) Overvoltage.
 - 4) Line fault.
 - 5) Overcurrent.
 - 6) External fault.
- i. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual-speed-control potentiometer and elapsed time meter.
- m. Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
- 1) Output frequency (Hertz).
 - 2) Motor speed (rpm).
 - 3) Motor status (running, stop, fault).
 - 4) Motor current (amperes).
 - 5) Motor torque (percent).
 - 6) Fault or alarming status (code).
 - 7) Proportional-integral-derivative (PID) feedback signal (percent).
 - 8) DC-link voltage (volts direct current).
 - 9) Set-point frequency (Hertz).
 - 10) Motor output voltage (volts).
- n. Control Signal Interface:
- 1) Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
 - 2) Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:
 - a) 0 to 10-V dc.
 - b) 0-20 or 4-20 mA.
 - c) Potentiometer using up/down digital inputs.
 - d) Fixed frequencies using digital inputs.
 - e) RS485.
 - f) Keypad display for local hand operation.
 - 3) Output signal interface with a minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - a) Output frequency (Hertz).
 - b) Output current (load).
 - c) DC-link voltage (volts direct current).
 - d) Motor torque (percent).
 - e) Motor speed (rpm).
 - f) Set-point frequency (Hertz).
 - 4) Remote indication interface with a minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a) Motor running.
 - b) Set-point speed reached.
 - c) Fault and warning indication (overtemperature or overcurrent).
 - d) High- or low-speed limits reached.
- o. Communications: RS485 interface allows VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- p. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker **OR** NEMA AB 1, molded-case switch **OR** NEMA KS 1, nonfusible switch **OR** NEMA KS 1, fusible switch, **as directed**, with lockable handle.
- q. Accessories:
- 1) Devices shall be factory installed in controller enclosure unless otherwise indicated.
 - 2) Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - 3) Standard Displays:



- a) Output frequency (Hertz).
- b) Set-point frequency (Hertz).
- c) Motor current (amperes).
- d) DC-link voltage (volts direct current).
- e) Motor torque (percent).
- f) Motor speed (rpm).
- g) Motor output voltage (volts).

C. Coil Section

1. General Requirements for Coil Section:

- a. Comply with ARI 410.
- b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- c. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
- d. Coils shall not act as structural component of unit.
- e. Seismic Fabrication Requirements: Fabricate coil section, internal mounting frame and attachment to coils, and other coil section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when coil-mounting frame and air-handling-unit mounting frame are anchored to building structure.

2. Electrical Heating Coils, Controls, and Accessories: Comply with UL 1995.

- a. Casing Assembly: Slip-in **OR** Flanged, **as directed**, type with galvanized-steel frame.
- b. Sheathed Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.

OR

Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.

- c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
- d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- e. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection.
 - 1) Magnetic **OR** Mercury, **as directed**, contactor.
 - 2) Solid-state, stepless pulse controller.
 - 3) Toggle switches, one per step.
 - 4) Step controller.
 - 5) Time-delay relay.
 - 6) Pilot lights, one per step.
 - 7) Airflow proving switch.

D. Air Filtration Section

1. General Requirements for Air Filtration Section:

- a. Comply with NFPA 90A.
- b. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
- c. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

2. Disposable Panel Filters:

- a. Factory-fabricated, viscous-coated, flat-panel type.
- b. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
- c. Dust-Holding Capacity: as directed by the Owner.



- d. Initial Resistance: as directed by the Owner.
 - e. Recommended Final Resistance: as directed by the Owner.
 - f. Arrestance (ASHRAE 52.1): 80.
 - g. Merv (ASHRAE 52.2): 5.
 - h. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
 - i. Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
3. Extended-Surface, Disposable Panel Filters:
- a. Factory-fabricated, dry, extended-surface type.
 - b. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
 - c. Dust-Holding Capacity: as directed by the Owner.
 - d. Initial Resistance: as directed by the Owner.
 - e. Recommended Final Resistance: as directed by the Owner.
 - f. Arrestance (ASHRAE 52.1): 90.
 - g. Merv (ASHRAE 52.2): 7.
 - h. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
 - i. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
 - j. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks.
4. Extended-Surface, Nonsupported-Media Filters:
- a. Factory-fabricated, dry, extended-surface, self-supporting type.
 - b. Dust-Holding Capacity: as directed by the Owner.
 - c. Initial Resistance: as directed by the Owner.
 - d. Recommended Final Resistance: as directed by the Owner.
 - e. Arrestance (ASHRAE 52.1): 95.
 - f. Merv (ASHRAE 52.2): 13.
 - g. Media: Fibrous material with antimicrobial agent, **as directed**, constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions.
 - h. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
 - i. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
5. Automatic Roll Filters:
- a. Factory-fabricated, automatic, motor-driven, roll type.
 - b. Arrangement: Horizontal **OR** Vertical, **as directed**.
 - c. Dust-Holding Capacity: as directed by the Owner.
 - d. Initial Resistance: as directed by the Owner.
 - e. Recommended Final Resistance: as directed by the Owner.
 - f. Arrestance (ASHRAE 52.1): 80.
 - g. Merv (ASHRAE 52.2): 5.
 - h. Media: Compressed and rolled, fibrous-glass material viscous coated, and with antimicrobial agent, **as directed**.
 - i. Holding Frame: Galvanized steel, with enclosed, clean media roll arranged to allow upstream replacement of filter media.
 - j. Auxiliary Frame: Locate on downstream side of unit with downstream **OR** side, **as directed**, access.
 - k. Final Filter: Extended-surface, retained-media **OR** nonsupported-media **OR** HEPA, **as directed**, filters.
 - l. Control and Drive:
 - 1) Mechanism: Electric, gear-reducer, motor-driven, feed control equipped with manual media advance and runout switches for stopping media movement of filter bank and operating remote warning signal lights.



- 2) Manual Control: Manual switch to advance media and wired to override automatic controls.
 - 3) Automatic Control: Prewired control package to advance media when filter resistance exceeds adjustable high limit **OR** after adjustable operating time, **as directed**.
6. Activated-Carbon Panel Filters:
 - a. Factory-fabricated unit with activated-carbon media.
 - b. Flat-Panel Media: Multilayer filter with inlet layer of polyester fibers, layer of activated-carbon granules bonded to fibers, layer of polyurethane foam, and housed in cardboard frame.
 - c. Pleated Media: Multilayer filter with inlet layer of cotton and synthetic fibers and layer of activated-carbon granules bonded to synthetic fibers, formed into deep-V-shaped pleats and held by self-wire grid, and housed in nonflammable cardboard frame.
 - d. Mounting Frames: Welded galvanized steel, with polyurethane gaskets and fasteners, capable of holding media and media frame in place and suitable for bolting together into built-up filter banks.
 7. Activated-Carbon Filters:
 - a. Factory-fabricated unit in deep-V arrangement with disposable panel prefilter.
 - b. Media: Activated carbon mounted in removable carbon-cell trays of epoxy-coated steel.
 - c. Activated-Carbon Capacity: 12 lb (5.4 kg) of activated carbon per 500 cfm (236 L/s) **OR** 8.8 lb (4.0 kg) of activated carbon per 2000 cfm (944 L/s), **as directed**, of airflow.
 - d. Housing: 0.064-inch- (1.6-mm-) thick, galvanized steel, for side servicing through gasketed access doors on both sides. Equip housings with metal slide channel tracks to hold activated-carbon trays.
 8. HEPA Filters:
 - a. Factory-fabricated unit.
 - b. Dust-Holding Capacity: as directed by the Owner.
 - c. Initial Resistance: as directed by the Owner.
 - d. Recommended Final Resistance: as directed by the Owner.
 - e. Arrestance (ASHRAE 52.1): 95 percent on 0.3-micrometer D.O.P. particles **OR** 99.97 percent on 0.3-micrometer D.O.P. particles **OR** 99.9995 percent on 0.1- and 0.2-micrometer D.O.P. particles **OR** 99.99995 percent on 0.1- and 0.2-micrometer D.O.P. particles, **as directed**.
 - f. Media: UL 586, fibrous glass, constructed of continuous sheets with closely spaced pleats with aluminum separators **OR** vinyl-coated aluminum separators **OR** separators of ribbons of filter media, **as directed**.
 - g. Frame Material: 3/4-inch- (19-mm-) thick, fire-retardant plywood **OR** 3/4-inch- (19-mm-) thick, fire-retardant particleboard **OR** 3/4-inch- (19-mm-) thick plywood **OR** 3/4-inch- (19-mm-) thick particleboard **OR** Galvanized steel **OR** Aluminized steel **OR** Cadmium-plated steel **OR** Stainless steel **OR** Aluminum, **as directed**.
 - h. Media to Frame Side Bond: Polyurethane foam **OR** Silicone **OR** Neoprene adhesive **OR** Fiberglass-mat packing **OR** Thermosetting sealant **OR** Knife edge in fluid-filled channel, **as directed**.
 - i. Face Gasket: Neoprene expanded rubber **OR** Ceramic fiber **OR** Silicone, **as directed**.
 - j. Mounting Frames: Downstream corners of holding device shall have cushion pads to protect media. Bolted filter-sealing mechanism shall mount and continuously seal each individual filter.
 9. Filter Gage:
 - a. 3-1/2-inch- (90-mm-) **OR** 2-inch- (50-mm-), **as directed**, diameter, diaphragm-actuated dial in metal case.
 - b. Vent valves.
 - c. Black figures on white background.
 - d. Front recalibration adjustment.
 - e. 2 **OR** 3, **as directed**, percent of full-scale accuracy.



- f. Range: 0- to 0.5-inch wg (0 to 125 Pa) **OR** 0- to 1.0-inch wg (0 to 250 Pa) **OR** 0- to 2.0-inch wg (0 to 500 Pa) **OR** 0- to 3.0-inch wg (0 to 750 Pa) **OR** 0- to 4.0-inch wg (0 to 1000 Pa), **as directed**.
- g. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch (6-mm) aluminum **OR** plastic, **as directed**, tubing, and 2- or 3-way vent valves.

E. Dampers

- 1. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm (10-m/s) face velocity through damper and 4-inch wg (1000-Pa) pressure differential.
- 2. Damper Operators: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".

OR

Electronic Damper Operators:

- a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
- b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Work Results For Hvac".
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
- d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
- e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
- f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - 2) Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - 3) Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
 - 4) Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
- g. Coupling: V-bolt and V-shaped, toothed cradle.
- h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
- i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
- j. Power Requirements (Two-Position Spring Return): 24 **OR** 120 **OR** 230, **as directed**, -V ac.
- k. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
- l. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
- m. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) **OR** 40 to 104 deg F (5 to 40 deg C), **as directed**.



- n. Run Time: 12 seconds open, 5 seconds closed **OR** 30 seconds **OR** 60 seconds **OR** 120 seconds, **as directed**.
- OR**
- Pneumatic Damper Operators:
- a. Rolling-diaphragm piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Where actuators operate in sequence, provide pilot positioners.
 - b. Pneumatic Damper Position Indicator: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.
 - c. Pilot Positioners:
 - 1) Start Point: Adjustable from 2 to 12 psig (14 to 83 kPa).
 - 2) Operating Span: Adjustable from 5 to 13 psig (35 to 90 kPa).
 - 3) Linearity: Plus or minus 10 percent of output signal span.
 - 4) Hysteresis: 3 percent of span.
 - 5) Response: 0.25-psig (1723-Pa) input change.
 - 6) Maximum Pilot Signal Pressure: 20 psig (140 kPa).
 - 7) Maximum Control Air-Supply Pressure: 60 psig (410 kPa).
 - d. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 deg F (10 to 60 deg C) unless located in return-air plenums, **as directed**.
 - e. Inlet-Vane Operators: High pressure, with pilot positioners.
3. Zone Dampers: Two single-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers offset 90 degrees from each other on cadmium-plated, **as directed**, steel operating rod rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
 4. Face-and-Bypass Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with cadmium-plated, **as directed**, steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
 5. Outdoor- and Return-Air Mixing Dampers: Parallel-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers mechanically fastened to cadmium-plated, **as directed**, steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
 6. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade **OR** parallel-blade, **as directed**, arrangement with cadmium-plated, **as directed**, steel operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).
 7. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.
 8. Combination Filter and Mixing Section:
 - a. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat, permanent or throwaway filters.
 - b. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

F. Humidifiers

1. Steam Grid Humidifier:
 - a. Manifold:



- 1) ASTM A 666, Type 304 stainless steel.
- 2) Steam jacketed.
- 3) Insulated with 1/2-inch (13-mm) fiberglass and stainless-steel jacket.
- 4) Manifold shall extend the full width of unit with mounting brackets at ends.
- b. Steam Separator: Cast iron, **OR** ASTM A 666, Type 304 stainless steel, **as directed**, with separate, **as directed**, humidifier control valve.
- c. Humidifier Control Valve: Actuator: Pneumatic **OR** Electric, **as directed**, modulating with spring return.
OR
Humidifier Control Valve: Actuator: As specified in Division 23 Section "Instrumentation And Control For Hvac".
- d. Steam Trap: Inverted-bucket type, sized for a minimum of three times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) inlet pressure.
- e. Aquastat: For separate mounting on steam condensate, return piping to prevent cold operation of humidifier.
- f. Strainer: In-line type.
- g. Airflow Switch: To prevent humidifier operation in the absence of airflow.
2. Wet Glass Cell Washer Section:
 - a. 3-inch- (75-mm-) deep cells with random packed, glass-fiber media in galvanized-steel **OR** stainless-steel, **as directed**, frames.
 - b. Access Door: Watertight with brass fittings, wire glass window, **as directed**, and locking handles.
 - c. Spray Tree Assembly: Brass **OR** Stainless-steel, **as directed**, nozzles and galvanized-steel **OR** stainless-steel, **as directed**, piping.
 - d. Eliminator: Galvanized-steel **OR** Stainless-steel, **as directed**, plates.
 - e. Tank:
 - 1) Welded steel **OR** stainless steel, **as directed**, with interior and exterior surfaces blasted and painted with zinc-chromate paint, **as directed**.
 - 2) Copper suction screen.
 - 3) Drain, overflow, and suction connections.
 - 4) Makeup connection with brass, **as directed**, float valve, and with quick-fill connection.
 - f. Insulate exterior with duct insulation and mount on 2-inch (-50-mm-) thick, rigid insulation board.
3. Evaporative Humidifier Section:
 - a. Access Door: Watertight cast iron, **as directed**, with brass fittings, wire glass window, and locking handles.
 - b. Spray Tree Assembly: Brass nozzles and galvanized piping, galvanized eliminator plates with flooding nozzles and header, and galvanized antisplash baffles **OR** cross-fluted cellulose media, **as directed**.
 - c. Tank:
 - 1) Welded steel tank with interior and exterior surfaces blasted and painted with zinc-chromate paint.
 - 2) Copper suction screen, drain, overflow, and suction connections.
 - 3) Makeup connection with brass, **as directed**, float valve, and with quick-fill connection.
 - d. Insulation: Insulate with duct insulation on exterior and mount on 2-inch (-50-mm-) thick, rigid insulation board.

G. Air-To-Air Energy Recovery

1. Heat Wheels:
 - a. Casing:
 - 1) Steel, with manufacturer's standard paint coating.
 - 2) Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.



- 3) Casing seals on periphery of rotor, on duct divider, and on purge section.
- 4) Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.
- b. Rotor: Aluminum, segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating, **as directed**. Construct media for passing maximum 500 **OR** 800 **OR** 1200, **as directed**, -micrometer solids.

OR

 Rotor: Glass-fiber **OR** Polymer, **as directed**, segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating. Construct media for passing maximum 800 **OR** 1200, **as directed**, -micrometer solids.
- c. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller, **as directed**, and self-adjusting multilink belt around outside of rotor.
- d. Controls:
 - 1) Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - 2) Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.

OR

 Variable frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.

OR

 Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing, **as directed**, and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
 - 3) Pilot-Light Indicator: Display rotor rotation and speed.
 - 4) Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
2. Fixed-Plate Sensible Heat Exchangers:
 - a. Casing: Aluminum **OR** Galvanized steel **OR** Enameled steel, with galvanized-steel liner **OR** Enameled steel, **as directed**.
 - b. Plates: Evenly spaced and sealed and arranged for counter airflow.
 - c. Plate Material: Embossed aluminum **OR** Stainless steel **OR** Polypropylene copolymer (high-density plastic), **as directed**.
 - 1) Plate Coating: Epoxy **OR** Air-dried phenolic, **as directed**.
 - d. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.
 - e. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock, with detergent injection, **as directed**.
 - f. Heat-Exchanger Prefilters: 1 inch (25 mm) thick, disposable **OR** 2 inches (50 mm) thick, disposable **OR** Medium efficiency **OR** Electrostatic, **as directed**.
- H. Source Quality Control
 1. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
 2. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."
 3. Water Coils: Factory tested to 300 psig (2070 kPa) according to ARI 410 and ASHRAE 33.
 4. Steam Coils: Factory tested to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater according to ARI 410 and ASHRAE 33.
 5. Refrigerant Coils: Factory tested to 450 psig (3105 kPa) according to ARI 410 and ASHRAE 33.



1.3 EXECUTION

A. Installation

1. Equipment Mounting: Install air-handling units on concrete bases using elastomeric pads **OR** using elastomeric mounts **OR** using restrained spring isolators **OR** without vibration isolation devices, **as directed**. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
 - b. Install galvanized-steel **OR** stainless-steel, **as directed**, plate to equally distribute weight over elastomeric pad.
 - c. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - d. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - e. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - f. Install anchor bolts to elevations required for proper attachment to supported equipment.

OR

- Equipment Mounting: Install air-handling unit using elastomeric pads **OR** using elastomeric mounts **OR** using restrained spring isolators **OR** without vibration isolation devices, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- g. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
 - h. Install galvanized-steel **OR** stainless-steel, **as directed**, plate to equally distribute weight over elastomeric pad.
2. Suspended Units: Suspend and brace, **as directed**, units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 3. Arrange installation of units to provide access space around air-handling units for service and maintenance.
 4. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
 5. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

B. Connections

1. Comply with requirements for piping specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to air-handling unit to allow service and maintenance.
3. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
4. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B 88, Type M (ASTM B 88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
5. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
6. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam And Condensate Heating Piping". Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and



inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.

7. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping". Install shutoff valve and union or flange at each supply and return connection.
8. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories".

C. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
 - b. Charge refrigerant coils with refrigerant and test for leaks.
 - c. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - d. Automatic-Roll-Filter Operational Test: Operate filters to demonstrate compliance with requirements. Test for leakage of unfiltered air while system is operating.
 - e. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
 - f. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME N510, pressure-decay method.
 - g. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
4. Prepare test and inspection reports.

D. Startup Service

1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Verify that shipping, blocking, and bracing are removed.
 - c. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - d. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - e. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 - f. Verify that zone dampers fully open and close for each zone.
 - g. Verify that face-and-bypass dampers provide full face flow.
 - h. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 - i. Comb coil fins for parallel orientation.
 - j. Verify that proper thermal-overload protection is installed for electric coils.
 - k. Install new, clean filters.
 - l. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
2. Starting procedures for air-handling units include the following:
 - a. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions, **as directed**.
 - b. Measure and record motor electrical values for voltage and amperage.



- c. Manually operate dampers from fully closed to fully open position and record fan performance.

- E. Adjusting
 - 1. Adjust damper linkages for proper damper operation.
 - 2. Comply with requirements in Division 23 Section "Testing, Adjusting, And Balancing For Hvac" for air-handling system testing, adjusting, and balancing.

- F. Cleaning
 - 1. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

- G. Demonstration
 - 1. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 13 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 73 13 00	07 72 23 00	Roof Accessories



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SECTION 23 74 13 00 - ROOFTOP REPLACEMENT AIR UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for rooftop replacement-air units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes cooling-only and cooling and heating rooftop replacement-air units.

C. Definitions

1. DDC: Direct-digital controls.

D. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. Shop Drawings: Include details of installation and wiring diagrams.
3. Coordination Drawings: Rooftop replacement-air units to roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - a. Size and location of rooftop replacement-air unit mounting rails and anchor points and methods for anchoring units to roof curb.
 - b. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.
4. Startup service reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.
7. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Final Completion.
 - b. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five **OR** 10, **as directed**, years from date of Final Completion.



1.2 PRODUCTS

A. Cabinet

1. Construction: Single **OR** Double, **as directed**, wall.
2. Exterior Casing: Galvanized steel with baked-enamel paint finish and **OR** Stainless steel, **as directed**, with lifting lugs and knockouts for electrical and piping connections.
3. Interior Casing: Galvanized-steel **OR** Stainless steel, **as directed**.
4. Base Rails: Galvanized-steel **OR** Stainless-steel, **as directed**, rails for mounting on roof curb.
5. Service Doors: Hinged access doors with neoprene gaskets.
6. Internal Insulation: Fibrous-glass duct lining complying with ASTM C 1071, Type II.
 - a. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Insulation Adhesive: Comply with ASTM C 916, Type I.
 - c. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.
7. Condensate Drain Pans: Formed sections of galvanized-steel **OR** stainless-steel, **as directed**, sheet designed for self-drainage. Fabricate pans and drain connection to comply with ASHRAE 62.1.
8. Roof Curb: Full-perimeter curb of sheet metal, minimum 8 inches (200 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm), **as directed**, high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
9. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Supply-Air Fan

1. Fan: Forward-curved centrifugal; statically and dynamically balanced, galvanized **OR** coated, **as directed**, steel, mounted on solid-steel shaft with self-aligning, permanently lubricated ball bearings **OR** pillow-block bearings rated L₅₀ for 200,000 hours and having external grease fittings, **as directed**.
2. Motor: Open dripproof **OR** Totally enclosed, **as directed**, single-speed **OR** two-speed, **as directed**, motor.
3. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly with minimum 1.4 service factor.
4. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, **as directed**, elastomeric **OR** spring, **as directed**, isolators.

C. Refrigeration System

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
2. Compressors: Reciprocating **OR** Scroll, **as directed**, compressors with integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heater, **as directed**.
3. Minimum Efficiency: As defined by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
4. Refrigerant: R-407C **OR** R-410A, **as directed**.
5. Refrigeration System Specialties:
 - a. Expansion valve with replaceable thermostatic element.
 - b. Refrigerant dryer.
 - c. High-pressure switch.
 - d. Low-pressure switch.
 - e. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
 - f. Brass service valves installed in discharge and liquid lines.
 - g. Operating charge of refrigerant.



6. Capacity Control: Hot-gas bypass refrigerant control for capacity control with continuous dehumidification on a single compressor.
OR
Capacity Control: Patented, Rawal APR control with zero to 100 percent modulating capacity control using hot-gas bypass. Evaporator coil shall be continuously active for dehumidification.
OR
Capacity Control: Single compressor with evaporator and condenser coil within the refrigerant section to provide initial precooling and reheat for humidity control.
OR
Capacity Control: Heat-pipe heat exchanger shall wrap around the evaporator coil to precool the air entering the evaporator coil, and reheat the air leaving the evaporator coil to control humidity.
 7. Refrigerant Coils: Evaporator and condenser **OR** Evaporator, condenser, and reheat condenser, **as directed**, coils shall be designed, tested, fabricated, and rated according to ARI 410 and ASHRAE 33. Coils shall be leak tested under water with air at 315 psig (2170 kPa).
 - a. Capacity Reduction: Circuit coils for face **OR** row **OR** interleaved, **as directed**, control.
 - b. Tubes: Copper.
 - c. Fins: Aluminum **OR** Copper, **as directed**, with minimum fin spacing of 0.071 inch (1.81 mm), **as directed**.
 - d. Fin and Tube Joint: Mechanical bond.
 - e. Suction and Distributor: Seamless copper tube with brazed joints.
 - f. Coating: Phenolic epoxy corrosion-protection coating on both coils.
 - g. Source Quality Control: Test to 450 psig (3105 kPa), and to 300 psig (2070 kPa) underwater.
 8. Condenser Fan: Propeller type, directly driven by motor.
 9. Safety Controls:
 - a. Compressor motor and outside-coil fan motor low ambient lockout.
 - b. Overcurrent protection for compressor motor and outside-coil fan motors.
- D. Direct-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code"; ANSI Z83.4, "Non-Recirculating Direct Gas-Fired Industrial Air Heaters"; and ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters," for direct-fired gas furnace.
 2. Burners: Cast-iron burner with stainless-steel mixing plates.
 - a. Rated for a maximum turndown ratio of 30:1.
 - b. Fuel: Natural **OR** Propane, **as directed**, gas.
 3. Safety Controls:
 - a. Gas manifold safety switches and controls shall comply with ANSI standards and FMG **OR** and IRI, **as directed**.
 - b. Pilot: Intermittent spark igniter.
 - c. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
 - d. External gas-pressure regulator shall regulate pressure to not more than 0.5 psig (3.4 kPa).
 - e. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
 - f. Manual-Reset, High-Limit Switch: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - g. Gas Train: Redundant, main gas valves, electric pilot valve, main and pilot gas-pressure regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas-pressure switches **OR** to comply with FMG requirements **OR** to comply with IRI requirements, **as directed**.
- E. Indirect-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
 - a. AGA Approval: Designed and certified by and bearing label of AGA.



2. Burners: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
 - a. Minimum AFUE: **<Insert value>** percent.
OR
 Minimum Thermal Efficiency: **<Insert value>** percent.
OR
 Minimum Combustion Efficiency: **<Insert value>** percent.
 - b. Fuel: Natural **OR** Propane, **as directed**, gas.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. High-Altitude Model **OR** Kit, **as directed**: For Project elevations more than 2000 feet (610 m) above sea level.
 3. Heat-Exchanger Drain Pan: Stainless steel.
 4. Venting: Gravity vented.
OR
 Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
 5. Safety Controls:
 - a. Gas Control Valve: Single stage **OR** Two stage **OR** Electronic modulating, **as directed**.
 - b. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
- F. Electric-Resistance Heating
1. Electric-Resistance Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
OR
 Electric-Resistance Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - a. Heating Capacity: Low density 35 W per sq. in. (54 kW per sq. m), factory wired for single-point wiring connection; with time delay for element staging, and overcurrent and overheat protective devices.
 - b. Safety Controls:
 - 1) Blower-motor interlock, air-pressure switch.
 - 2) Quiet mercury contactors.
 - 3) Time delay between steps.
 - 4) Integral, nonfused power disconnect switch.
- G. Heating Coils
1. Hot-Water Coils: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**, coil fabricated and tested according to ARI 410 with aluminum fins and seamless copper tube in galvanized-steel **OR** stainless-steel, **as directed**, casing.
 - a. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
 - b. Control valves are specified in Division 23 Section "Instrumentation And Control For Hvac".
 2. Steam Coils: Distributing coil fabricated and tested according to ARI 410, with threaded steam supply and condensate connections. Nonfreeze type having aluminum-plate fin and seamless copper double tube in galvanized-steel casing, pitched for proper drainage; tested to 150 psig (1035 kPa) and leak tested to 100 psig (690 kPa) with air under water.
 - a. Control valves are specified in Division 23 Section "Instrumentation And Control For Hvac".
- H. Cooling Coils
1. Chilled-Water Coils: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**, coil fabricated and tested according to ARI 410 with aluminum fins and seamless copper tube in galvanized-steel **OR** stainless-steel, **as directed**, casing.



- a. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
 - b. Control valves are specified in Division 23 Section "Instrumentation And Control For Hvac".
- I. Outdoor-Air Intake And Dampers
1. Dampers: Leakage rate, according to AMCA 500, shall not exceed 2 percent of air quantity at face velocity of 2000 fpm (10 m/s) through damper and pressure differential of 4-inch wg (1000 Pa).
 2. Damper Operators: Electric.
 3. Mixing Boxes: Parallel-blade, galvanized-steel dampers mechanically fastened to steel operating rod inside cabinet. Connect operating rods with common interconnecting linkages so dampers operate simultaneously.
 4. Outdoor-Air Intake Hoods: Galvanized-steel **OR** Stainless steel, **as directed**, with bird screen complying with ASHRAE 62.1 and finish to match cabinet.
- J. Filters
1. Comply with NFPA 90A.
 2. Cleanable Filters: 2-inch- (50-mm-) thick, cleanable metal mesh.
OR
Disposable Panel Filters: 2-inch- (50-mm-) thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1, **as directed**.
 - a. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
 - b. Frame: Galvanized steel.
- K. Controls
1. Factory-wire connection for controls' power supply.
 2. Control devices, including sensors, transmitters, relays, switches, thermostats, humidistats, detectors, operators, actuators, and valves, shall be manufacturer's standard items to accomplish indicated control functions.
 3. Unit Controls: Solid-state control board and components with field-adjustable control parameters.
 4. Supply-Fan Control: Units shall be electrically interlocked with corresponding exhaust fans, to operate continuously when exhaust fans are running. Time clock shall switch operation from occupied to unoccupied. Night setback thermostat shall cycle fan during unoccupied periods to maintain space temperature.
 - a. Timer: Seven-day electronic clock.
 - b. Electrically interlock kitchen hood fire-extinguishing system to de-energize replacement-air unit when fire-extinguishing system discharges.
 5. Remote **OR** Unit, **as directed**,-Mounted Status Panel:
 - a. Cooling/Off/Heating Controls: Control operational mode.
 - b. Damper Position: Indicates position of outdoor-air dampers in terms of percentage of outdoor air.
 - c. Status Lights:
 - 1) Filter dirty.
 - 2) Fan operating.
 - 3) Cooling operating.
 - 4) Heating operating.
 6. Refrigeration System Controls:
 - a. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb (65 kJ/kg) of dry air or outdoor-air temperature is less than 60 deg F (15 deg C).
 - b. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than 60 deg F (15 deg C).
 - c. Wall-mounting, relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 60 percent.



7. Heating Controls:
 - a. Factory-mounted sensor in supply-fan outlet **OR** Remote-mounting sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel modulates gas furnace burner to maintain space temperature.
 - b. Wall-mounting, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, that modulates gas furnace burner to maintain space temperature.
 - c. Remote Setback Thermostat: Adjustable room thermostat selected by timer, set at 50 deg F (10 deg C); cycles supply fan and gas furnace burner to maintain space temperature.
 - d. Staged Burner Control: Two **OR** Four, **as directed**, steps of control.
OR
Electromechanical or Electronic Burner Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual furnace units.
 8. Electric-Resistance Heating Controls: Wall-mounting thermostat controls SCR **OR** sequences stages, **as directed**.
 9. Damper Controls:
 - a. Wall-mounting pressure sensor modulates outdoor- and return-air dampers to maintain a positive pressure in space served by rooftop replacement-air unit at minimum 0.05-inch wg (12.4 Pa).
 - b. When exhaust fans stop, set outdoor- and return-air damper to 75 **OR** 50 **OR** 25, **as directed**, percent outdoor air. When exhaust fans start, close return-air damper and fully open outdoor-air damper.
 10. Integral Smoke Alarm: Smoke detector installed in supply and return air.
 11. DDC Temperature Control: Stand-alone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac". Links shall include the following:
 - a. Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition.
 - b. Hardware interface or additional sensors for the following:
 - 1) Room temperature.
 - 2) Discharge air temperature.
 - 3) Refrigeration system operating.
 - 4) Furnace operating.
- L. Motors
1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

1.3 EXECUTION

A. Installation

1. Install roof curb on roof structure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install and secure rooftop replacement-air units on curbs and coordinate roof penetrations and flashing with roof construction.
OR
Install restrained vibration isolation roof-curb rails on roof structure according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install and secure rooftop replacement-air units on rails and coordinate roof penetrations and flashing with roof construction. Restrainted isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".



2. Install wall- and duct-mounting sensors, thermostats, and humidistats furnished by manufacturers for field installation. Install control wiring and make final connections to control devices and unit control panel.
3. Install 3000-psi (20.7-MPa), compressive strength (28-day) concrete base inside roof curb, 4 inches (100 mm) thick. Concrete and reinforcement are specified in Division 31.

B. Connections

1. Piping installation requirements are specified in other Division 21-. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
 - a. Gas Burner Connections: Comply with requirements in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping to burner, full size of gas train inlet, and connect with union, pressure regulator, **as directed**, and shutoff valve with sufficient clearance for burner removal and service.
 - b. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
 - c. Steam Coil Connections: Comply with requirements in Division 23 Section "Steam And Condensate Heating Piping". Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.
3. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to rooftop replacement-air units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".
4. Electrical Connections: Comply with requirements in Division 22 for power wiring, switches, and motor controls.
5. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".

C. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
2. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for visible damage to furnace combustion chamber.
 - b. Inspect for visible damage to compressor, air-cooled outside coil, and fans.
 - c. Inspect casing insulation for integrity, moisture content, and adhesion.
 - d. Verify that clearances have been provided for servicing.
 - e. Verify that controls are connected and operable.
 - f. Verify that filters are installed.
 - g. Clean outside coil and inspect for construction debris.
 - h. Clean furnace flue and inspect for construction debris.
 - i. Inspect operation of power vents.
 - j. Purge gas line.
 - k. Inspect and adjust vibration isolators and seismic restraints.
 - l. Verify bearing lubrication.
 - m. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - n. Adjust fan belts to proper alignment and tension.
 - o. Start unit.
 - p. Start refrigeration system when outdoor-air temperature is within normal operating limits.
 - q. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
 - r. Operate unit for run-in period.
 - s. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:



- 1) Measure gas pressure at manifold.
 - 2) Measure combustion-air temperature at inlet to combustion chamber.
 - 3) Measure flue-gas temperature at furnace discharge.
 - 4) Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - 5) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
- t. Calibrate thermostats.
- u. Adjust and inspect high-temperature limits.
- v. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers, **as directed**.
- w. Start refrigeration system and measure and record the following:
- 1) Coil leaving-air, dry- and wet-bulb temperatures.
 - 2) Coil entering-air, dry- and wet-bulb temperatures.
 - 3) Outdoor-air, dry-bulb temperature.
 - 4) Outdoor-air-coil, discharge-air, dry-bulb temperature.
- x. Verify operational sequence of controls.
- y. Measure and record the following airflows. Plot fan volumes on fan curve.
- 1) Supply-air volume.
 - 2) Return-air volume.
 - 3) Outdoor-air intake volume.
- z. Simulate maximum cooling demand and inspect the following:
- 1) Compressor refrigerant suction and hot-gas pressures.
 - 2) Short circuiting of air through outside coil or from outside coil to outdoor-air intake.
- aa. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
- 1) High-limit heat exchanger.
 - 2) Alarms.
3. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
 4. Remove and replace components that do not pass tests and inspections and retest as specified above.
 5. Prepare written report of the results of startup services.
- D. Adjusting
1. Adjust initial temperature and humidity set points.
 2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.
- E. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop replacement-air units.

END OF SECTION 23 74 13 00



SECTION 23 74 13 00a - SELF-CONTAINED AIR-CONDITIONERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for self-contained air-conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged air **OR** water-cooled air-conditioning units, **as directed**, with refrigerant compressors and controls, intended for indoor installations.

C. Submittals

1. Product Data: For each unit indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
4. Samples for Initial Selection: For units with factory-applied color finishes.
5. Operation and Maintenance Data: For self-contained air conditioners to include in emergency, operation, and maintenance manuals.
6. Warranty: Sample of special warranty.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency and marked for intended locations and application.
2. ARI Compliance:
 - a. Applicable requirements in ARI 210/240.
 - b. Applicable requirements in ARI 340/360.
 - c. Applicable requirements in ARI 390.
3. ASHRAE Compliance:
 - a. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 - b. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of self-contained air conditioners that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period:
 - 1) For Compressor: One **OR** Five year(s), **as directed**, from date of Final Completion.
 - 2) For Parts: One **OR** Five year(s), **as directed**, from date of Final Completion.
 - 3) For Labor: One **OR** Five year(s), **as directed**, from date of Final Completion.



1.2 PRODUCTS

A. Packaged Units

1. Description: Factory-assembled, wired, and tested, and fully charged with refrigerant and oil.
2. Configuration: Horizontal, ceiling-plenum mounted.
3. Configuration: Vertical, floor mounted; vertical and horizontal discharge.
4. Configuration: Horizontal, ceiling mounted and vertical, floor mounted; vertical and horizontal discharge.
5. Disconnect Switch: Factory mounted in control panel **OR** on equipment, **as directed**.

B. Cabinet

1. Frame and Panels: Structural-steel frame with galvanized-steel panels and access doors or panels.
 - a. Exterior-Surface Finish: Factory painted in color selected by Architect.
 - b. Interior-Surface Finish: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Insulation: Minimum 1-inch- (25-mm-), thick, glass-fiber duct liner complying with ASTM C 1091 and having a microbial coating on cabinet interior and control panel. 1/2-inch- (13-mm-) thick liner is acceptable for units smaller than 15 tons (50 kW).
3. Return-Air Opening: Rear, open **OR** flange for duct connection, **as directed**.
4. Corrosion-Resistant Treatment: Phenolic coating on unit interior and exterior.

C. Supply-Air Fan

1. Fan Material: Galvanized steel.
2. Configuration: Double-width, double-inlet, forward-curved **OR** airfoil, **as directed**, centrifugal fan; statically and dynamically balanced. Vertical **OR** Horizontal discharge, **as directed**, with flexible discharge collar.
3. Drive: Belt, with fan mounted on permanently lubricated bearings **OR** Direct, with fan and motor resiliently mounted, **as directed**.
4. Fan Sheaves: Variable pitch, dynamically balanced, bored to fit shafts and keyed for initial startup.
5. Motor Sheave: Variable and adjustable pitch dynamically balanced, and selected to achieve specified rpm when set at midposition.
6. Belt Rating: As recommended by the manufacturer or a minimum of one and one-half times nameplate rating of motor.
7. Bearings: Grease lubricated with grease lines extended to exterior of unit with L-50 life at 200,000 hours.
8. Variable Air Volume: Variable-frequency motor controller with bypass.
9. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Special Motor Features: Premium efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment".
10. Isolation: Mount fan and motor on common subbase and mount assembly on spring isolators with minimum static deflection of **1 inch (25 mm)**.
11. Outdoor-Air-Intake Accessories:
 - a. Barometric Outdoor-Air Damper: Adjustable-blade damper allowing induction of up to 25 percent outdoor air when evaporator fan is running.
 - b. Motorized Outdoor-Air Damper: Motorized, two-position blade damper allowing induction of up to 25 percent outdoor air; with spring-return, low-voltage damper motor.
 - c. Energy-Recovery Ventilator: Assembly of desiccant-coated, heat-recovery wheels and centrifugal exhaust fans to transfer approximately 67 percent of the difference between the sensible and latent heat of outdoor and exhaust air.



- d. Air-Side Economizer: Damper assembly allowing induction of up to 100 percent outdoor air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.
- D. Refrigeration System
- 1. Compressor: Scroll type, hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.
 - 2. Refrigerant Coils (Indoor and Outdoor for Air-Cooled Units): Seamless copper tubes expanded into aluminum fins.
 - a. Corrosion-Resistant Treatment: Phenolic coating applied with multiple dips and baked.
 - b. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve with adjustable superheat, filter dryer, sight glass, high-pressure relief valve, and charging valves.
 - c. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
 - d. Refrigerant: R-407C or R-410A.
 - e. Expansion valve with replaceable thermostatic element.
 - f. Refrigerant dryer.
 - g. High-pressure switch.
 - h. Low-pressure switch.
 - i. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
 - j. Low ambient temperature switch.
 - k. Brass service valves installed in discharge and liquid lines.
 - 3. Water-Cooled Condenser:
 - a. Description: Factory assembled and tested; tube in tube coaxial type with water-regulating valve.
 - b. Tubing: Nonferrous **OR** Copper **OR** Cupro-nickel, **as directed**, inner tube; steel with corrosion-resistant coating; refrigerant and water-side leak tested to 400 psig (2760 kPa) underwater.
 - 4. Water-Side Economizer Section:
 - a. Description: Factory assembled and tested; consisting of water coil, modulating valves, controls, piping with cleanouts, and access panels.
 - b. Water Coil: Two **OR** Four rows, **as directed**, copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and copper **OR** cast-iron, **as directed** headers; leak tested to 300 psig (2070 kPa) underwater; and having a two-position control valve.
- E. Heating Coil
- 1. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a two-position control valve.
 - 2. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow-proving device; and one-time fuses in terminal box for overcurrent protection.
- F. Controls
- 1. Control Package: Factory wired, including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay.
 - 2. Time-Delay Relay: Five-minute delay to prevent compressor cycling.
 - 3. Adjustable Thermostat: Unit mounted **OR** Remote, **as directed**, to control the following:
 - a. Supply fan.
 - b. Compressor.
 - c. Condenser.



- d. Hot-water coil valve.
 - e. Electric heater.
 4. System Selector Switch: Heat-off-cool **OR** Off-heat-auto-cool, **as directed**.
 5. Fan Control Switch: Auto-on.
 6. Time Clock, **as directed**: Cycle unit on and off.
 7. Microprocessor Control Panel: Controls unit functions, including refrigeration and safety controls, and the following:
 - a. Supply fan.
 - b. Supply-fan motor speed.
 - c. Compressors.
 - d. Air-cooled condenser.
 - e. Cooling tower pump.
 - f. Modulating, hot-water coil valve.
 - g. Multistep, electric heater.
 - h. Time-of-day control to cycle unit on and off.
 - i. Night-heat, morning warm-up cycle.
 - j. Economizer control.
 - k. Panel-mounted control switch to operate unit in remote or local control mode, or to stop or reset.
 - l. Panel-mounted indication of the following:
 - 1) Operating status.
 - 2) System diagnostics and safety alarms.
 - 3) Supply-air temperature set point.
 - 4) Zone heating-temperature set point.
 - 5) Supply-air pressure set point.
 - 6) Economizer minimum position set point.
 - 7) Supply-air-pressure, high-limit set point.
 - 8) Monitor constant and variable motor loads.
 - 9) Monitor variable-frequency drive operation.
 - 10) Monitor economizer cycle.
 - 11) Monitor cooling load.
 - 12) Monitor air distribution static pressure and ventilation air volumes.
- G. Evaporator Coil
1. Direct-Expansion Coil: Seamless copper tubes expanded into aluminum fins.
 - a. Corrosion-Resistant Treatment, **as directed**: Phenolic coating applied with multiple dips and baked.
 2. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve with adjustable superheat, **as directed**, filter-dryer, sight glass, high-pressure relief valve, **as directed**, and charging valves.
- H. Remote Air-Cooled Condenser
1. Description: Factory assembled and tested; consisting of condenser coil, fans and motors, and operating controls; suitable for roof mounting.
 - a. Condenser Coil: Aluminum-fin copper tube with integral subcooler; leak tested to 450 psig (3110 kPa).
 - b. Condenser Fans: Direct-drive propeller type.
 - c. Fan Motors: Three-phase, permanently lubricated, ball-bearing motors with built-in thermal-overload protection. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - d. Refrigerant Line Kits: Annealed-copper suction and liquid lines that are factory cleaned, dried, pressurized, and sealed; insulated suction line; flared fittings at evaporator end, no fitting at condenser end; and service valves for both suction and liquid lines.
 - e. Terminate suction and liquid refrigerant piping with service valves within unit.
 - f. Low Ambient Control: Cycles fans to permit operation down to 45 deg F (7 deg C).



OR

Low Ambient Control: Cycles fans and modulates condenser fan damper assembly to permit operation down to 0 deg F (minus 18 deg C).

- g. Coil Guard: Painted galvanized steel with louvered grilles.
- h. Corrosion-Resistant Treatment: Phenolic coating applied in multiple dips and baked.

I. Integral Air-Cooled Condenser For Units 15 Tons (50 kW) And Smaller

- 1. Description: Factory assembled and tested; consisting of condenser coil, fans and motors, and cabinet.
 - a. Condenser Coil: Aluminum-fin copper tube with integral subcooler; leak tested to 425 psig (2930 kPa).
 - b. Condenser Fan: Direct-drive propeller type with permanently lubricated motor with built-in thermal-overload protection.
 - c. Low Ambient Control: Cycles fans to permit operation down to 0 deg F (minus 18 deg C).

J. Air Filters

- 1. Permanent Filters: 1-inch- (25-mm-) thick, cleanable panel filters.

OR

Disposable Filters: 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, glass-fiber, flat **OR** pleated, **as directed**, panel filters.

OR

Extended-Surface, Disposable Panel Filters: 2-inch- (50-mm-) **OR** 4-inch- (100-mm-), **as directed**, thick, dry, filters with fibrous media material formed into deep-V-shaped pleats and held by self-supporting wire grid holding frames, with nonflammable cardboard media and media-grid frame.

- a. Efficiency: ASHRAE 52.2 MERV rating of 6 or higher.
- 2. Air-Pressure Switch (for units larger than 15 tons (50 kW)): Indicates dirty filters.

K. Accessories:

- 1. Manual outdoor-air damper.
- 2. Motorized outdoor-air damper.
- 3. Air-side economizer.
- 4. Water-side economizer.
- 5. Hot-gas bypass.
- 6. Air Pressure Switch: Indicates when differential pressure exceeds set point representing dirty filters.

L. Single-Point Electrical Characteristics:

- 1. Volts: 120 **OR** 208 **OR** 230 **OR** 460, **as directed**.
- 2. Phase: Single **OR** Three, **as directed**.
- 3. Hertz: 60.
- 4. Full-Load Amperes: **as directed**.
- 5. Minimum Circuit Ampacity: **as directed**.
- 6. Maximum Overcurrent Protection: **as directed**.

1.3 EXECUTION

A. Installation

- 1. Install units level and plumb.
- 2. Anchor units to structure.
- 3. Install seismic restraints.
- 4. Install static-pressure probe (for units larger than 15 tons (50 kW) equipped with inlet vanes).



5. Install water-cooled units with thermometer and pressure gage at the water supply and return connection.
6. Install vibration spring isolators under base of unit, with minimum static deflection of 1 inch (25 mm). Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 - a. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
 - b. Water-Cooled Condenser Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
2. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
3. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to self-contained air-conditioners with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".

C. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
2. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
 - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Units will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.

D. Startup Service

1. Engage a factory-authorized service representative to perform **OR** perform startup service, **as directed**.

E. Demonstration

1. Engage a factory-authorized service representative to train **OR train** the Owner's maintenance personnel, **as directed** to adjust, operate, and maintain units.

END OF SECTION 23 74 13 00a



SECTION 23 74 13 00b - UNIT VENTILATORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for unit ventilators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes unit ventilators and accessories with the following heating and cooling features:
 - a. Hydronic, Steam, and Electric heating coil.
 - b. Hydronic, Steam, and Electric reheat coil.
 - c. Hydronic and Direct-expansion refrigerant cooling coil.

C. Definitions

1. BAS: Building automation system.
2. HGBP: Hot-gas bypass.

D. Submittals

1. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each unit type and configuration.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Plans, elevations, sections, and details.
 - b. Details of anchorages and attachments to structure and to supported equipment.
 - c. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that unit ventilators, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.
3. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Warranty



1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Compressor failure.
 - 2) Condenser coil leak.
 - b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Final Completion.
 - c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Final Completion.
 - d. Warranty Period (Condenser Coil Only): Five years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units

1. Description: Factory-packaged and -tested units rated according to ARI 840, ASHRAE 33, and UL 1995, including finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in blow-through **OR** draw-through, **as directed**, configuration, and hydronic cooling coil.

B. Cabinets

1. Insulation: Minimum 1/2-inch (13-mm) **OR** 1-inch (25-mm), **as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 - a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Drain Pans: Plastic **OR** Insulated galvanized steel with plastic liner, **as directed**, formed as required by ASHRAE 62.1. Drain pan shall be removable, **as directed**.
3. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors, **as directed**.
 - a. Steel components exposed to moisture shall be hot-dip galvanized after fabrication.
4. Cabinet Finish: Baked-on primer ready for field painting.
5. Cabinet Finish: Baked enamel, in manufacturer's standard **OR** custom, **as directed**, paint color as selected by the Owner.
6. Indoor-Supply-Air Grille: Steel **OR** Aluminum, **as directed**, double deflection, adjustable **OR** adjustable linear bar, **as directed**.
7. Return-Air Inlet: Front toe space **OR** Back inlet with top inlet grille, **as directed**.
8. End Panels: Matching material and finish of unit ventilator.
9. Outdoor-Air Wall Box: Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
 - a. Louver Configuration: Horizontal **OR** Vertical, **as directed**, rain-resistant louver.
 - b. Louver Material: Aluminum **OR** Steel, **as directed**.
 - c. Bird Screen: 1/2-inch (13-mm) mesh screen on interior side of louver.
 - d. Decorative Grille: On outside of intake.
 - e. Finish: Anodized aluminum **OR** Baked enamel, **as directed**, color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.

C. Coils

1. Test and rate unit ventilator coils according to ASHRAE 33.
2. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.



3. Steam Coils: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).
 4. Electric-Resistance Heating Coils: Nickel-chromium heating wire or tubular elements in coil fins, free of expansion noise and hum, with fuses in terminal box for overcurrent protection, and continuous limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
 5. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum 450 psig (3105 kPa) for a minimum 300-psig (2070-kPa) working pressure. Include thermal expansion valve.
- D. Indoor Fan
1. Fan and Motor Board: Removable.
 - a. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels; and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - b. Fan Shaft and Bearings: Hollow steel shaft with permanently lubricated, resiliently mounted bearings.
 - c. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - d. Wiring Termination: Connect motor to chassis wiring with plug connection.
- E. Dampers
1. Mixing Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric **OR** pneumatic, **as directed**, actuator.
 2. Outdoor-Air Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric **OR** pneumatic, **as directed**, actuator.
 3. Face and Bypass Dampers: Galvanized-steel damper blades with edge and end seals and nylon bearings; with factory-mounted electric **OR** pneumatic, **as directed**, actuator.
 4. Comply with ASHRAE/IESNA 90.1.
- F. Accessories
1. Exhaust Shutter: Barometric **OR** Motorized, modulating, **as directed**, type designed to limit room pressure to maximum 0.10-inch wg (25 kPa) with steel **OR** aluminum **OR** fabric, **as directed**, damper blades including edge and end seals, in galvanized-steel frame with outdoor **OR** indoor **OR** outdoor and interior, **as directed**, wall grille.
 2. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.
 3. Insulated false back with gasket seals on wall and outdoor-air plenum.
 - a. Insulation: Minimum 1/2-inch (13-mm) **OR** 1-inch (25-mm), **as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 - 1) Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - 2) Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 4. Return-air plenum, 6 inches (150 mm) thick, designed to take return air from top inlet grilles in cabinets on both sides of unit ventilator with gasket seals on wall and outdoor-air plenum extension.
 5. Duct flanges for supply-, return-, and outdoor-air connections.
 6. Radiation Grille: Steel **OR** Aluminum, **as directed**, linear-bar **OR** stamped, **as directed**, grille with finish to match discharge-air grille.



7. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
 - a. Washable Foam: 70 percent arrestance and 3 MERV.
OR
Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
OR
Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
 8. Energy Recovery Wheel:
 - a. Casing: Steel with manufacturer's standard paint coating and with the following:
 - 1) Integral purge section.
 - 2) Casing seals on periphery of rotor, on duct divider, and on purge section.
 - 3) Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.
 - b. Rotor: Corrugated-aluminum, segmented wheel strengthened with radial spokes, and having nontoxic, noncorrosive silica-gel desiccant coating. Construct media for passing maximum 800-micrometer solids and maximum 0.04 percent cross contamination by volume of exhaust air. Drive rotor with belt around outside of rotor.
 - c. Defrost Coils: Electric defrost coil in the exhaust airstream.
 - d. Drive: Fractional horsepower motor and gear reducer, with speed changed by adjustable variable frequency controller.
 - e. Inlet and Discharge Fans: Forward curved, centrifugal; resiliently mounted with flexible duct connections.
 - 1) Motor and Drive: Permanently lubricated, direct driven. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - f. Filters: 1-inch- (25-mm-) thick, disposable type, mounted in galvanized-steel frame upstream of energy recovery wheel in both supply and exhaust airstreams.
 - g. Electrical: Single electrical connection from attached unit ventilator.
- G. Factory Hydronic Piping Package
1. Piping: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet. Crossover piping, NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, with shutoff valves.
 2. Control Valves: Electric **OR** Pneumatic, **as directed**, actuators compatible with terminal controller and building controls.
 - a. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for dual-temperature-water coil.
 - b. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
 - c. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for hot-water heating coil.
 - d. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for hot-water reheat coil.
 3. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
 - a. Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
 - b. Minimum Diameter: Equal to unit ventilator connection size.
 4. Isolation Valves, Strainers, Unions, and Balance Valves:
 - a. Two-Piece Ball Valves: Bronze body with stainless-steel ball and stem and galvanized-steel lever handle for each supply and return connection. If balancing device is combination shutoff type with memory stop, isolation valve may be omitted on the return.
 - b. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.



- c. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
 - d. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
 - e. Wrought-Copper Unions: ASME B16.22.
- H. Remote Condensing Units
1. Description: Factory assembled and tested; consisting of compressors, condenser coils, fans, motors, refrigerant receiver, and operating controls. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
 2. Casing: Steel with baked-enamel finish; removable panels for access to controls, weep holes for water drainage, and mounting holes in base.
 - a. Casing Finish: Baked enamel, in manufacturer's standard **OR** custom, **as directed**, paint color as selected by the Owner.
 3. Compressor: Hermetic, scroll **OR** reciprocating, **as directed**, type; internally isolated for vibration with factory-installed safety devices as follows:
 - a. Antirecycle timer.
 - b. High-pressure cutout.
 - c. Low-pressure cutout or loss-of-charge switch.
 - d. Internal thermal-overload protection.
 - e. Current and voltage sensitive safety devices.
 4. Compressor Motor: Start capacitor, relay, and contactor. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 5. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
 6. Refrigerant Piping Materials:
 - a. Drawn-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B).
 - b. Annealed-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type K (ASTM B 88M, Type A), **as directed**.
 - c. Wrought-Copper Fittings: ASME B16.22.
 7. Refrigerant: R-407C **OR** R-410A, **as directed**.
 8. Low ambient controls to permit operation down to 45 deg F (7 deg C).
 9. Crankcase heater.
 10. Charging and service fittings on exterior of casing.
 11. Filter dryer.
 12. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.
 13. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
 14. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
 15. Condenser Fan: Direct-drive, aluminum propeller fan; motor with thermal-overload protection.
 - a. Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 16. Accessories: Polyethylene mounting base to provide a permanent foundation.
- I. Integral Cooling Chassis
1. Description: Assembly mounted within unit ventilator, factory assembled and tested; consisting of compressors, condenser coils, fans, motors, and refrigerant receivers; removable for maintenance, with plug and receptacle connections for control and power wiring. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
 2. Casing: Galvanized steel with removable panels for access to controls and refrigerant piping.
 3. Exterior Louver: Extruded aluminum.



4. Compressor: Hermetic, scroll **OR** reciprocating, **as directed**, type; internally isolated for vibration with factory-installed safety devices as follows:
 - a. Antirecycle timer.
 - b. High-pressure cutout.
 - c. Low-pressure cutout or loss-of-charge switch.
 - d. Internal thermal-overload protection.
 - e. Current- and voltage-sensitive safety devices.
5. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
6. Refrigerant Piping Materials:
 - a. Drawn-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B).
 - b. Annealed-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type K (ASTM B 88M, Type A), **as directed**.
 - c. Wrought-Copper Fittings: ASME B16.22.
7. Refrigerant: R-407C **OR** R-410A, **as directed**.
8. Low ambient controls to permit operation down to 45 deg F (7 deg C).
9. Crankcase heater.
10. Charging and service fittings.
11. Filter dryer.
12. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.
13. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
14. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
15. Direct-Driven Condenser Fan: Forward curved, double width, centrifugal; thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.
 - a. Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

J. Basic Unit Controls

1. Control devices and operational sequences are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
OR
Basic Unit Controls:
 - a. Control voltage transformer.
 - b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) Fan-speed switch.
 - 4) Manual **OR** Automatic, **as directed**, changeover.
 - 5) Adjustable deadband.
 - 6) Concealed **OR** Exposed, **as directed**, set point.
 - 7) Concealed **OR** Exposed, **as directed**, indication.
 - 8) Degree F **OR** Degree C, **as directed**, indication.
 - c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
 - 1) Concealed **OR** Exposed, **as directed**, set point.
 - 2) Concealed **OR** Exposed, **as directed**, indication.
 - d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
 - e. Unoccupied-period-override push button.
 - f. Data entry and access port.
 - 1) Input data includes room temperature and humidity set points, and occupied and unoccupied periods.
 - 2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
2. DDC, **as directed**, Terminal Controller:



- a. Safety Controls Operation: Freezestat shall stop fan and close outdoor-air damper if air less than 38 deg F (3 deg C) enters coils.
- b. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
- c. Unoccupied Period Override Operation: Two, **as directed**, hours.
- d. Dual-Temperature Coil Operation:
 - 1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat set point.
 - 2) Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.
- e. Hydronic Cooling-Coil Operation:
 - 1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to provide cooling if room temperature exceeds thermostat set point.
 - 2) Unoccupied Periods: Close control valve.
- f. Refrigerant-Coil Operation:
 - 1) Occupied Periods: Start compressor to maintain room temperature.
 - 2) Unoccupied Periods: Stop compressor cooling **OR** Cycle compressor for heating to maintain setback temperature, **as directed**.
- g. Supplemental, **as directed**, Heating-Coil Operation:
 - 1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
 - 2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
 - 3) Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below 25 deg F (4 deg C).
- h. Reheat-Coil Operation:
 - 1) Humidity Control for Occupied Periods: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
 - 2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
- i. Outdoor-Air Damper Operation: Open to 25 percent fixed minimum intake during occupied periods, and close during unoccupied periods.
- j. Outdoor-Air Damper Operation: Open to 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II during occupied periods, and close during unoccupied periods. Microprocessor controller shall permit air-side economizer operation when outdoor air is less than 60 deg F (15 deg C).
- k. Carbon Dioxide Sensor Operation: During occupied periods, reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 800-ppm concentration.
- l. Face-and-Bypass Damper Operation: Position damper to face of coils until room temperature equals thermostat set point; bypass after room-temperature set point is achieved.
- m. Cooling Lockout: During economizer cycle operation, block out cooling.
- n. HGBP: Open HGBP solenoid valve to maintain minimum suction pressure at compressor.
- o. Energy Recovery Wheel Operation:
 - 1) Factory-mounted and -wired, starting relay and manual motor starter for field wiring.
 - 2) Occupied period is established by remote signal **OR** room occupancy sensor, **as directed**.
 - 3) Energy recovery wheel and inlet and discharge fans operate during occupied periods after room temperature set point has been achieved.



- 4) Energy recovery wheel operates during occupied periods, but stops when unit ventilator controls call for cooling, and outdoor-air temperatures permit free air cooling.
- 5) Energy recovery wheel and fans stop during unoccupied periods.
- p. Controller shall have volatile-memory backup.
3. BAS Interface Requirements:
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at the central workstation.
 - c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
 - 1) Adjust set points.
 - 2) Unit ventilator start, stop, and operating status.
 - 3) Data inquiry to include outdoor-air damper position, **as directed**, supply- and room-air temperature and humidity, **as directed**.
 - 4) Occupied and unoccupied schedules.
4. Electrical Connection: Factory wire motors and controls for a single electrical connection.

K. Metal Shelves And Cabinets

1. Include manufacturer's standard cabinets to match unit ventilators with required installation hardware as indicated:
 - a. Open Shelving with Reinforced Shelves:
 - 1) Return-air plenum **OR** Radiation enclosure, **as directed**, and aluminum bar grille with finish to match unit ventilator grille.
 - 2) Through-piping enclosure with solid top.
 - b. Closed Shelving with Reinforced Shelves:
 - 1) Return-air plenum **OR** Radiation enclosure, **as directed**, and aluminum bar grille with finish to match unit ventilator grille.
 - 2) Through-piping enclosure with solid top.
 - 3) Two sliding doors with key-operated locks.
 - c. Utility compartment with access panel with key-operated lock.
 - d. Wall and corner filler sections, and end panels finished to match shelving.
2. Painted Finish: Manufacturer's standard **OR** custom, **as directed**, baked enamel, in color selected by the Owner, applied to shelving before shipping.
3. Cabinet Top: Plastic-laminate top in color and pattern selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.

1.3 EXECUTION

A. Installation

1. Install unit ventilators to comply with NFPA 90A.
2. Suspend horizontal unit ventilators from structure with threaded steel rods and minimum 0.25-inch (6.35-mm) static-deflection, elastomeric vibration isolation hanger **OR** 1.0-inch (25-mm) static-deflection spring hangers, **as directed**. Vibration isolators are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**, above finished floor.
4. Refer to Division 23 Section "Packaged Compressor And Condenser Units" for condensing units matched to refrigerant cooling coil packaged in unit ventilators.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - a. Install piping adjacent to machine to allow service and maintenance.



- b. Connect piping to unit ventilator factory hydronic piping package. Install piping package if shipped loose.
 - c. Connect condensate drain to indirect waste.
 2. Install refrigerant piping as required by Division 23 Section "Refrigerant Piping", and add refrigerant as required to compensate for length of piping.
 3. Connect supply and return ducts to unit ventilators with flexible duct connectors specified in Division 23 Section "Air Duct Accessories". Comply with safety requirements in UL 1995 for duct connections.
 4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 5. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
 - C. Field Quality Control
 1. Perform the following field tests and inspections and prepare test reports:
 - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
 - d. Record temperatures entering and leaving energy recovery wheel when outdoor-air temperature is a minimum of 15 deg F (8.3 deg C) higher, or 20 deg F (11 deg C) lower, than room temperature.
 2. Remove and replace malfunctioning units and retest as specified above.
 - D. Adjusting
 1. Adjust initial temperature and humidity set points.
 2. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
 - E. Demonstration
 1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit ventilators.

END OF SECTION 23 74 13 00b



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 74 13 00	07 72 13 00	Packaged, Outdoor, Central-Station Air-Handling Units



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SECTION 23 74 23 00 - DIRECT-FIRED, MAKEUP AIR UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for direct-fired H&V units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes direct-fired H&V units with an evaporative cooling package, **as directed**.

C. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. LEED Submittal:
 - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings:
 - a. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 - b. Wiring Diagrams: Power, signal, and control wiring.
4. Operation and maintenance data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.
3. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.2 PRODUCTS

A. Packaged Units

1. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, **as directed**, evaporative cooling package, **as directed**, and direct-fired gas furnace to be installed outside **OR** inside, **as directed**, the building.

B. Cabinet

1. Cabinet: Single-wall **OR** Double-wall, **as directed**, galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Cabinet shall be fully weatherized for outside installation, **as directed**.
2. Access Panels: Lift-out **OR** Piano hinged with cam-lock fasteners, **as directed**, for furnace and fan motor assemblies on both sides of unit.
3. Internal Insulation: Fibrous-glass duct lining, comply with ASTM C 1071, Type II, applied on complete unit **OR** furnace and fan sections only, **as directed**.
 - a. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Insulation Adhesive: Comply with ASTM C 916, Type I.



- c. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
 - 4. Finish: Heat-resistant, baked enamel.
 - 5. Discharge: Horizontal **OR** Vertical, **as directed**, -pattern, galvanized-steel assembly with diffusers incorporating individually adjustable vanes.
 - 6. Roof Curb: Full-perimeter curb of sheet metal, minimum 16 inches (400 mm) high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
 - 7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Supply-Air Fan
- 1. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings **OR** pillow-block bearings rated for L50 or 200,000 hours with external grease fittings, **as directed**.
 - 2. Motor: Open dripproof **OR** Totally enclosed, **as directed**, single **OR** two, **as directed**, -speed motor.
 - 3. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
 - 4. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, **as directed**, elastomeric **OR** spring, **as directed**, isolators.
- D. Outdoor-Air Intake
- 1. Outdoor-Air Hood: Galvanized steel with rain baffles, bird screen complying with ASHRAE 62.1, **as directed**, and finish to match cabinet; and sized to supply maximum 100 percent outdoor air.
- E. Air Filters
- 1. Comply with NFPA 90A.
 - 2. Cleanable Filters: 1-inch- (25-mm-) **OR** 2-inch-0 (50-mm-), **as directed**, thick, cleanable metal mesh.
 - 3. Disposable Panel Filters: 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1, **as directed**.
 - a. Media: Interlaced glass **OR** polyester, **as directed**, fibers.
 - b. Frame: Galvanized steel.
- F. Dampers
- 1. Outdoor-Air and Return-Air, **as directed**, Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 2-inch wg (448 Pa).
 - 2. Fan-Discharge Dampers: Galvanized-steel, opposed-blade damper.
 - 3. Balancing/Bypass Dampers: Galvanized-steel, opposed-blade damper.
 - 4. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.
- G. Direct-Fired Gas Furnace
- 1. Description: Factory assembled, piped, and wired; and complying with ANSI Z83.4, "Direct Gas-Fired Make-Up Air Heaters"; ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters"; and NFPA 54, "National Fuel Gas Code."
 - 2. Inside Unit External Housing: Steel cabinet with integral support inserts.
 - 3. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts.
 - a. External Casing and Cabinet Finish: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface in color to match fan section.
 - 4. Burners: Cast-iron burner with stainless-steel mixing plates.



- a. Control Valve: Single stage **OR** Two stage **OR** Modulating with minimum turndown ratio of 25:1 or as otherwise directed, **as directed**.
 - b. Fuel: Natural **OR** Propane, **as directed**, gas.
 - c. Pilot: Electrically ignited by hot-surface ceramic igniter.
5. Safety Controls:
- a. Gas Manifold: Safety switches and controls to comply with ANSI standards **OR** FMG **OR** IRI, **as directed**.
 - b. Purge-Period Timer: Automatically delays burner ignition and bypasses low-limit control.
 - c. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
 - d. Manual-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - e. Gas Train: Redundant, automatic main gas valves, electric pilot valve, hydraulic **OR** electronic, **as directed**, -modulating temperature control valve, main and pilot gas regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas pressure switches, **as directed**, to comply with IRI requirements **OR** to comply with FMG requirements, **as directed**.
 - f. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
 - g. Control Transformer: Integrally mounted 24-V ac.
- H. Evaporative Cooling Package
1. Cabinet: Single-wall **OR** Double-wall, **as directed**, galvanized- or aluminized-steel panels lined with ABS polymer, **as directed**, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs and having a stainless-steel reservoir with overflow and drain with full-port, brass-fitted ball valve. Cabinet shall be fully weatherized for outside installation, **as directed**.
 - a. External Casing and Cabinet Finish: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface in color to match fan section.
 2. Media: UL 900, Class 2, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 12-inch- (300-mm-), **as directed**, thick cellulose **OR** glass-fiber, **as directed**, media with rigidizing agents, fungicides, and wetting agents. Minimum 90 percent contact factor.
 - a. Moisture elimination pad.
 3. Water-Circulation System: Submersible centrifugal sump pump with inlet strainer, brass balancing valve located in pump discharge, and thermally protected motor; water distribution troughs or piping at top of media pads; and float-operated, makeup water and bleed-off valves.
 - a. Automatic Fill and Drain Kit: Water supply and drain, solenoid valves for initial sump fill and for draining sump.
 4. Water-Saver System: Timer, solenoid valve, and water distribution piping to apply the water supply to the media.
 5. Comply with applicable requirements in ASHRAE 62.1.
- I. Controls
1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
 2. Control Panel: Surface-mounted **OR** Recessed, with trim ring, **as directed**, remote panel, with engraved plastic cover, and the following lights and switches:
 - a. On-off **OR** On-off-auto, **as directed**, switch.
 - b. Summer-winter **OR** Heat-off-cool, **as directed**, switch. Automatic changeover, **as directed**.
 - c. Supply-fan operation indicating light.
 - d. Heating operation indicating light.
 - e. Damper position potentiometer.
 - f. Thermostat.
 - g. Cooling operation indicating light.



- h. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 - i. Safety-lockout indicating light.
3. Refer to Division 23 Section "Instrumentation And Control For Hvac" for control equipment and sequence of operation.
4. Control Devices:
- a. Remote Thermostat: Adjustable room thermostat with temperature readout.
 - b. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
 - c. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - d. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature.
 - e. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
- OR**
- Timers: Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.
- f. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.
 - g. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed. Equip with filtered circuit to eliminate radio interference.
5. Fan Control: Interlock fan to start with exhaust fan(s). See Division 23 Section(s) "Axial Hvac Fans" OR "Centrifugal Hvac Fans" OR "Hvac Power Ventilators" OR "Sequence Of Operations For Hvac Controls", **as directed**, for exhaust fan controls.
- OR**
- Fan Control: Timer starts and stops direct-fired H&V unit and exhaust fan(s).
- a. Fan-Discharge Thermostat: Stops fan when discharge-air temperature is less than 40 deg F (4 deg C).
 - b. Smoke detectors, located in supply and return, **as directed**, air, shall stop fans when the presence of smoke is detected.
 - c. Controls two **OR** variable, **as directed**, -speed motor controller using speed switch on control panel **OR** variable-speed potentiometer on control panel **OR** static-pressure transmitter, **as directed**.
6. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
- OR**
- Outdoor-Air and Fan-Discharge Damper Control, 100 Percent Outdoor-Air Units:
- a. Outdoor-air damper shall open when supply fan starts, and close when fan stops.
 - b. Fan-discharge dampers shall operate to vary the amount of outdoor air to match exhaust-fan operation.
- OR**
- Outdoor-Air and Balancing/Bypass Damper Control, Variable Outdoor-Air Units:
- a. Outdoor-air damper shall open when supply fan starts, and close when fan stops.
 - b. Balancing/bypass dampers shall modulate to maintain minimum air velocity through burner.
- OR**
- Outdoor-Air, Balancing/Bypass, and Return-Air Damper Control:
- a. Outdoor-air damper shall open when supply fan starts, and close when fan stops.



- b. Return-air dampers shall modulate in response to potentiometer on control panel **OR** building pressure control, **as directed**.
- c. Balancing/bypass dampers shall modulate to maintain minimum air velocity through the burner.
- 7. Temperature Control: Operates gas valve to maintain supply-air or room temperature.
 - a. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in fan outlet.
OR
Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment, **as directed**, and unit-mounted control adjustment **OR** and adjustment on remote control panel, **as directed**.
 - b. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F (10 deg C).
- 8. Evaporative Cooling Controls:
 - a. Start and stop water-circulation-system sump pump to maintain space temperature.
 - b. Automatic Fill Control: A switch in the unit control panel shall close sump drain valve and open makeup water valve.
 - c. Automatic Drain Control: Opens sump drain valve and closes makeup water valve from a switch in the unit control panel **OR** when an outside thermostat senses 40 deg F (4 deg C) or less, **as directed**.
 - d. Water-Saver System: Remote thermostat shall open water-supply valve to maintain dry-bulb temperature in space. Timer shall activate thermostat circuit.
- 9. DDC: Stand-alone control module for link between unit controls and DDC system. Control module shall be compatible with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
 - a. Provide start and stop interface relay, and relay to notify DDC system alarm condition.
 - b. Provide hardware interface or additional sensors as follows:
 - 1) Room temperature.
 - 2) Discharge-air temperature.
 - 3) Furnace operating.

J. Motors

- 1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

1.3 EXECUTION

A. Installation

- 1. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
- 2. Install roof curb on roof structure, according to ARI Guideline B **OR** NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts", **as directed**. Install and secure direct-fired H&V units on curbs, and coordinate roof penetrations and flashing with roof construction.
OR
Install restrained vibration isolation roof-curb rails on roof structure according to ARI Guideline B **OR** NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts", **as directed**. Install and secure direct-fired H&V units on rails, and coordinate roof penetrations and flashing with roof construction. Restrained isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- 3. Install suspended units from spring hangers with minimum 1-inch (25-mm) static deflection; refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
OR



Install floor-mounted units on restrained, **as directed**, spring isolators with minimum 1-inch (25-mm) static deflection; refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

4. Install controls and equipment shipped by manufacturer for field installation with direct-fired H&V units.

B. Connections

1. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.
 - a. Gas Piping: Comply with requirements in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.
 - b. Makeup Water: Comply with requirements in Division 22 Section "Domestic Water Piping" for valves and accessories on piping connections to evaporative cooling units.
 - c. Drain: Comply with requirements in Division 22 Section "Sanitary Waste And Vent Piping" for traps and accessories on piping connections to evaporative cooling units.
2. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to direct-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".
3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Startup Service

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for visible damage to furnace combustion chamber.
 - b. Inspect casing insulation for integrity, moisture content, and adhesion.
 - c. Verify that clearances have been provided for servicing.
 - d. Verify that controls are connected and operable.
 - e. Verify that filters are installed.
 - f. Purge gas line.
 - g. Inspect and adjust vibration isolators and seismic restraints, **as directed**.
 - h. Verify bearing lubrication.
 - i. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - j. Adjust fan belts to proper alignment and tension.
 - k. Start unit according to manufacturer's written instructions.
 - l. Complete startup sheets and attach copy with Contractor's startup report.
 - m. Inspect and record performance of interlocks and protective devices; verify sequences.
 - n. Operate unit for run-in period recommended by manufacturer.
 - o. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
 - 1) Measure gas pressure on manifold.
 - 2) Measure combustion-air temperature at inlet to combustion chamber.
 - 3) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 - p. Calibrate thermostats.
 - q. Adjust and inspect high-temperature limits.
 - r. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 - s. Start evaporative cooler system and measure and record the following:
 - 1) Leaving-air, dry- and wet-bulb temperatures.
 - 2) Entering-air, dry- and wet-bulb temperatures.



- t. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 - u. Measure and record airflow. Plot fan volumes on fan curve.
 - v. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - 1) High-limit heat.
 - 2) Alarms.
 - w. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
- 2. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.
 - 3. Prepare written report of the results of startup services.
- D. Adjusting
- 1. Adjust initial temperature set points.
 - 2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 - 3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Demonstration
- 1. Train Owner's maintenance personnel to adjust, operate, and maintain direct-fired H&V units.

END OF SECTION 23 74 23 00



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SECTION 23 74 23 00a - INDIRECT-FIRED, PACKAGED H&V UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for indirect-fired, H&V units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes indirect-fired H&V units with the following accessories:
 - a. Gas or Oil furnace.
 - b. Evaporative cooling package.

C. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. Shop Drawings:
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 - c. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
 - d. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and maintenance data.
4. Warranty: Special warranty specified in this Section.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to replace heat exchangers of indirect-fired H&V units that fail in materials or workmanship within five years **OR** 10 years, **as directed**, from date of Final Completion.

1.2 PRODUCTS

A. Packaged Units

1. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, evaporative cooling package, **as directed**, and indirect-fired gas **OR** oil, **as directed**, furnace to be installed outside **OR** inside, **as directed**, the building.

B. Cabinet

1. Cabinet: Single-wall **OR** Double-wall, **as directed**, galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Cabinet shall be fully weatherized for outside installation, **as directed**.
2. Access Panels: Lift-out **OR** Piano hinged with cam-lock fasteners, **as directed**, for furnace and fan motor assemblies on both sides of unit.



3. Internal Insulation: Fibrous-glass duct lining, comply with ASTM C 1071, Type II, applied on complete unit for outside unit or furnace and fan sections only for inside unit.
 - a. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
 - b. Insulation Adhesive: Comply with ASTM C 916, Type I.
 - c. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
 4. Finish: Heat-resistant, baked enamel.
 5. Discharge: Horizontal-pattern **OR** Vertical-pattern, **as directed**, galvanized-steel assembly with diffusers incorporating individually adjustable vanes.
 6. Roof Curb: Full-perimeter curb of sheet metal, minimum 16 inches (400 mm), unless directed otherwise, high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
- C. Supply-Air Fan
1. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings **OR** pillow-block bearings rated for L50 or 200,000 hours with external grease fittings, **as directed**.
 2. Motor: Open dripproof **OR** Totally enclosed, **as directed**, single-speed motor.
 3. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
 4. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained (for seismic areas), elastomeric **OR** spring, **as directed**, isolators.
- D. Outdoor-Air Intake
1. Outdoor-Air Hood: Galvanized steel with rain baffles, bird screen, and finish to match cabinet; and sized to supply maximum 30 percent **OR** 100 percent, **as directed**, outdoor air.
- E. Air Filters
1. Comply with NFPA 90A.
 2. Cleanable Filters: 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, cleanable metal mesh.
 3. Disposable Panel Filters: 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1.
 - a. Media: Interlaced glass **OR** polyester, **as directed**, fibers.
 - b. Frame: Galvanized steel.
- F. Dampers
1. Outdoor-Air and Return-Air, **as directed**, Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 2-inch wg (448 Pa).
 2. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.
- G. Indirect-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and NFPA 54, "National Fuel Gas Code."
 - a. AGA Approval: Designed and certified by and bearing label of AGA.
 - b. Burners: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
 - 1) Gas Control Valve: Single stage **OR** Two stage **OR** Modulating, **as directed**.
 - 2) Fuel: Natural **OR** Propane, **as directed**, gas.
 - 3) Minimum Thermal Efficiency: 80 percent.
 - 4) Ignition: Electronically controlled electric spark with flame sensor.
 - 5) High-Altitude Model **OR** Kit, **as directed**: For Project elevation above sea level.



2. Venting: Gravity vented.
 3. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
 4. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.
 5. Inside Unit External Housing: Steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.
 6. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.
 - a. External Casing and Cabinet Finish: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface in color to match fan section.
 7. Internal Casing: Aluminized steel, arranged to contain airflow, with duct flanges at inlet and outlet.
 8. Heat Exchanger: Aluminized **OR** Stainless steel, **as directed**.
 9. Heat-Exchanger Drain Pan: Stainless steel.
 10. Safety Controls:
 - a. Vent Flow Verification: Differential pressure switch to verify open vent **OR** Flame rollout switch, **as directed**.
 - b. Control Transformer: 24-V ac.
 - c. High Limit: Thermal switch or fuse to stop burner.
 - d. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, hydraulic-modulating **OR** electronic-modulating, **as directed**, temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - e. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
 - f. Gas Manifold: Safety switches and controls to comply with ANSI standards and FMG **OR** IRI, **as directed**.
 - g. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - h. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - i. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
- H. Oil-Fired Furnace
1. Description: Factory assembled, piped, and wired; and complying with UL 727, "Oil-Fired Central Furnaces."
 2. Inside Unit External Housing: Steel cabinet with integral support inserts and removable bottom arranged to serve as a drain pan.
 3. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.
 - a. External Casing and Cabinet Finish: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface in color to match fan section.
 4. Internal Casing: Aluminized steel, arranged to contain airflow, with duct flanges at inlet and outlet.
 5. Heat Exchanger: Welded, stainless steel, unless directed otherwise, with flame observation port, carbon dioxide sample port, and access panels for clean-out and service.
 6. Burners: Flame-retention, pressure-atomizing, forced-draft, gun type; with integral fuel pump and electronic spark ignition.
 - a. Fuel: No. 2, unless directed otherwise, fuel oil.
 - b. Minimum Thermal Efficiency: 80 percent **OR** 81 percent, **as directed**.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 7. Safety Controls:
 - a. Factory piped and wired to electrical junction box mounted on unit.
 - b. Oil-pressure switch.
 - c. Control Transformer: Integrally mounted 24-V ac.
 - d. Cad-cell safety system.
 - e. Manual reset flame safety.
 8. Accessories:



- a. Factory mounted and wired to electrical junction box on unit.
 - b. Oil Booster Pump: 30-gph (108-L/h) **OR** 70-gph (252-L/h), **as directed**, capacity; motor and 2-stage fuel unit with pressure-regulating valve and strainer.
 - c. Oil-pressure relief valve.
 - d. Outdoor Combustion-Air Adapter: Sealed to housing and fitted with quick access cover, or door and fitting for terminating outdoor-air duct.
- I. Evaporative Cooling Package
1. Cabinet: Single-wall **OR** Double-wall, **as directed**, galvanized- or aluminized-steel panels lined with ABS polymer, as required, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs and having a stainless-steel reservoir with overflow and drain with full-port, brass-fitted ball valve. Cabinet shall be fully weatherized for outside installation, **as directed**.
 - a. External Casing and Cabinet Finish: Baked enamel, **unless directed otherwise to be** Powder coating, over corrosion-resistant-treated surface in color to match fan section.
 2. Media: UL 900, Class 2, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 12-inch- (300-mm-), **as directed**, thick cellulose **OR** glass-fiber, **as directed**, media with rigidizing agents, fungicides, and wetting agents. Minimum 90 percent contact factor.
 - a. Moisture elimination pad.
 3. Water-Circulation System: Submersible centrifugal sump pump with inlet strainer, brass balancing valve located in pump discharge, and thermally protected motor; water distribution troughs or piping at top of media pads; and float-operated, makeup water and bleed-off valves.
 - a. Automatic Fill and Drain Kit: Water supply and drain, solenoid valves for initial sump fill and for draining sump.
 4. Water-Saver System: Timer, solenoid valve, and water distribution piping to apply the water supply to the media.
- J. Controls
1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
 2. Control Panel: Surface-mounted **OR** Recessed, **as directed**, with trim ring, remote panel, with engraved plastic cover, and the following lights and switches:
 - a. On-off **OR** On-off-auto, **as directed**, fan switch.
 - b. Summer-winter **OR** Heat-off-cool, **as directed**, switch. Automatic changeover, **as directed**.
 - c. Supply-fan operation indicating light.
 - d. Heating operation indicating light.
 - e. Damper position potentiometer.
 - f. Thermostat.
 - g. Cooling operation indicating light.
 - h. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 - i. Safety-lockout indicating light.
 3. Control Devices:
 - a. Remote Thermostat: Adjustable room thermostat with temperature readout.
 - b. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
 - c. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - d. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature.
 - e. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.

OR



- Timers: Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.
- f. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.
4. Fan Control: Interlock fan to start with exhaust fan(s). See Division 23 Section(s) "Axial Hvac Fans" OR "Centrifugal Hvac Fans" OR "Hvac Power Ventilators" OR "Sequence Of Operations For Hvac Controls", **as directed**, for exhaust fan controls.
5. Fan Control: Timer starts and stops direct-fired H&V unit and exhaust fan(s).
- a. Fan-Discharge Thermostat (for units with evaporative cooling package): Stops fan when discharge-air temperature is less than 40 deg F (4 deg C).
- b. Smoke detectors, located in supply and return, **as directed**, air, shall stop fans when the presence of smoke is detected.
6. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
7. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:
- a. Minimum 30 percent outdoor air.
- b. Outdoor-air quantity adjusted by potentiometer on control panel.
- c. Outdoor-air quantity to maintain minimum building static pressure.
8. Temperature Control: Operates gas valve to maintain supply-air temperature.
- a. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
- b. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment, **as directed**, and unit-mounted control adjustment, **OR** and adjustment on remote-control panel, **as directed**.
- c. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F (10 deg C).
- d. Furnace Control: Two or four steps of control using one or two furnace sections in series.
OR
Furnace Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual furnace units.
9. Evaporative Cooling Controls:
- a. Start and stop water-circulation-system sump pump to maintain space temperature.
- b. Automatic Fill Control: A switch in the unit control panel shall close sump drain valve and open makeup water valve.
- c. Automatic Drain Control: Opens sump drain valve and closes makeup water valve from a switch in the unit control panel **OR** when an outside thermostat senses 40 deg F (4 deg C) or less, **as directed**.
- d. Water-Saver System: Remote thermostat shall open water-supply valve to maintain dry-bulb temperature in space. Timer shall activate thermostat circuit.
10. DDC: Stand-alone control module for link between unit controls and DDC system. Control module shall be compatible with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
- a. Provide start and stop interface relay, and relay to notify DDC system alarm condition.
- b. Provide hardware interface or additional sensors as follows:
- 1) Room temperature.
- 2) Discharge-air temperature.
- 3) Furnace operating.

K. Motors



1. Comply with requirements are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".

1.3 EXECUTION

A. Installation

1. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
2. Install oil-fired duct heaters and associated fuel and vent piping according to NFPA 31 and applicable local codes and regulations.
3. Install roof curb on roof structure, according to ARI Guideline B **OR** NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts," **as directed**. Install and secure direct-fired H&V units on curbs, and coordinate roof penetrations and flashing with roof construction.
OR
Install restrained vibration isolation roof-curb rails on roof structure according to ARI Guideline B **OR** NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts," **as directed**. Install and secure indirect-fired H&V units on rails, and coordinate roof penetrations and flashing with roof construction. Restrained isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Install suspended units from spring hangers with minimum 1-inch (25-mm) static deflection; refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Install floor-mounted units on restrained, **as directed**, spring isolators with minimum 1-inch (25-mm) static deflection; refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install controls and equipment shipped by manufacturer for field installation with indirect-fired H&V units.
7. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.
 - a. Gas Piping: Comply with requirements in Division 23 Section(s) "Facility Natural-gas Piping" **OR** "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.
 - b. Fuel Oil Piping: Comply with requirements in Division 23 Section "Facility Fuel-oil Piping". Connect to fuel oil supply and return piping with shutoff valve and union at each connection.
 - c. Makeup Water: Comply with requirements in Division 22 Section "Domestic Water Piping" for valves and accessories on piping connections to evaporative cooling units.
 - d. Drain: Comply with requirements in Division 22 Section "Sanitary Waste And Vent Piping" for traps and accessories on piping connections to evaporative cooling units.
8. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to indirect-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".
9. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
10. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

END OF SECTION 23 74 23 00a



SECTION 23 76 13 00 - DEHUMIDIFICATION UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for mechanical dehumidification units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes packaged, factory-assembled and -tested, refrigerant-type, mechanical dehumidification units designed for outdoor and indoor installation.

C. Performance Requirements

1. Seismic Performance: Dehumidification units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals

1. Product Data: For each dehumidification unit indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5, "Systems and Equipment."
3. Shop Drawings: For each dehumidification unit indicated. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For dehumidification units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Seismic Qualification Certificates: For accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Source quality-control reports.
7. Field quality-control reports.
8. Operation and Maintenance Data: For dehumidification units to include in emergency, operation, and maintenance manuals.
9. Warranty: Sample of special warranty.



- E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. ASHRAE Compliance:
 - a. Applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment" and Section 7, "Construction and Startup."
 - b. Applicable requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."
 3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."
- F. Coordination
1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
 2. Coordinate installation of roof curbs, equipment supports, and roof penetrations.
- G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of dehumidification units that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Compressors: Manufacturer's standard, but not less than two **OR** five, **as directed**, years from date of Final Completion.
 - b. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than five years from date of Final Completion.

1.2 PRODUCTS

- A. Casings
1. Casing: Single-wall **OR** Double-wall, **as directed**, construction with corrosion-protective coating and exterior baked-enamel **OR** powder-coated, **as directed**, finish, stainless-steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.
 - a. Access: Removable panels **OR** Hinged access doors, **as directed**, with neoprene gaskets.
 - b. Insulation: Minimum 1/2-inch- (13-mm-) thick thermal insulation **OR** 2-inch- (50-mm-) thick, glass-fiber-insulation fill with no metal structure through the insulation, **as directed**.
 - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 2. Drain Pan and Connection: Plastic **OR** Stainless steel, **as directed**; insulated and complying with ASHRAE 62.1, **as directed**.
- B. Fans
1. Supply Fans: Forward curved **OR** Backward inclined, **as directed**, centrifugal; galvanized steel with baked-enamel **OR** powder-coated, **as directed**, finish; belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing of dehumidification unit.
 2. Exhaust **OR** Return, **as directed**, Fans: Forward curved **OR** Backward inclined, **as directed**, centrifugal; galvanized steel with baked-enamel **OR** powder-coated, **as directed**, finish; belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing of dehumidification unit.
 3. Fan Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Enclosure Type: Totally enclosed, fan cooled.
- C. Filters
1. Glass Fiber: Minimum 80 percent arrestance according to ASHRAE 52.1, and MERV 5 according to ASHRAE 52.2.



2. Pleated: Minimum 90 percent arrestance according to ASHRAE 52.1, and MERV 7 according to ASHRAE 52.2.

D. Refrigeration System

1. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1.
2. Refrigerant Coils: Copper tubes with mechanically bonded aluminum fins; factory fabricated and tested to comply with ASHRAE 33 and ARI 410; with multiple refrigerant circuits, seamless-copper headers with brazed connections, and galvanized **OR** stainless, **as directed**, -steel frame. Coil and fins shall have a polyester coating. Coils shall have a minimum 300-psig (2070-kPa) working-pressure rating and be factory tested to 450 psig (3105 kPa) and to 300 psig (2070 kPa) while underwater.
3. Compressors: Hermetic, scroll compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-dryers, sight glasses, compressor service valves, and liquid- and suction-line service valves.
 - a. Number of Refrigerant Circuits: Two for compressor capacities more than 7-1/2 tons (26.4 kW).
 - b. Refrigerant: R-134a **OR** R-407C **OR** R-410A, **as directed**.
 - c. Capacity Control:
 - 1) Hot-gas bypass valve and piping on one compressor.
 - 2) Cycle compressor.
 - d. Low-Pressure Cutout: Manual reset after three automatic-reset failures.
 - e. High-Pressure Cutout: Manual reset.
 - f. Compressor Motor Overload Protection: Manual reset.
 - g. Antirecycling Timing Device: Prevent compressor restart for five minutes after shutdown.
 - h. Defrost Cycle (for ice rinks): Adjustable timer shuts off supply fan. Compressor cycles until suction line temperature confirms thawed evaporator coil. Timer limits defrost time to 10 minutes.
4. Energy Recovery Heat Exchanger (Pool Heater): Cupronickel, coaxial, vented, double-wall construction for potable-water service.

E. Remote-Mounted, Air-Cooled Condenser Unit

1. Casing: Steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Refrigerant Coil: ARI 210/240, copper tube with mechanically bonded aluminum fins; with liquid subcooler.
3. Fan: Aluminum-propeller type, directly connected to permanently lubricated motor with integral thermal-overload protection.
4. Adjustable, Low Ambient Head-Pressure Control: Designed to operate at temperatures as low as 0 deg F (minus 18 deg C) by cycling condenser fans and controlling speed of last fan of each circuit.
5. Mounting Base: Polyethylene.

F. Heating Coils

1. Hot-Water Coil: Continuous circuit coil fabricated according to ARI 410.
 - a. Tubes: Copper.
 - b. Fins: Aluminum **OR** Copper, **as directed**, with fin spacing 0.125 inch (3.18 mm) **OR** 0.091 inch (2.31 mm) **OR** 0.071 inch (1.80 mm) **OR** 0.067 inch (1.70 mm) **OR** 0.056 inch (1.42 mm) **OR** 0.0075 inch (0.19 mm), **as directed**.
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: Cast iron with drain and air vent tapings.
 - e. Frames: Galvanized-steel channel, 0.052 inch (1.3 mm).
 - f. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
 - 1) Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
 - g. Source Quality Control: Test to 300 psig (2070 kPa).



2. Steam Coil: Distribution header coil fabricated according to ARI 410, with threaded steam supply and condensate connections.
 - a. Tubes: Copper.
 - b. Fins: Aluminum **OR** Copper, **as directed**, with fin spacing 0.125 inch (3.18 mm) **OR** 0.091 inch (2.31 mm) **OR** 0.071 inch (1.80 mm) **OR** 0.067 inch (1.70 mm) **OR** 0.056 inch (1.42 mm) **OR** 0.0075 inch (0.19 mm), **as directed**.
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: Cast iron with drain and air vent tappings.
 - e. Frames: Galvanized-steel channel, 0.052 inch (1.3 mm).
 - f. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
 - 1) Working-Pressure Ratings: 100 psig (690 kPa), 400 deg F (205 deg C).
 - g. Source Quality Control: Test to 200 psig (1380 kPa).
3. Electric-Resistance Heating Coil: Comply with UL 1995.
 - a. Heating Element: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated steel fins continuously brazed to sheath.
OR
Heating Element: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.
 - b. Overtemperature Protection: Disk-type, automatic-reset, thermal-cutout safety device; serviceable through terminal box without removing heater from unit.
 - c. Thermal Cutouts: Load carrying, manual reset or replaceable, and factory wired in series with each heater stage.
 - d. Control: Disconnecting means, overcurrent protection, and airflow proving switch.

G. Dampers

1. Outdoor-Air Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rod rotating in sintered bronze or nylon bearings. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod. Size for 0 to 25 percent outdoor air, with manual **OR** motorized, **as directed**, operator and filter.
2. Face-and-Bypass Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in sintered bronze or nylon bearings with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
3. Outdoor- and Return-Air **OR** Outdoor-, Return-, and Exhaust-Air, **as directed**, Dampers: Parallel-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers mechanically fastened to steel **OR** cadmium-plated steel, **as directed**, operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
4. Outdoor- and Return-Air **OR** Outdoor-, Return-, and Exhaust-Air, **as directed**, Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade **OR** parallel-blade, **as directed**, arrangement with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).
5. Damper Operator: 115 **OR** 24, **as directed**, -V ac, close coupled, with gear train sealed in oil and with spring return.

H. Controls



1. Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac" for control equipment and in Division 23 Section "Sequence Of Operations For Hvac Controls".
2. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
3. Building Automation System Interface: Factory-installed hardware and software to enable the building automation system to monitor, control, and display status and alarms.
4. Operating Control: Space humidistat cycles the compressor. Humidistat shall incorporate fan on-off-auto switch.
5. Operating Controls (for indoor pool units with typical manufacturer's control panel): Factory-installed microprocessor controller, capable of being remotely mounted.
 - a. Display the following on the face of controller:
 - 1) System on.
 - 2) System dehumidifying mode.
 - 3) System air-conditioning mode.
 - 4) System outdoor-air (economizer) mode.
 - 5) System heating pool water.
 - 6) Auxiliary space heat is operating.
 - 7) Unit requires service.
 - 8) Return-air (space) temperature.
 - 9) Return-air (space) humidity.
 - 10) Pool-water temperature.
 - 11) Outdoor-air temperature.
 - b. Indicate the following sensor failures on panel:
 - 1) Airflow: Dirty air filter, blocked airflow, and fan failure.
 - 2) Refrigerant high and low pressure.
 - 3) High water temperature.
 - 4) High and low evaporator temperature.
 - 5) Low water flow.
 - 6) Communication fault.
 - 7) System off.
 - 8) Antishort cycle delay.
 - 9) Power failure.
 - c. Provide access to the following set points on panel:
 - 1) Space temperature.
 - 2) Space relative humidity.
 - 3) Outdoor ventilation/air-conditioning changeover temperature.
 - 4) Airflow alarm.
 - d. Provide the following displays on panel:
 - 1) Space temperature.
 - 2) Space relative humidity.
 - 3) Outdoor-air temperature.
 - 4) Supply-air temperature.
 - 5) Return-air temperature.
 - 6) Airflow rating.
 - 7) Air-off evaporator temperature.
 - 8) Return-air relative humidity.
 - 9) Service codes.
 - e. Provide the following controls on panel:
 - 1) System on-off, fan continues to run.
 - 2) Fan on-off.
 - 3) Service code access.
 - 4) System dehumidifying mode.
 - 5) System air-conditioning mode.
 - 6) System outdoor-air (economizer) mode.



- 7) Auxiliary space heat is operating.
 - 8) Outdoor-air-temperature, conditioned-space-temperature, and control set-point-temperature digital display.
 - 9) Outdoor enthalpy digital display.
 - 10) Filter pressure drop digital display.
 - 11) Status: Airflow, fans, system, unit operation, and operating mode.
 - 12) Alarm digital display.
6. Operating Controls: Factory-installed microprocessor controller.
- a. Factory-installed operator panel with backlit display, capable of being remotely mounted, allows menu-driven display for navigation and control of unit.
 - b. Integral clock.
 - c. Personal computer interface.
 - d. Integral local area network for direct connection to BACnet **OR** LonWorks **OR** MODBUS, **as directed**.
 - e. Factory programmed.
 - f. Unit-Mounted Sensors:
 - 1) Airflow switch.
 - 2) Compressor-discharge temperature.
 - 3) Evaporator-air temperature.
 - 4) Pool-water-out temperature.
 - 5) Pool-water-in temperature.
 - 6) Relative humidity.
 - 7) Return-air temperature.
 - 8) Supply-air temperature.
 - g. Integral diagnostics.
 - h. Nonvolatile memory.
 - i. IP or SI display.
 - j. Provide the following status and alarm functions:
 - 1) System: On-off.
 - 2) Power failure.
 - 3) Fan: Off, overload.
 - 4) Compressor: On, turned off, overload, high pressure, low pressure, overheat, oil failure, and pumpdown.
 - 5) Evaporator damper closed.
 - 6) Pool: Low water flow, heating on.
 - 7) Dehumidification: Call for, on.
 - 8) Air Conditioning: Call for, on.
 - 9) System outdoor-air (economizer) mode.
 - 10) Auxiliary space heat on.
 - 11) Alarms: Firestat, freezestat, and filters.
 - k. Provide the following controls via operator panel:
 - 1) Compressor auto-off.
 - 2) Fan auto-off.
 - 3) Set-Point Adjustments: Relative humidity, temperatures, deadbands, and differentials.
 - 4) Sensor calibration.
 - l. Monitor constant and variable motor loads.
 - m. Monitor cooling load.
 - n. Monitor economizer cycles.
 - o. Monitor ventilation air volumes.
- I. Accessories
1. Water-Cooling Heat Exchanger: Coaxial, vented, double-wall construction; with three-way refrigerant control valve.
 2. Smoke Detectors: Photoelectric detector located in return-air plenum, to de-energize unit.



- a. Operating Voltage: 24-V dc, nominal.
 - b. Self-Restoring: Detectors do not require resetting or readjusting after actuation to restore them to normal operation.
 - c. Plug-in Arrangement: Detector and associated electronic components mounted in module with tamper-resistant connection to fixed base with twist-locking plug. Terminals in fixed base accept building wiring.
 - d. Integral Visual-Indicating Light: Digital-display type indicating detector operation.
 - e. Sensitivity: Can be tested and adjusted in-place after installation.
 - f. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the fire-alarm control panel.
 - g. Sensor: Digital display or infrared light source with matching silicon-cell receiver.
 - h. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) of smoke obscuration when tested according to UL 268A.
 - i. Integral Thermal Detector: Fixed-temperature type with 135 deg F (57 deg C) setting.
3. Electrical Convenience Outlet: 115-V ac fused, duplex, straight-blade receptacles, separately fused and located inside casing of dehumidification unit or in roof-curb perimeter.

J. Roof Curbs

1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
3. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C 1071, Type I or II.
 - b. Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**.
 - c. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - d. Liner Adhesive: Comply with ASTM C 916, Type I.
 - e. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - f. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.
4. Curb Height: 14 inches (355 mm) **OR** 24 inches (610 mm) **OR** 36 inches (910 mm), **as directed**.
5. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match dehumidification unit; used to anchor unit to the curb and designed for loads at Project site. Comply with requirements in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for wind-load requirements.

K. Source Quality Control

1. Verification of Performance: Factory test and rate dehumidification units according to ARI 910.
2. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to ARI 575.

1.3 EXECUTION

A. Examination

1. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
2. Examine roughing-in for hot-water **OR** steam **OR** refrigerant, **as directed**, piping systems to verify actual locations of piping connections before equipment installation.
3. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.
4. Proceed with installation only after unsatisfactory conditions have been corrected.

**B. Installation**

1. Equipment Mounting (for indoor or outdoor equipment supported on slabs-on-grade without vibration isolation devices): Install dehumidification units on concrete base(s). Comply with requirements for concrete base(s) specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Equipment Mounting (for indoor or outdoor equipment supported on concrete equipment base with vibration isolation devices): Install dehumidification units on concrete base(s) using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base(s) specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting (for installation of indoor or outdoor equipment on vibration isolation devices without concrete base): Install dehumidification units using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
4. Equipment Mounting (for installation of indoor or outdoor equipment on vibration isolation equipment base): Install dehumidification units on vibration isolation equipment base. Comply with requirements specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. For installation of indoor or outdoor equipment without vibration isolation devices, with seismic restraints, and without concrete base: Install dehumidification units with **<Insert seismic-restraint device>**. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. For indoor units suspended from structure: Install continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of size required to support weight of dehumidification unit.
 - a. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Fabricate brackets or supports as required.
 - b. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
7. Curb Support (if curbs are furnished with dehumidification units for rooftop installations): Install roof curb on roof structure, level and secure, according to NRCA's "The NRCA Roofing and Waterproofing Manual, Fifth Edition." Install and secure dehumidification units on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.
8. Unit Support: Install dehumidification units level on structural curbs **OR** pilings, **as directed**. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.



9. Isolation Curb Support (for units mounted on isolation curbs): Install dehumidification units on isolation curbs, and install flexible duct connectors and vibration isolation and seismic-control devices. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories". Vibration isolation and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

C. Connections

1. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.
2. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.
3. Connect condensate drain pans using minimum NPS 1-1/4 (DN 32) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.
4. Refrigerant Piping: Comply with requirements in Division 23 Section "Refrigerant Piping". Connect to supply and return coil tapplings with shutoff valve and union or flange at each connection.
5. Hot-Water Piping: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply coil tapplings with shutoff valve, return coil tapplings with balancing valve, and union or flange at each connection.
6. Steam and Condensate Piping: Comply with requirements in Division 23 Section "Steam And Condensate Heating Piping". Connect with shutoff valve and union or flange.
7. Duct installation requirements are specified in other Division 21. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - a. Install ducts to termination in roof-mounted frames. Where indicated, terminate return-air duct through roof structure and insulate the space between roof and bottom of dehumidification unit.

D. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
 - b. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Dehumidification unit will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

E. Startup Service

1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
2. Perform the following final checks before startup:
 - a. Verify that shipping, blocking, and bracing are removed.
 - b. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - c. Perform cleaning and adjusting specified in this Section.
 - d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - e. Check lubrication of bearings, pulleys, belts, and other moving parts.
 - f. Set outside- and return-air mixing dampers to minimum outside-air setting.
 - g. Install clean filters.
 - h. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.



3. Starting procedures for dehumidification units include the following:
 - a. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
 - b. Measure and record motor's electrical values for voltage and amperage.
 - c. Manually operate dampers from fully closed to fully open position and record fan performance.
 4. Comply with requirements in Division 23 Section "Testing, Adjusting, And Balancing For Hvac" for testing, adjusting, and balancing of dehumidification unit.
 5. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.
- F. Adjusting
1. Adjust damper linkages for proper damper operation.
 2. Adjust initial temperature and humidity set points.
- G. Cleaning
1. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.
 2. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.
- H. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain dehumidification units.

END OF SECTION 23 76 13 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 76 13 00	23 74 23 00	Direct-Fired, Makeup Air Units
23 76 13 00	23 74 23 00a	Indirect-Fired, Packaged H&V Units



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SECTION 23 81 13 00 - PACKAGED TERMINAL AIR CONDITIONERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for packaged terminal air conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes packaged terminal air conditioners and their accessories and controls, in the following configurations:
 - a. Through-the-wall and freestanding air conditioners.
 - b. Cooling-only units.
 - c. Heat-pump units.
 - d. Cooling units with electric heat.
 - e. Cooling units with hydronic heat.
 - f. Cooling units with indirect-fired gas heat.

C. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For packaged terminal air conditioners. Include plans, elevations, sections, details for wall penetrations, seismic bracing, **as directed**, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
4. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.
5. Field quality-control reports.
6. Operation and maintenance data.
7. Warranty: Sample of special warranty.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged terminal air conditioners that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than five years from date of Final Completion, including components and labor.
 - b. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than five years from date of Final Completion, including only components and excluding labor.



- c. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units

1. Description: Factory-assembled and -tested, self-contained, packaged terminal air conditioner with room cabinet, electric refrigeration system, heating, **as directed**, and temperature controls; fully charged with refrigerant and filled with oil; with cord-connected **OR** hardwired, **as directed**, chassis.

B. Chassis

1. Cabinet: 0.052-inch- (1.32-mm-) thick steel with removable front panel with concealed latches.
 - a. Mounting: Wall with wall sleeve **OR** Floor with subbase, **as directed**.
 - b. Discharge Grille: Punched-louver discharge grille allowing four-way discharge-air pattern **OR** Extruded-aluminum discharge grille **OR** Reversible polycarbonate discharge grille allowing upward and horizontal airflow, **as directed**.
 - c. Louvers: Extruded aluminum with enamel finish **OR** Stamped aluminum with clear-anodized finish **OR** Stamped steel with enamel finish, **as directed**; white **OR** bronze **OR** brown **OR** beige, **as directed**, color.
 - d. Finish: Epoxy coating **OR** Baked enamel, **as directed**.
 - e. Access Door: Hinged door in top of cabinet for access to controls.
 - f. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
 - g. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - h. Subbase: Enameled steel with adjustable leveling feet and adjustable end plates, with factory-installed and -wired, fused disconnect switch and receptacle sized for unit, **as directed**.
 - i. Wall Sleeves: Galvanized steel with polyester finish **OR** Molded polymer **OR** Molded fiberglass-reinforced polyester, **as directed**.
2. Refrigeration System: Direct-expansion indoor coil with capillary restrictor; and hermetically sealed scroll compressor with vibration isolation and overload protection.
 - a. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins with capillary tube distributor on indoor coil, **as directed**.
 - b. Accumulator.
 - c. Constant-pressure expansion valve.
 - d. Reversing valve.
 - e. Charge: R-407C **OR** R-410A, **as directed**.
3. Indoor Fan: Forward curved, centrifugal; with motor and positive-pressure ventilation damper with concealed manual **OR** electric, **as directed**, operator.
4. Filters: Washable polyurethane in molded plastic frame.
5. Condensate Drain: Drain pan to direct condensate to outdoor coil for re-evaporation **OR** and piping to direct condensate to building waste and vent piping, **as directed**.
 - a. Comply with ASHRAE 62.1 for drain pan construction and connections.
6. Outdoor Fan: Forward curved, centrifugal **OR** Propeller, **as directed**, type with separate **OR** driven by indoor fan, **as directed**, motor.
 - a. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - 1) Fan Motors: Permanently lubricated split capacitor.
 - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.



- 3) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

C. Heating

1. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.
OR
Hot-Water Heating Coil: Seamless copper tubes mechanically expanded into aluminum fins with two-way modulating control valve and air vent.
OR
Gas Heat:
 - a. General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.86/CSA 2.32, "Vented Gas-Fired Space Heating Appliances," and with NFPA 54.
 - b. Type of Gas: Natural **OR** Propane, **as directed**.
 - c. Heat Exchanger: Aluminized-steel **OR** Stainless steel, **as directed**.
 - d. Burner:
 - 1) Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
 - 2) Ignition: Electric pilot ignition with hot-surface igniter or electric spark ignition.
 - e. Gas-Burner Safety Controls:
 - 1) Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
 - 2) Flame Rollout Switch: Installed on burner box; prevents burner operation.
 - 3) Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
 - f. Combustion-Air Inducer: Centrifugal fan prepurges heat exchanger and vents combustion products; thermally protected motor with sleeve bearings; pressure switch prevents operation if combustion-air inlet or flue outlet is blocked.
 - g. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; and terminals for connection to accessories.

D. Controls

1. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:
 - a. Low Ambient Lockout Control: Prevents cooling-cycle operation below 40 deg F (5 deg C) outdoor air temperature.
 - b. Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above 40 deg F (5 deg C) and to supplemental heating below plus 25 deg F (minus 4 deg C).
 - c. Temperature-Limit Control: Prevents occupant from exceeding preset setback **OR** setup, **as directed**, temperature.
 - d. Building Automation System Interface: Allows remote on-off control with setback temperature control.
 - e. Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on indoor **OR** outdoor, **as directed**, coil and reverses unit to melt frost.
2. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage adjustable thermostat with heat anticipator, heat-off-cool-auto **OR** heat-off-cool, **as directed**, switch, and on-auto, **as directed**, fan switch.
3. Outdoor Air: Manual **OR** Motorized, **as directed**, intake damper. Open intake when unit indoor air fan runs, **as directed**.

E. Source Quality Control

1. Sound-Power Level Ratings: Factory test to comply with ARI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."



2. Unit Performance Ratings: Factory test to comply with ARI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

1.3 EXECUTION

A. Installation

1. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.
2. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants".
3. Install and anchor wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

B. Connections

1. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements for piping specified in Division 23 Section "Facility Natural-gas Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to machine to allow service and maintenance.

C. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - b. After installing packaged terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Packaged terminal air conditioners will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

D. Startup Service

1. Perform startup service.
2. After installation, verify the following:
 - a. Unit is level on base and is flashed in exterior wall.
 - b. Unit casing has no visible damage.
 - c. Compressor, air-cooled condenser coil, and fans have no visible damage.
 - d. Labels are clearly visible.
 - e. Controls are connected and operable.
 - f. Shipping bolts, blocks, and tie-down straps are removed.
 - g. Filters are installed and clean.
 - h. Drain pan and drain line are installed correctly.
 - i. Electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 22.
 - j. Installation. Perform startup checks according to manufacturer's written instructions, including the following:
 - 1) Lubricate bearings on fan.
 - 2) Check fan-wheel rotation for correct direction without vibration and binding.
3. After startup service and performance test, change filters.

E. Adjusting



1. Adjust initial temperature set points.
2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

F. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain packaged terminal air conditioners.

END OF SECTION 23 81 13 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 16 00	23 81 13 00	Packaged Terminal Air Conditioners



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SECTION 23 81 23 00 - COMPUTER-ROOM AIR-CONDITIONERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for computer-room air-conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Floor-mounted computer-room air conditioners, 6 tons (21 kW) and larger.
 - b. Floor-mounted computer-room air conditioners, 5 tons (18 kW) and smaller.
 - c. Ceiling-mounted computer-room air conditioners.
 - d. Console computer-room air conditioners.

C. Definition

1. BAS: Building automation system.

D. Performance Requirements

1. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
 - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
 - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For computer-room air conditioners. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Wiring Diagrams: For power, signal, and control wiring.
4. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.
5. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.
6. Field quality-control reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
 - a. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."



- b. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
- 3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
- 4. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

G. Warranty

- 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for Compressors: Manufacturer's standard, but not less than five **OR** 10, **as directed**, years from date of Final Completion.
 - b. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Final Completion.
 - c. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Final Completion.

1.2 PRODUCTS

A. Floor-Mounted Units 6 Tons (21 kW) And Larger

- 1. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet, fans, filters, humidifier, and controls.
- 2. Cabinet and Frame: Welded steel, braced for rigidity, and supporting compressors and other mechanical equipment and fittings.
 - a. Doors and Access Panels: Galvanized steel with polyurethane gaskets, hinges, and concealed fastening devices.
 - b. Insulation: Thermally and acoustically insulate cabinet interior with 1-inch- (25-mm-) thick duct liner.
 - c. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - d. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel; color as selected from manufacturer's standard colors **OR** to match computer equipment, **as directed**.
 - e. Floor Stand: Welded tubular steel with adjustable legs and vibration isolation pads.
- 3. Supply-Air Fan(s):
 - a. Double-inlet, forward-curved centrifugal fan(s); statically and dynamically balanced.
 - b. Drive: V-belt, with steel shaft with self-aligning ball bearings and cast-iron or steel sheaves, variable- and adjustable-pitch motor sheave, minimum of two matched belts, with drive rated at a minimum of two times the nameplate rating of motor.
- 4. Refrigeration System:
 - a. Compressors: Semihermetic reciprocating; with suction-gas-cooled, 1750-rpm motors; thermal overloads; oil sight glass; suction-line strainer; and reversible oil pumps; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.
OR
Compressors: Hermetic reciprocating; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.

Compressors: Hermetic scroll; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.



- b. Refrigeration Circuits: Two; each with hot-gas mufflers, thermal-expansion valve with external equalizer, liquid-line solenoid valve, liquid-line filter-dryer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
- c. Refrigerant: R-407C **OR** R-410A, **as directed**.
- d. Refrigerant Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins.
 - 1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
- e. Integral, Water-Cooled Refrigerant Condenser: Shell-and-tube type fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII **OR** Coaxial tube-in-tube type, **as directed**, with liquid-line stop valve and head-pressure-actuated, two-way **OR** three-way, **as directed**, regulating valve. Terminate fluid connections outside cabinet.
 - 1) Cooling Medium: Water **OR** Glycol solution, **as directed**.

OR

Remote Air-Cooled Refrigerant Condenser: Corrosion-resistant cabinet, copper-tube aluminum-fin coils arranged for two circuits, multiple direct-drive propeller fans with permanently lubricated ball bearings, and single-phase motors with internal overload protection and integral electric control panel and disconnect switch, **as directed**. Control capacity by cycling fans **OR** modulating fan speeds **OR** three-way refrigerant bypass with receiver and isolation valve, **as directed**.
- 5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating two-way **OR** three-way, **as directed**, control valve.
 - a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
 - b. Control Valve: Class 125 body.
 - 1) Maximum Pressure Drop: 3 psig (21 kPa) **OR** 5 psig (35 kPa), **as directed**, at design flow rate.
 - 2) Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
 - c. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

OR

Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, multiple direct-drive propeller fans with fan guards, and single-phase motors with internal overload protection and integral electric control panel. Control capacity by cycling fans.

- d. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- 6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing one **OR** two, **as directed**, centrifugal pump(s) with mechanical seals; electrical-control cabinet with starters, lead-lag switch, automatic switchover, and alarm light.
 - a. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, check valves in pump discharge, unions, and pressurized expansion tank with air purge vent and system-charging connection.
 - b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
 - c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- 7. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for minimum of three stages, with thermal safety switches, manual-reset overload protection, and branch-circuit overcurrent protection.

OR

Refrigerant Heating Coil: Hot-gas coil of seamless copper tubes expanded into aluminum fins with three-way solenoid valve on first-stage refrigerant circuit.

OR



Hot-Water Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve and strainer.

- a. Control Valve: Class 125 body.
 - 1) Maximum Pressure Drop: 3 psig (21 kPa) **OR** 5 psig (35 kPa), **as directed**, at design flow rate.
 - 2) Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

OR

Steam Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve, strainer, and float-and-thermostatic trap.

- b. Control Valve: Class 125 body.
 - 1) Maximum Pressure Drop (15-psig (103-kPa) Steam): 80 percent of inlet steam pressure.
 - 2) Close-Off (Differential) Pressure Rating: 150 percent of operating (inlet) pressure.
8. Extended-Surface, Disposable, Panel Filter: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame with 2-inch- (50-mm-) thick, disposable, glass-fiber prefilter, **as directed**.
 - a. Thickness: 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
 - b. Initial Resistance: as directed by the Owner.
 - c. Recommended Final Resistance: as directed by the Owner.
 - d. Arrestance (ASHRAE 52.1): 90 percent.
 - e. Merv (ASHRAE 52.2): 7.
 9. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and using condensate water from cooling coils with stainless-steel or brass float-valve mechanism; located in bypass airstream; with flush-cycle timer and solenoid drain valve.
 10. Evaporative Pan Humidifier: Stainless-steel pan and cover, serviceable without disconnecting water, drain, or electrical connections; prepiped with stainless-steel or brass float-valve mechanism; electric-resistance heating coil; low-water-cutoff switch; flush-cycle timer; and solenoid drain valve.
 11. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
 - a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 - b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 - c. Drain Cycle: Field-adjustable drain duration and drain interval.
 12. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.
 13. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
 14. Electronic-Control System: Solid state, with start button, stop button, temporary loss of power indicator, manual-reset circuit breakers, temperature control, humidity control, and monitor panel.
 - a. Monitor Panel: Backlighted, with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of airflow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
 - b. Temperature- and Humidity-Control Modules: Solid state, plug-in; with adjustable set point, push-to-test calibration check button, and built-in visual indicators to show mode of operation.
 - c. Location: Behind hinged door in front of unit; isolated from conditioned airstream to allow service while system is operating.



15. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence with room temperature and continues to display fault when malfunction is cleared until system is reset.
- a. Malfunctions:
 - 1) Power loss.
 - 2) Loss of airflow.
 - 3) Clogged air filter.
 - 4) High room temperature.
 - 5) Low room temperature.
 - 6) High humidity.
 - 7) Low humidity.
 - 8) Smoke/fire.
 - 9) Water under floor.
 - 10) Supply fan overload.
 - 11) Compressor No. 1 - Overload.
 - 12) Compressor No. 1 - Low Pressure.
 - 13) Compressor No. 1 - High Pressure.
 - 14) Compressor No. 2 - Overload.
 - 15) Compressor No. 2 - Low Pressure.
 - 16) Compressor No. 2 - High Pressure.
 - b. Digital Display:
 - 1) Control power on.
 - 2) Humidifying.
 - 3) Dehumidifying.
 - 4) Compressor No. 1 - Operating.
 - 5) Compressor No. 2 - Operating.
 - 6) Heat operating.
 - 7) Economy cooling.
 - c. Push buttons shall stop and start process cooling system, silence audible alarm, test indicators, and display room's relative humidity.
 - d. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display unit status and alarms.
 - 1) Hardwired Points:
 - a) Monitoring: On-off status, common trouble alarm **OR** space temperature **OR** space relative humidity, **as directed**.
 - b) Control: On-off operation, space temperature set-point adjustment **OR** space relative humidity set-point adjustment, **as directed**.
 - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.
- B. Floor-Mounted Units 5 Tons (18 kW) And Smaller
- 1. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.
 - 2. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with 1-inch- (25-mm-) thick duct liner.
 - a. Floor Stand: Welded tubular steel with adjustable legs and vibration isolation pads.
 - b. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 3. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.
 - 4. Refrigeration System:



- a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
 - b. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
 - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
 - d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
 - 1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
 - e. Integral, Water-Cooled Refrigerant Condenser: Brazed-plate type with liquid-line stop valve and head-pressure-actuated, two-way regulating valve.
 - 1) Cooling Medium: Water **OR** Glycol solution, **as directed**.

OR

Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct **OR** belt, **as directed**, driven.

 - 2) Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating three-way control valve.
- a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
 - b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
- OR**
- Remote Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.
- c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
- a. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
 - b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
 - c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.
8. Filter: 2-inch- (50-mm-) thick, disposable, glass-fiber media.
- a. Initial Resistance: as directed by the Owner.
 - b. Recommended Final Resistance: as directed by the Owner.
 - c. Arrestance (ASHRAE 52.1): 90 percent.
 - d. Merv (ASHRAE 52.2): 7.
9. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.
10. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.



- a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 - b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 - c. Drain Cycle: Field-adjustable drain duration and drain interval.
11. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
 12. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature- and humidity-, **as directed**, control modules, humidity contactor, **as directed**, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.
- C. Ceiling-Mounted Units
1. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting to fit T-bar ceiling opening of 24 by 48 inches (610 by 1220 mm).
 2. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch- (13-mm-) thick duct liner.
 - a. Integral factory-supplied supply and return grille to fit ceiling grid kit of 24 by 48 inches (610 by 1220 mm), with filter.
 - b. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 3. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.
 4. Refrigeration System:
 - a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
 - b. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
 - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
 - d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
 - 1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
 - e. Integral, Water-Cooled Refrigerant Condenser: Coaxial, counterflow, tube-in-tube **OR** Brazed-plate, **as directed**, type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
 - 1) Cooling Medium: Water **OR** Glycol solution, **as directed**.**OR**
Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct driven.
 - f. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
 5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.
 - a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
 - b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.**OR**
Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.



6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
 - a. Piping: Interconnecting piping, to and from remote, air-cooled glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
 - b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
 7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switches.
 8. Filter: 1-inch- (25-mm-) thick, disposable, glass-fiber media.
 - a. Initial Resistance: as directed by the Owner.
 - b. Recommended Final Resistance: as directed by the Owner.
 - c. Arrestance (ASHRAE 52.1): 90 percent.
 - d. Merv (ASHRAE 52.2): 7.
 9. Atomizing Humidifier: Centrifugal atomizer with stainless-steel pan, demister pad, and solenoid valve.
 10. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
 - a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 - b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 - c. Drain Cycle: Field-adjustable drain duration and drain interval.
 11. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
 12. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature- and humidity-, **as directed**, control modules, humidity contactor, **as directed**, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.
- D. Console Units
1. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.
 2. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.
 - a. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 3. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.
 4. Refrigeration System:
 - a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
 - b. Refrigeration Circuit: Filter/dryer, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
 - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
 - d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
 - 1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.



- e. Integral, Water-Cooled Refrigerant Condenser: Coaxial, counterflow, tube-in-tube **OR** Brazed-plate, **as directed**, type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
OR
Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct driven.
 - f. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
 - 5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve.
 - a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
 - b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.**OR**
Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motor with internal overload protection.
 - 6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
 - a. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
 - b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
 - 7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.
 - 8. Filter: Cleanable.
OR
Filter: 1-inch- (25-mm-) thick, disposable, glass-fiber media.
 - a. Initial Resistance: as directed by the Owner.
 - b. Recommended Final Resistance: as directed by the Owner.
 - c. Arrestance (ASHRAE 52.1): 90 percent.
 - d. Merv (ASHRAE 52.2): 7.
 - 9. Electrode Steam Humidifier: Self-contained and microprocessor controlled; with replaceable cylinder.
 - 10. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
 - 11. Control System: Unit-mounted panel with contactors, control transformer with circuit breaker, and solid-state temperature- and humidity-, **as directed**, control modules. Provide solid-state, unit-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.
- E. Fan Motors
- 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

1.3 EXECUTION

A. Installation



1. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B, **as directed**.
 2. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 3. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of size required to support weight of computer-room air conditioner.
 - a. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Fabricate brackets or supports as required.
 - b. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
 4. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 5. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
 - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
 6. Glycol-Solution Pump Package Mounting: Install using elastomeric pads **OR** elastomeric mounts, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- B. Connections
1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install piping adjacent to machine to allow service and maintenance.
 3. Water and Drainage Connections: Comply with applicable requirements in Division 22 Section "Domestic Water Piping". Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
 4. Hot-Water Heating Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Provide shutoff valves in inlet and outlet piping to heating coils.
 5. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam And Condensate Heating Piping". Provide shutoff valves in steam inlet and steam trap in condensate outlet piping to heating coils.
 6. Condenser-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Provide shutoff valves in water inlet and outlet piping on water-cooled units.
 7. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping". Provide shutoff valves and piping.
- C. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - b. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.



- d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
 4. Prepare test and inspection reports.
 5. After startup service and performance test, change filters and flush humidifier.
- D. Adjusting
1. Adjust initial temperature and humidity, **as directed**, set points.
 2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 23 81 23 00



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23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 43 00	23 81 13 00	Packaged Terminal Air Conditioners
23 81 49 00	23 63 13 00a	Split-System Air-Conditioning Units



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**SECTION 23 82 16 00 - AIR COILS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for air coils. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following types of air coils that are not an integral part of air-handling units:
 - a. Hot-water.
 - b. Chilled-water.
 - c. Steam.
 - d. Refrigerant.
 - e. Electric.

C. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil. Include rated capacity and pressure drop for each air coil.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and maintenance data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance:
 - a. Comply with ASHRAE 15 for refrigeration system safety.
 - b. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
 - c. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

1.2 PRODUCTS

A. Water Coils

1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure/Temperature Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
3. Source Quality Control: Factory tested to 300 psig (2070 kPa).
4. Tubes: ASTM B 743 copper, minimum 0.020 inch (0.508 mm) **OR** 0.035 inch (0.889 mm) **OR** 0.049 inch (1.245 mm), **as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum 0.006 inch (0.152 mm) **OR** 0.010 inch (0.254 mm), **as directed**, thick.
6. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Steel with brazed joints, prime coated, **as directed**.
7. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.6 mm), **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.

**OR**

Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum 0.0625 inch (1.6 mm) thick for slip-in **OR** flanged, **as directed**, mounting.

8. Hot-Water Coil and Steam Coil, Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.
 - a. Coil Configuration: Horizontal **OR** Vertical, **as directed**, tubes.
 - b. Dampers: Extruded-aluminum **OR** Galvanized-steel, **as directed**, blades with edge and end seals; full-length drive rod and mount for actuator in **OR** outside, **as directed**, the airstream.

B. Steam Coils

1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure/Temperature Ratings: 100 psig (690 kPa), 400 deg F (204 deg C).
3. Source Quality Control: Factory tested to 300 psig (2070 kPa).
4. Tubes: ASTM B 743 copper, minimum 0.025 inch (0.635 mm) **OR** 0.035 inch (0.889 mm) **OR** 0.049 inch (1.245 mm), **as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum 0.006 inch (0.152 mm) **OR** 0.010 inch (0.254 mm), **as directed**, thick.
6. Headers: Cast iron with drain and air vent tapplings **OR** Cast iron with cleaning plugs, and drain and air vent tapplings **OR** Seamless copper tube with brazed joints, prime coated **OR** Steel with brazed joints, prime coated, **as directed**.
7. Tube Type: Single or distributing as indicated.
8. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.6 mm), **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.

OR

Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum 0.0625 inch (1.6 mm) thick for slip-in **OR** flanged, **as directed**, mounting.

9. Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.
 - a. Coil Configuration: Horizontal **OR** Vertical, **as directed**, tubes.
 - b. Dampers: Extruded-aluminum **OR** Galvanized-steel, **as directed**, blades with edge and end seals; full-length drive rod and mount for actuator in **OR** outside, **as directed**, the airstream.

C. Refrigerant Coils

1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure Rating: 300 psig (2070 kPa).
3. Source Quality Control: Factory tested to 450 psig (3105 kPa).
4. Tubes: ASTM B 743 copper, minimum 0.020 inch (0.508 mm) **OR** 0.035 inch (0.889 mm) **OR** 0.049 inch (1.245 mm), **as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum 0.006 inch (0.152 mm) **OR** 0.010 inch (0.254 mm), **as directed**, thick.
6. Suction and Distributor Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper tube with brazed joints.
7. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.6 mm), **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.

OR

Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum 0.0625 inch (1.6 mm) thick for slip-in **OR** flanged, **as directed**, mounting.

D. Electric Coils

1. Coil Assembly: Comply with UL 1995.



2. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
OR
Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, and fastened to supporting brackets.
3. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.
 - a. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
4. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.6 mm), **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.
5. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection. Include the following controls:
 - a. Magnetic contactor.
 - b. Mercury contactor.
 - c. Toggle switches; one per step.
 - d. Step controller.
 - e. Time-delay relay.
 - f. Pilot lights; one per step.
 - g. Airflow proving switch.
6. Refer to Division 23 Section "Instrumentation And Control For Hvac" for thermostat.
OR
Thermostats: Wall-mounted thermostats, with temperature range from 50 to 90 deg F (10 to plus 32 deg C), and 2.5 deg F (1.4 deg C) throttling range.

1.3 EXECUTION

A. Installation

1. Install coils level and plumb.
2. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
3. Install galvanized-steel **OR** stainless-steel, **as directed**, drain pan under each cooling coil.
 - a. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1, **as directed**.
 - b. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
 - c. Extend drain pan upstream and downstream from coil face.
 - d. Extend drain pan under coil headers and exposed supply piping.
4. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
5. Straighten bent fins on air coils.
6. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to coils to allow service and maintenance.
3. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Division 23 Section "Instrumentation And Control For Hvac", and other piping specialties are specified in Division 23 Section "Hydronic Piping".
4. Connect steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping. Control



valves are specified in Division 23 Section "Instrumentation And Control For Hvac", and other piping specialties are specified in Division 23 Section "Steam And Condensate Heating Piping".

5. Connect refrigerant piping according to Division 23 Section "Refrigerant Piping".
6. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
7. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
 - a. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 82 16 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 16 00	23 74 13 00b	Unit Ventilators
23 82 19 00	23 64 16 16	Fan-Coil Units



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SECTION 23 82 29 00 - CONVECTION HEATING UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for convection heating units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Hydronic, Steam, and Electric baseboard radiators.
 - b. Hydronic, Steam, and Electric finned-tube radiators.
 - c. Hydronic, Steam, and Electric convectors.
 - d. Flat-pipe steel radiators.

C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Field quality-control test reports.
4. Operation and maintenance data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Electric Baseboard Radiators

1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.
3. Enclosures: Minimum 0.0329-inch- (0.85-mm-) **OR** 0.0428-inch- (1.1-mm-), **as directed**, thick steel, removable front cover.
4. Rust-Resistant Enclosures: Minimum 0.040-inch- (1.0-mm-) **OR** 0.052-inch- (1.3-mm-), **as directed**, thick ASTM A 653/A 653M, G60 galvanized-steel, removable front cover.
 - a. Full-height back.
 - b. Full-length damper.
 - c. End panel.
 - d. Plastic end **OR** End, **as directed**, caps.
 - e. Inside and outside corners.
 - f. Joiner pieces to snap together.
 - g. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
 - h. Element Brackets: Primed and painted steel to support front panel and element.
5. Unit Controls: Integral line-voltage thermostat **OR** Integral electronic thermostat **OR** Remote line-voltage thermostat, **as directed**.



6. Accessories:
 - a. Filler sections without a heating element matching the adjacent enclosure.
 - b. Straight-blade-type receptacles complying with DSCC W-C-596G/GEN, NEMA WD 1, NEMA WD 6, and UL 498; in color selected.
- B. Hot-Water Baseboard Radiators
1. Performance Ratings: Rate baseboard radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Baseboard Radiation."
 2. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on polypropylene element glides. One end of tube shall be belled.
 - a. Tube Diameter: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20) **OR** NPS 1 (DN 25) **OR** NPS 1-1/4 (DN 32), **as directed**.
 - b. Fin Size: 2-1/2 by 2-1/2 inches (63 by 63 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**.
 - c. Fin Spacing: 40 per foot (131 per meter) **OR** 50 per foot (164 per meter) **OR** 58 per foot (190 per meter), **as directed**.
 - d. Entering Air Temperature: 65 deg F (18 deg C).
 - e. Average Water Temperature: 180 deg F (82 deg C).
 - f. Minimum Water Velocity: 1/2 fps (0.15 m/s).
 - g. Entering Steam Pressure: 1 psig (6.9 kPa).
 3. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on polypropylene element glides. Tube ends shall be threaded.
 - a. Tube Diameter: NPS 1-1/4 (DN 32).
 - b. Fin Size: 3 by 3 inches (76 by 76 mm).
 - c. Fin Spacing: 52 per foot (171 per meter).
 - d. Entering Air Temperature: 65 deg F (18 deg C).
 - e. Average Water Temperature: 180 deg F (82 deg C).
 - f. Minimum Water Velocity: 1/2 fps (0.15 m/s).
 - g. Entering Steam Pressure: 1 psig (6.9 kPa).
 4. Enclosures: Minimum 0.0329-inch- (0.85-mm-) **OR** 0.0428-inch- (1.1-mm-), **as directed**, thick steel, removable front cover.
 5. Rust-Resistant Enclosures: Minimum 0.040-inch- (1.0-mm-) **OR** 0.052-inch- (1.3-mm-), **as directed**, thick ASTM A 653/A 653M, G60 galvanized-steel, removable front cover.
 - a. Full-height back.
 - b. Full-length damper.
 - c. End panel.
 - d. End caps.
 - e. Inside and outside corners.
 - f. Valve access door.
 - g. Joiner pieces to snap together.
 - h. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
 - i. Element Brackets: Primed and painted steel to support front panel and element.
- C. Electric Finned-Tube Radiators
1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
 2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded into fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.
 3. Front Panel: Minimum 0.0428-inch- (1.1-mm-) **OR** 0.0528-inch- (1.35-mm-), **as directed**, thick steel.
 4. Rust-Resistant Front Panel: Minimum 0.052-inch- (1.3-mm-) **OR** 0.064-inch- (1.6-mm-), **as directed**, thick ASTM A 653/A 653M, G60 galvanized steel.
 5. Wall-Mounting Back Panel: Minimum 0.0329-inch- (0.85-mm-) thick steel, full height, with full-length channel support for front panel without exposed fasteners.



6. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
 7. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
 8. Finish: Baked-enamel **OR** epoxy, **as directed**, finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
 9. Damper: Knob-operated internal damper at enclosure outlet.
 10. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
 11. Enclosure Style: Sloped **OR** Flat, **as directed**, top.
 - a. Front Inlet Grille: Punched louver; painted to match enclosure.
 - b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
 - 3) Painted to match enclosure.
 - c. Top **OR** Front, **as directed**, Outlet Grille: Punched louver; painted to match enclosure.
 - d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
 - 3) Painted to match enclosure.
 12. Unit Controls: Integral line-voltage thermostat with minimum range of 60 to 90 deg F (15 to 32 deg C) **OR** low-voltage relay and control transformer for remote thermostat, **as directed**.
 13. Accessories: Integral disconnect switch, filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.
- D. Hot-Water Finned-Tube Radiators
1. Performance Ratings: Rate finned-tube radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."
 2. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One tube end shall be belled.
 - a. Tube Diameter: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25) **OR** NPS 1-1/4 (DN 32), **as directed**.
 - b. Fin Size: 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**.
 - c. Fin Spacing: 40 per foot (131 per meter) **OR** 50 per foot (164 per meter) **OR** 58 per foot (190 per meter), **as directed**.
 - d. Entering Air Temperature: 65 deg F (18 deg C).
 - e. Average Water Temperature: 180 deg F (82 deg C).
 - f. Minimum Water Velocity: 1/2 fps (0.15 m/s).
 - g. Entering Steam Pressure: 1 psig (6.9 kPa).
 3. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on element supports. Tube ends shall be threaded.
 - a. Tube Diameter: NPS 1-1/4 (DN 32).
 - b. Fin Size: 4 by 4 inches (102 by 102 mm).
 - c. Fin Spacing: 52 per foot (171 per meter).
 - d. Entering Air Temperature: 65 deg F (18 deg C).
 - e. Average Water Temperature: 180 deg F (82 deg C).
 - f. Minimum Water Velocity: 1/2 fps (0.15 m/s).
 - g. Entering Steam Pressure: 1 psig (6.9 kPa).
 4. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
 5. Front Panel: Minimum 0.0428-inch- (1.1-mm-) **OR** 0.0528-inch- (1.35-mm-), **as directed**, thick steel.
 6. Rust-Resistant Front Panel: Minimum 0.052-inch- (1.3-mm-) **OR** 0.064-inch- (1.6-mm-), **as directed**, thick, ASTM A 653/A 653M, G60 galvanized steel.



7. Wall-Mounting Back Panel: Minimum 0.0329-inch- (0.85-mm-) thick steel, full height, with full-length channel support for front panel without exposed fasteners.
8. Floor-Mounting Pedestals: Conceal insulated piping at maximum 36-inch (914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.
9. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
10. Finish: Baked-enamel **OR** epoxy, **as directed**, finish in manufacturer's standard **OR** custom, **as directed** color as selected.
11. Damper: Knob-operated internal damper at enclosure outlet.
12. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
13. Enclosure Style: Sloped **OR** Flat, **as directed**, top.
 - a. Front Inlet Grille: Punched louver; painted to match enclosure.
 - b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
 - 3) Painted to match enclosure.
 - c. Top **OR** Front, **as directed**, Outlet Grille: Punched louver; painted to match enclosure.
 - d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
 - 3) Painted to match enclosure.
14. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

E. Electric Convectors

1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded into fins, with high-temperature cutout and sensor running the full length of element. Element supports shall eliminate thermal expansion noise.
 - a. Heat Output: 300 **OR** 500 **OR** 750 **OR** 1000 **OR** 1250 **OR** 1500 **OR** 1750 **OR** 2000 **OR** 2250 **OR** 2500, **as directed**, W.
3. Front and Top Panel: Minimum 0.0528-inch- (1.35-mm-) **OR** 0.0677-inch- (1.7-mm-), **as directed** thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
4. Wall-Mounting Back and End Panels: Minimum 0.0428-inch- (1.1-mm-) thick steel.
5. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
6. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
7. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside of the back of the enclosure.
8. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
9. Damper: Knob-operated internal damper.
10. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
11. Enclosure Style: Sloped **OR** Flat, **as directed**, top.
 - a. Front Inlet Grille: Punched louver; painted to match enclosure.
 - b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.



- 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
 - 3) Painted to match enclosure.
 - c. Top **OR** Front, **as directed**, Outlet Grille: Punched louver; painted to match enclosure.
 - d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
 - 3) Painted to match enclosure.
 12. Unit Controls: Integral line-voltage thermostat with minimum range of 60 to 90 deg F (15 to 32 deg C) **OR** low-voltage relay and control transformer for remote thermostat, **as directed**.
 13. Accessories: Integral disconnect switch, recessing flanges finished to match enclosure or overlapping front cover for fully recessed units, and rubber gaskets to seal cabinet at wall.
- F. Hot-Water Or Steam Convectors
 1. Convector Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum 100 psig (690 kPa).
 - a. Entering Air Temperature: 65 deg F (18 deg C).
 - b. Average Water Temperature: 180 deg F (82 deg C).
 - c. Temperature Drop: 10 deg F (5.56 deg C) **OR** 20 deg F (11.1 deg C) **OR** 30 deg F (16.6 deg C), **as directed**.
 - d. Entering Steam Pressure: 1 psig (6.9 kPa).
 2. Front and Top Panel: Minimum 0.0528-inch- (1.35-mm-) **OR** 0.0677-inch- (1.7-mm-), **as directed**, thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
 3. Wall-Mounting Back and End Panels: Minimum 0.0428-inch- (1.1-mm-) thick steel.
 4. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
 5. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
 6. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside of the back of the enclosure.
 7. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed** color as selected.
 8. Damper: Knob-operated internal damper.
 9. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
 10. Enclosure Style: Sloped **OR** Flat, **as directed**, top.
 - a. Front Inlet Grille: Punched louver; painted to match enclosure.
 - b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
 - 3) Painted to match enclosure.
 - c. Top **OR** Front, **as directed**, Outlet Grille: Punched louver; painted to match enclosure.
 - d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
 - 3) Painted to match enclosure.
- G. Flat-Pipe Steel Radiators
 1. Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of 0.109 inches (2.76 mm). Include threaded piping and air vent connections.



- a. Working Pressure 56 psig (386 kPa): 0.048 inch (1.22 mm).
 - b. Working Pressure 85 psig (585 kPa): 0.058 inch (1.47 mm).
 - c. Working Pressure 128 psig (881 kPa): 0.078 inch (1.98 mm).
 - d. Room Air Temperature: 65 deg F (18 deg C).
 - e. Average Water Temperature: 180 deg F (82 deg C).
 - f. Temperature Drop: 10 deg F (5.56 deg C) **OR** 20 deg F (11.1 deg C) **OR** 30 deg F (16.6 deg C), **as directed**.
2. Mounting: Wall brackets **OR** Floor pedestals, **as directed**, on maximum spacing of 36 inches (914 mm).
 3. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
 4. Accessories:
 - a. Steel piping covers finished to match radiator finish.
 - b. Flexible Expansion Compensation Hoses: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99.5 deg C).
 - 1) Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
 - 2) Minimum Diameter: Equal to connection size.

1.3 EXECUTION

A. Baseboard Radiator Installation

1. Install units level and plumb.
2. Install baseboard radiators according to Guide 2000 - Residential Hydronic Heating.
3. Install enclosure continuously around corners, using outside and inside corner fittings.
4. Join sections with splice plates and filler pieces to provide continuous enclosure.
5. Install access doors for access to valves.
6. Install enclosure continuously from wall to wall.
7. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
8. Install valves within reach of access door provided in enclosure.
9. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.
10. Install piping within pedestals for freestanding units.

B. Finned-Tube Radiator Installation

1. Install units level and plumb.
2. Install finned-tube radiators according to Guide 2000 - Residential Hydronic Heating.
3. Install enclosure continuously around corners, using outside and inside corner fittings.
4. Join sections with splice plates and filler pieces to provide continuous enclosure.
5. Install access doors for access to valves.
6. Install enclosure continuously from wall to wall.
7. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.
8. Install valves within reach of access door provided in enclosure.
9. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.
10. Install piping within pedestals for freestanding units.

C. Convector Installation

1. Install units level and plumb.
2. Install valves within reach of access door provided in enclosure.
3. Install air-seal gasketing between wall and recessing flanges or front cover of fully recessed unit.
4. Install piping within pedestals for freestanding units.

D. Flat-Pipe Steel Radiator Installation

1. Install units level and plumb.



2. Install expansion compensation hoses.
3. Install piping covers.

E. Connections

1. Piping installation requirements are specified in Division 23 Section(s) "Hydronic Piping" OR "Steam And Condensate Heating Piping", **as applicable**. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect hot-water units and components to piping according to Division 23 Section "Hydronic Piping".
 - a. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
3. Connect steam units and components to piping according to Division 23 Section "Steam And Condensate Heating Piping".
 - a. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.
4. Install control valves as required by Division 23 Section "Instrumentation And Control For Hvac".
5. Install piping adjacent to convection heating units to allow service and maintenance.
6. Ground electric convection heating units according to Division 26 Section "Grounding And Bonding For Electrical Systems".
7. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

F. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
 - a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper convection heating unit operation.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

END OF SECTION 23 82 29 00



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Task	Specification	Specification Description
23 82 29 00	01 22 16 00	No Specification Required
23 82 33 00	01 22 16 00	No Specification Required
23 82 33 00	23 82 29 00	Convection Heating Units
23 82 36 00	01 22 16 00	No Specification Required
23 82 36 00	23 82 29 00	Convection Heating Units
23 82 39 13	01 22 16 00	No Specification Required
23 82 39 13	23 55 33 00a	Unit Heaters
23 82 39 16	01 22 16 00	No Specification Required
23 82 39 16	23 55 33 00a	Unit Heaters
23 82 39 19	01 22 16 00	No Specification Required
23 82 39 19	23 55 33 00a	Unit Heaters
23 83 13 00	07 72 56 00	Radiant-Heating Electric Cables
23 83 13 00	07 72 56 00a	Heat Tracing for Fire-Suppression Piping
23 83 13 00	07 72 56 00b	Heat Tracing for Plumbing Piping
23 83 13 00	07 72 56 00c	Heat Tracing for HVAC Piping



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**SECTION 23 84 13 00 - HUMIDIFIERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for humidifiers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following humidifiers:
 - a. Atomizing.
 - b. Steam injection.
 - c. Self-contained.
 - d. Heated pan.
 - e. Heat exchanger.

C. Definition

1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with ARI 640, "Commercial and Industrial Humidifiers."

1.2 Products

A. Water-Pressure Atomizing Humidifiers

1. Nozzles: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel.
2. Manifold: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel piping.
3. Droplet Filter: Biocide-treated polyethylene with maximum 0.30-inch wg (75-Pa) resistance.
4. Piping and Fittings: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel pipe and fittings.
OR
Piping and Fittings: ASTM B 88 (ASTM B 88M), Type L copper pipe and wrought-copper fittings with brazed joints.
5. Water Pump: Enclosed belt-drive ceramic plunger pump with stainless-steel **OR** bronze, **as directed**, heads, and single **OR** variable, **as directed**, -speed, totally enclosed, fan-cooled motor.
6. Final Water-Filter Efficiency: Minimum 98 percent retention of suspended particles 10 **OR** 20, **as directed**, microns and larger from makeup water.



7. Final Water-Filter Pressure Drop: Maximum 2 psig (14 kPa) at design flow when clean, and **<Insert value>** when dirty, **as directed**.
 8. Pump Controls:
 - a. Cycle **OR** Vary speed of, **as directed**, motor to satisfy humidistat.
 - b. High-pressure solenoid valve for each control zone shown on Drawings.
 - c. Building automation system interface for each control zone for start/stop and status indication and control at central workstation.
 9. Dispersion Fan:
 - a. Aluminum blade propeller fan with finger guard and single-speed motor interlocked to operate with humidifier.
 - b. Fan Mounting: Above and behind manifold on bracket integral to wall-mounting manifold.
 10. Accessories:
 - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full-modulation or cycling control.
 - b. Duct-mounting, high-limit humidistat.
 - c. Airflow switch for preventing humidifier operation without airflow.
- B. Compressed-Air Atomizing Humidifiers
1. Nozzles: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel.
 2. Manifold: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel piping.
 3. Droplet Filter: Biocide-treated polyethylene with maximum 0.30-inch wg (75-Pa) resistance.
 4. Piping and Fittings: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel pipe and fittings.
 5. Compressed-Air and Water, **as directed**, Piping and Fittings: ASTM B 88 (ASTM B 88M), Type L copper pipe and wrought-copper fittings with soldered joints.
 6. Final Water-Filter Efficiency: Minimum 98 percent retention of suspended particles 10 **OR** 20, **as directed**, microns and larger from makeup water.
 7. Final Water-Filter Pressure Drop: Maximum 2 psig (14 kPa) at design flow when clean, and **<Insert value>** when dirty, **as directed**.
 8. Air and Water Solenoid Controls:
 - a. Cycle valves to satisfy humidistat.
 - b. Solenoid valves for each control zone shown on Drawings.
 - c. Building automation system interface for each control zone for start/stop and status indication and control at central workstation.
 9. Dispersion Fan:
 - a. Aluminum blade propeller fan with finger guard and single-speed motor interlocked to operate with humidifier.
 - b. Fan Mounting: Above and behind manifold on bracket integral to wall-mounting manifold.
 10. Accessories:
 - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full-modulation or cycling control.
 - b. Duct-mounting, high-limit humidistat.
 - c. Airflow switch for preventing humidifier operation without airflow.
- C. Steam-Injection Humidifiers
1. Manifold: ASTM A 666, Type 304 stainless steel, steam jacketed, **as directed**; insulated with 1/2-inch (13-mm) fiberglass and stainless-steel jacket; and , **as directed**, extending the full width of duct or plenum with mounting brackets at ends.
 2. Discharge Nozzle and Dispersion Fan:
 - a. Steam-jacketed discharge nozzle, aluminum blade propeller fan with finger guard, and single-speed motor interlocked to operate with humidifier.
 - b. Fan Mounting: Above and behind discharge outlet on bracket integral to discharge outlet.
 3. Steam Separator: Cast iron **OR** ASTM A 666, Type 304 stainless steel, **as directed**, with separate, **as directed**, humidifier control valve.
 4. Humidifier Control Valve:



- a. Actuator: Pneumatic **OR** Electric, **as directed**, modulating with spring return.
OR
Actuator: As specified in Division 23 Section "Instrumentation And Control For Hvac".
5. Steam Trap: Inverted-bucket type, sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) inlet pressure.
6. Accessories:
 - a. Wall **OR** Return-duct, **as directed**, -mounting humidistat.
 - b. Duct-mounting, high-limit humidistat.
 - c. Aquastat mounted on steam condensate return piping to prevent cold operation of humidifier.
 - d. In-line strainer.
 - e. Airflow switch for preventing humidifier operation without airflow.
- D. Self-Contained Humidifiers
 1. Electric-Resistance Heater Container: Cleanable, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel. Comply with UL 499.
 2. Electrode Cylinder: Replaceable plastic assembly with disposable ionic bed inserts, **as directed**. Comply with UL 499.
 3. Gas-Fired Steam Generator: Factory assembled and tested.
 - a. Standard: Fabricate and label steam generator to comply with CSA.
 - b. Maximum Steam Pressure: 10 inches wg (2488 Pa).
 - c. Burner Type: Natural-gas **OR** Propane, **as directed**, fired with modulating, low NOx infrared burner, minimum 82 percent efficient.
 - d. Gas Train: Safety shutoff valves, gas cock, strainer, pressure-regulating valve.
 - e. Ignition: Hot-surface ignition with flame safety system.
 - f. Combustion Chamber: Sealed with outdoor-air and flue-vent connections.
 - g. Heat-Exchanger Tank: Cleanable, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating and disposable ionic bed inserts, **as directed**.
 4. Manifold: Stainless-steel tube with integral fan to discharge vapor directly into occupied space.
OR
Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube extending across entire width of duct or plenum and equipped with mounting brackets on ends.
 5. Cabinet: Sheet metal enclosure for housing heater cylinder, electrical wiring, components, controls, and control panel. Enclosure shall include baked-enamel finish, hinged or removable access door, and threaded outlet in bottom of cabinet for drain piping.
 6. Control Panel:
 - a. Factory-wired disconnect switch.
 - b. Liquid-crystal display.
 - c. Programmable keyboard.
 - d. Set-point adjustment.
 - e. Warning signal indicating end of replaceable cylinder or ionic bed insert, **as directed**, life.
 - f. Low-voltage, control circuit.
 - g. Diagnostic, maintenance, alarm, and status features.
 - h. High-water sensor **OR** float, **as directed**, to prevent overfilling.
 7. Controls:
 - a. Microprocessor-based control system for modulating or cycling control, and start/stop and status monitoring for interface to central HVAC instrumentation and controls.
 - b. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
 - c. Field-adjustable timer to control drain cycle for flush duration and interval.
 - d. Controls shall drain tanks if no demand for humidification for more than 72 hours.
 - e. Conductivity **OR** Float, **as directed**, -type level controls.
 8. Accessories:
 - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
 - b. Duct-mounting, high-limit humidistat.
 - c. Airflow switch for preventing humidifier operation without airflow.



E. Heated-Pan Humidifiers

1. Heat Source: Hot water **OR** Steam **OR** Electric resistance, **as directed**.
2. Comply with UL 499.
3. Pan and Heat-Exchange Piping: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating, overflow, and drain fittings. Include disposable ionic bed inserts, **as directed**.
4. Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel, duct-mounting, single- or manifold-grid connected to heated-pan housing with flexible hose and extending across width of duct or plenum. Manifold shall have mounting brackets at both ends.
OR
Manifold: Inverted, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel U-tube with humidifier mounted directly under the duct.
OR
Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube with flexible hose to connect to humidifier, integral fan to discharge vapor directly into occupied space, and wall- or ceiling-mounting brackets.
5. Controls:
 - a. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
 - b. Field-adjustable timer to control drain cycle for flush duration and interval.
 - c. Conductivity **OR** Float, **as directed**, -type level controls.
6. Piping Specialties: Inlet strainer, control valve, and steam trap.
7. Piping Specialties: Inlet strainer and control valve.
8. Accessories:
 - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
 - b. Duct-mounting, high-limit humidistat.
 - c. Airflow switch for preventing humidifier operation without airflow.

F. Heat-Exchanger Humidifiers

1. Fabricate and label steam generator to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Heat Exchanger: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating, overflow, and drain fittings. Include disposable ionic bed inserts, **as directed**.
3. Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel, steam-jacketed, **as directed**, duct-mounting, single- or manifold-grid connected to steam generator with flexible hose and extending across width of duct or plenum. Manifold shall have mounting brackets for both ends. Insulate with 1/2-inch (13-mm) fiberglass and stainless-steel jacket extending full width of duct or plenum with mounting brackets at ends, **as directed**.
OR
Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube with flexible hose to connect to humidifier and integral fan to discharge vapor directly into occupied space. Manifold shall have wall- or ceiling-mounting brackets.
4. Controls:
 - a. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
 - b. Field-adjustable timer to control drain cycle for flush duration and interval.
 - c. Conductivity **OR** Float, **as directed**, -type level controls.
5. Accessories:
 - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full modulation.
 - b. Duct-mounting, high-limit humidistat.
 - c. Airflow switch for preventing humidifier operation without airflow.



1.3 EXECUTION

A. Installation

1. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1, **as directed**.
2. Seal humidifier manifold duct or plenum penetrations with flange.
3. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
4. Install galvanized **OR** stainless, **as directed**, -steel drain pan under each manifold mounted in duct.
 - a. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1, **as directed**.
 - b. Connect to condensate trap and drainage piping.
 - c. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.
5. Install manifold supply piping pitched to drain condensate back to humidifier.
6. Install drip leg upstream from steam trap a minimum of 12 inches (300 mm) tall for proper operation of trap.
7. Install steam generator level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac".
8. Concrete Bases: Anchor steam generator to concrete base.
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - e. Cast-in-place concrete materials and placement requirements are specified in Division 31.
9. Install seismic restraints on humidifiers. Seismic restraints are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
10. Install gas-fired steam generators according to NFPA 54.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
 - a. Install piping adjacent to humidifiers to allow service and maintenance.
 - b. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
2. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.
3. Install piping from safety relief valves to nearest floor drain.
4. Connect gas piping full size to steam-generator, gas-train inlet with union. Gas piping materials and specialties are specified in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**.
5. Connect breeching full size to steam-generator outlet. Venting materials are specified in Division 23 Section "Breechings, Chimneys, And Stacks".
6. Connect combustion-air inlet to intake terminal using PVC piping with solvent-cemented joints. Run from boiler connection to outside and terminate adjacent to flue termination.
7. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
8. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:



-
- a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning units and retest as specified above.

D. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION 23 84 13 00



23 - Heating, Ventilating, And Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 84 16 33	01 22 16 00	No Specification Required
23 84 16 33	23 76 13 00	Dehumidification Units



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Task	Specification	Specification Description
26 01 30 91	01 22 16 00	No Specification Required
26 01 50 51	01 22 16 00	No Specification Required
26 01 50 51	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 01 50 51	02 84 16 00a	Interior Lighting
26 01 50 51	02 84 16 00b	Exterior Lighting
26 01 50 52	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 01 50 52	02 84 16 00a	Interior Lighting
26 01 50 52	02 84 16 00b	Exterior Lighting
26 01 50 53	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 01 50 53	02 84 16 00a	Interior Lighting
26 01 50 53	02 84 16 00b	Exterior Lighting



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SECTION 26 05 00 00 - COMMON WORK RESULTS FOR ELECTRICAL

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for electrical. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Electrical equipment coordination and installation.
 - b. Sleeves for raceways and cables.
 - c. Sleeve seals.
 - d. Grout.
 - e. Common electrical installation requirements.

C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

D. Submittals

1. Product Data: For sleeve seals.

1.2 PRODUCTS

A. Sleeves For Raceways And Cables

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - a. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - 2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

B. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

C. Grout



1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

1.3 EXECUTION

A. Common Requirements For Electrical Installation

1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

B. Sleeve Installation For Electrical Penetrations

1. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
7. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
11. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

C. Sleeve-Seal Installation

1. Install to seal exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve



seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Firestopping

1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping".

END OF SECTION 26 05 00 00



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SECTION 26 05 13 00 - CONDUCTORS AND CABLES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of conductors and cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Building wires and cables rated 600 V and less.
 - b. Connectors, splices, and terminations rated 600 V and less.
 - c. Sleeves and sleeve seals for cables.

C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

D. Submittals

1. Product Data: For each type of product indicated.
2. Field quality-control test reports.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Conductors And Cables

1. Aluminum and Copper, **as directed**, Conductors: Comply with NEMA WC 70.
2. Conductor Insulation: Comply with NEMA WC 70 for Types THW **OR** THHN-THWN **OR** XHHW **OR** UF **OR** USE **OR** SO, **as directed**.
3. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC **OR** metal-clad cable, Type MC **OR** mineral-insulated, metal-sheathed cable, Type MI **OR** nonmetallic-sheathed cable, Type NM **OR** Type SO **OR** Type USE, **as directed**, with ground wire.

B. Connectors And Splices

1. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

C. Sleeves For Cables

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
4. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".



D. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

1.3 EXECUTION

A. Conductor Material Applications

1. Feeders: Copper **OR** Aluminum for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger, **as directed**. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
2. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Conductor Insulation And Multiconductor Cable Applications And Wiring Methods

1. Service Entrance: Type THHN-THWN, single conductors in raceway **OR** Type XHHW, single conductors in raceway **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Type SE or USE multiconductor cable, **as directed**.
2. Exposed Feeders: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
3. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
4. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway **OR** Underground feeder cable, Type UF, **as directed**.
5. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.
6. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
7. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
8. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
9. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway **OR** Underground branch-circuit cable, Type UF, **as directed**.
10. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.



11. Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.
 12. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
 13. Class 1 Control Circuits: Type THHN-THWN, in raceway.
 14. Class 2 Control Circuits: Type THHN-THWN, in raceway **OR** Power-limited cable, concealed in building finishes **OR** Power-limited tray cable, in cable tray, **as directed**.
- C. Installation Of Conductors And Cables
1. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
 2. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
 4. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
 5. Support cables according to Division 26 Section "Hangers And Supports For Electrical Systems".
 6. Identify and color-code conductors and cables according to Division 26 Section "Identification For Electrical Systems".
 7. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
 8. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - a. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
 9. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) **OR** 12 inches (300 mm), **as directed**, of slack.
- D. Sleeve Installation For Electrical Penetrations
1. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".
 2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
 3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 4. Rectangular Sleeve Minimum Metal Thickness:
 - a. For sleeve rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
 5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
 6. Cut sleeves to length for mounting flush with both wall surfaces.
 7. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
 8. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance, **as directed**.
 9. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies, **as directed**.
 10. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants".



11. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping".
12. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
13. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
14. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

E. Sleeve-Seal Installation

1. Install to seal underground exterior-wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

F. Firestopping

1. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping".

G. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
 - a. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services, **as directed**, for compliance with requirements.
 - b. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - c. Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - 1) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Final Completion.
 - 2) Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3) Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
4. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 13 00



SECTION 26 05 13 00a - UNDERCARPET CABLES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of undercarpet cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Undercarpet cable and service fittings for branch circuits.
 - b. Undercarpet cable and service fittings for communication and data transmission.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details of components, and attachments to other work.
 - a. Indicate cable types, accessories, and transition boxes.
 - b. Indicate proposed layering of cables, cable dimensions, and installation requirements.
3. Field quality-control test reports.
4. Operation and maintenance data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NEMA UC 2, "Undercarpet Power Distribution Systems" and with NFPA 70.

1.2 PRODUCTS

A. Power Distribution Cable

1. Cable: Factory laminated and complying with NEMA UC 2; three-piece assembly including bottom shield, conductor assembly, and top shield.
 - a. Bottom Shield: Abrasion resistant, nonmetallic **OR** Metallic, **as directed**.
 - b. Conductor Assembly: Two **OR** Three **OR** Four, **as directed**, -wire branch circuit with insulated ground, **as directed**.
 - c. Top Shield: Copper or copper alloy.
2. Current Rating: 20 **OR** 30 **OR** 20 and 30, **as directed**, A.

B. Communication And Data Cable

1. Category 5e Communication and Data Cable: Extruded-vinyl jacket over 4 unshielded, twisted pairs, No. 24 AWG, copper; complying with TIA/EIA 568-B; and tested to 300-lb (136-kg) rollover test.

C. Pedestals

1. Description: Manufacturer's standard low **OR** regular, **as directed**, -profile type, single **OR** two **OR** three, **as directed**, gang with single **OR** duplex, **as directed**, receptacles and Category 5e modular connectors, **as directed**.
 - a. Pedestal Colors: As selected from manufacturer's full range.

D. Power Cable Transition Unit



1. Description: Interface transition unit, with junction box, for connecting three-, four-, or five-conductor, flat-conductor cable to building wiring system.

E. Communication And Data Cable Transition Unit

1. Description: Category 5 transition termination circuit board in wall-mounted box to convert round incoming cable to outgoing flat-undercarpet cable.

1.3 EXECUTION

A. Installation

1. Do not begin installation until heavy construction is completed and wheeled traffic is no longer a threat.
2. Do not stack cables in circulation routes.
3. Limit total installed height to 0.09 inch (2.29 mm).
4. Install cables in proper order with power-transmission cable first, followed by telephone cable and then data cable. Cross cables at 90-degree angles.
5. Install undercarpet cables and accessories using special tools as recommended by undercarpet cable manufacturer.

B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect undercarpet cable and components to branch circuits and to ground as indicated and instructed by manufacturer.

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
 - a. Branch-Circuit Cables: After cables have been installed and energized, perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - b. Communication and Data Cables: After cables have been installed and connected between telecommunications outlet and system cross-connect panel, test each cable according to TIA/EIA TSB67. Certify compliance with test parameters.
3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 13 00a



SECTION 26 05 13 00b - MEDIUM-VOLTAGE CABLES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of medium-voltage cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

C. Definitions

1. NETA ATS: Acceptance Testing Specification.

D. Submittals

1. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.
2. Field quality-control test reports.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C2 and NFPA 70.

1.2 PRODUCTS

A. Cables

1. Cable Type: MV90 **OR** MV105, **as directed**.
2. Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682, **OR** ICEA S-94-649, **as directed**.
3. Conductor: Copper **OR** Aluminum, **as directed**.
4. Conductor Stranding: Compact round, concentric lay, Class B) **OR** Concentric lay, Class B, **as directed**.
5. Strand Filling: Conductor interstices are filled with impermeable compound.
6. Conductor Insulation: Crosslinked polyethylene **OR** Ethylene-propylene rubber, **as directed**.
 - a. Voltage Rating: 5 **OR** 8 **OR** 15 **OR** 25 **OR** 35, **as directed**, kV.
 - b. Insulation Thickness: 100 **OR** 133, **as directed**, percent insulation level.
7. Shielding: Copper tape **OR** Solid copper wires, **as directed**, helically applied over semiconducting insulation shield.
8. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.
9. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors, **as directed**.
 - a. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.
10. Cable Armor: Interlocked aluminum **OR** Interlocked galvanized steel **OR** Corrugated aluminum tube, **as directed**, applied over cable.
11. Cable Jacket: Sunlight-resistant PVC **OR** Chlorosulfonated polyethylene, CPE, **as directed**.

B. Splice Kits



1. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.
2. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
 - a. Combination tape and cold-shrink-rubber sleeve kit with re-jacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
 - b. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
 - c. Premolded, cold-shrink-rubber, in-line splicing kit.
 - d. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

C. Solid Terminations

1. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.
 - a. Compound-filled, cast-metal body, metal-clad cable terminator for metal-clad cable with **OR** without, **as directed**, external plastic jacket.
 - b. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
 - c. Heat-shrink sheath seal kit with phase- and ground-conductor re-jacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.
 - d. Cast-epoxy-resin sheath seal kit with wraparound mold and packaged, two-part, epoxy-resin casting material.
2. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
 - a. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
 - b. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
 - c. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
 - d. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
 - e. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
 - f. Class 3 Terminations: Kit with stress cone and compression-type connector.
3. Nonshielded-Cable Terminations: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

D. Separable Insulated Connectors

1. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
2. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
3. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.



4. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
5. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
 - a. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
 - b. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
 - c. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
 - d. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
6. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
7. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

E. Arc-Proofing Materials

1. Tape for First Course on Metal Objects: 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
2. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, compatible with cable jacket.
3. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch (13 mm) wide.

F. Fault Indicators

1. Indicators: Automatically **OR** Manually, **as directed**, reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
2. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

G. Source Quality Control

1. Test and inspect cables according to ICEA S-97-682 **OR** ICEA S-94-649, **as directed**, before shipping.
2. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

1.3 EXECUTION

A. Installation

1. Install cables according to IEEE 576.
2. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - a. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
 - b. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.



3. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
 4. Support cables according to Division 26 Section "Common Work Results For Electrical".
 5. Install direct-buried cables on leveled and tamped bed of 3-inch- (75-mm-) thick, clean sand. Separate cables crossing other cables or piping by a minimum of 4 inches (100 mm) of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.
 6. Install "buried-cable" warning tape 12 inches (305 mm) above cables.
 7. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.
 8. Install cable splices at pull points and elsewhere as indicated; use standard kits.
 9. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.
 10. Install separable insulated-connector components as follows:
 - a. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
 - b. Portable Feed-Through Accessory: Three.
 - c. Standoff Insulator: Three.
 11. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
 - a. Clean cable sheath.
 - b. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
 - c. Smooth surface contours with electrical insulation putty.
 - d. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
 - e. Band arc-proofing tape with 1-inch- (25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) o.c.
 12. Seal around cables passing through fire-rated elements according to Division 07 Section "Penetration Firestopping".
 13. Install fault indicators on each phase where indicated.
 14. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
 15. Identify cables according to Division 26 Section "Identification For Electrical Systems".
- B. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - b. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
 2. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 13 00b



SECTION 26 05 19 13 - UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of underfloor raceways for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Flat-top, single-channel, underfloor raceways.
 - b. Flat-top, multichannel, underfloor raceways.
 - c. Flush, flat-top underfloor raceways.
 - d. Cellular metal underfloor raceways.
 - e. Trench-type underfloor raceways.
 - f. Electrical connection components for precast concrete, hollow-core, floor decks.
 - g. Electrical connection components for electrified cellular steel floor decks.
 - h. Service fittings.

C. Definitions

1. Flush Outlet: Underfloor raceway outlet installed so the top of the fixed portions of the receptacles, jacks, and connector assemblies is located approximately at the surface of the floor or floor covering, and with the bodies of connected plugs exposed above the surface of the floor.
2. Flush Underfloor Raceway: Rectangular cross-section, flat-top raceway installed with the top of the raceway flush with the surface of the concrete in which it is embedded.
3. Header Raceway: Rectangular cross-section, single-channel or multichannel, underfloor raceway arranged as feeder raceway to bring wires and cables to service raceways from panelboards and communication terminal components.
4. Recessed Outlet: Underfloor raceway outlet installed with the top of the fixed portion of the connector assemblies located below the surface of the floor or floor covering and arranged to receive plug connectors with the bodies of the plugs concealed below the floor level.
5. Service Raceway: Underfloor distribution raceway providing direct connection to service fittings using preset or afterset inserts.
6. Trench Header: Trench-type raceway arranged as feeder raceway to bring wires and cables to service raceways from panelboards and communication terminal equipment.
7. Underfloor Raceway: A conduit, duct, or cell assembly, or trench located within the floor material or with its top at the floor surface.

D. Submittals

1. Product Data: For underfloor raceway components, fittings, and accessories.
2. Shop Drawings: For underfloor raceways. Include floor plans, assembly drawings, sections, and details.
 - a. Identify components and accessories such as expansion-joint assemblies, straight raceway lengths, preset and afterset inserts, and service fittings.
 - b. Provide dimensions locating raceway header and distribution elements. Include spacing between preset inserts and between preset inserts and ends of duct runs, walls, columns, junction boxes, and header duct connections.
 - c. Show connections between raceway elements and relationships between components and adjacent structural and architectural elements including slab reinforcement, floor finish work, permanent partitions, architectural module lines, and pretensioning or post-tensioning components.



- d. Indicate height of preset inserts, junction boxes, and raceways coordinated with depth of concrete slab and floor fill.
 - e. Indicate thickening of slabs where required for adequate encasement of raceway components.
 - f. Document coordination of exposed components with floor-covering materials to ensure that fittings and trim are suitable for indicated floor-covering material.
 - g. Revise locations from those indicated in the Contract Documents, as required to suit field conditions and to ensure a functioning layout. Identify proposed deviations from the Contract Documents.
 - h. Show details of connections and terminations of underfloor raceways at panelboards and communication terminal equipment in equipment rooms, wire closets, and similar spaces.
 - i. Identify those cells of cellular floor deck that are to be connected and fitted for the following underfloor distribution:
 - 1) Power.
 - 2) Voice.
 - 3) Data.
 - 4) Signal.
 - 5) Communications.
3. Samples: For typical underfloor raceway products, in specified finish, including the following:
- a. Service fittings and flush and recessed outlet and junction-box covers.
 - b. A section of each service raceway configuration with specified preset insert and service fitting installed.
 - c. A junction box of each size and type for use with underfloor raceway.
 - d. A section of each header raceway configuration, complete with provisions for connection with service raceway.
 - e. A section of trench-type raceway, complete with cover and required trim.
 - f. A junction box of each size and type, complete with cover and trim.
4. Operation and Maintenance Data: For underfloor raceways, to include in emergency, operation, and maintenance manuals. Include the following:
- a. Manufacturer's written instructions for locating preset inserts and for installing afterset inserts.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Flat-Top, Single-Channel, Underfloor Raceways

1. Description:
 - a. Material: Steel.
 - b. Cross-Section Shape: Rectangular.
 - c. Number of Levels: One **OR** Two, **as directed**.
 - d. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.
2. Service Raceways: Fitted with preset inserts.
 - a. Nominal Raceway Dimensions:
 - 1) Depth: 1-1/2 inches (38 mm).
 - 2) Power Service Raceway Width: 3-1/2 inches (90 mm).
 - 3) Communication Service Raceway Width: 3-1/2 inches (90 mm) **OR** 6-1/2 inches (165 mm), **as directed**.



- b. Number of Single-Channel Raceways per Run: One **OR** Two **OR** Three **OR** Four **OR** Five, **as directed**, unless otherwise indicated.
 - c. Preset Inserts: Rectangular **OR** Round, **as directed**.
 - 1) Spacing: 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed**, o.c.
 - 2) Size: Rectangular dimensions as required to accommodate mounting and connection of flush-mounted, duplex receptacle or dual communication-jack or connector service fitting.
 - 3) Size: 2 inches (50 mm) in diameter.
 - 4) Equip each insert with a disposable cover and select insert height so cover is 1/8 inch (3 mm) below surface of concrete.
 - 5) Arrange insert for optional attachment of flush-, surface-, or wiring- extension service fitting to replace disposable cover.
 - 3. Header Raceways: Single channel, without preset inserts (blank raceway).
 - a. Nominal Raceway Dimensions:
 - 1) Depth: 1-1/2 inches (38 mm).
 - 2) Power Header Raceway Width: 3-1/2 inches (90 mm).
 - 3) Communication Header Raceway Width: 3-1/2 inches (90 mm) **OR** 6-1/2 inches (165 mm), **as directed**.
 - b. Arrangement: In same plane as **OR** Below, **as directed**, service raceways.
 - c. Connections: Arranged to connect with service raceways at single-level **OR** two-level, **as directed**, junction boxes.
- B. Flat-Top, Multichannel, Underfloor Raceways
- 1. Description:
 - a. Material: Steel.
 - b. Cross-Section Shape: Rectangular.
 - c. Number of Longitudinal Channels: Two **OR** Three **OR** Four, **as directed**, separated by steel wall(s).
 - d. Number of Levels: One **OR** Two, **as directed**.
 - e. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.
 - 2. Service Raceways: Fitted with preset inserts.
 - a. Nominal Raceway Dimensions:
 - 1) Depth: 1-3/8 inches (35 mm).
 - 2) Power Service Channel Width: 3-1/2 inches (90 mm) **OR** 4-3/8-inches (111 mm), **as directed**.
 - 3) Communication Service Channel Width: 3-1/2 inches (90 mm) **OR** 4 inches (102 mm) **OR** 6-1/2 inches (165 mm), **as directed**.
 - b. Preset Inserts:
 - 1) Spacing: 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed**, o.c.
 - 2) Size: Dimensions as required to accommodate mounting and connection of flush- and surface-mounted, single- and multiple-system service fittings or to connect to wiring extensions for feeding wall outlets for power **OR** communications **OR** power and communications, **as directed**.
 - 3) Equip each insert with a disposable cover arranged for installation with top 1/8 inch (3 mm) below surface of concrete.
 - 4) Arrange inserts for optional attachment of flush-, surface-, or wiring-extension service fitting to replace disposable cover. Arrange brackets, mountings, barriers, and floor access covers to support, isolate, and provide access to flush or surface outlet-mounting connector, jack, and receptacle devices.
 - 3. Header Raceways: Multichannel, without preset inserts (blank raceway).
 - a. Nominal Raceway Dimensions:
 - 1) Header Raceway Depth: Same as service raceways **OR** 2-1/2 inches (64 mm) **OR** 2-3/4 inches (70 mm) **OR** 3 inches (76 mm) **OR** 3-1/2 inches (90 mm), **as directed**.



- 2) Power Header Channel Width: 3-1/2 inches (90 mm) **OR** 4-3/8-inches (111 mm), **as directed**.
- 3) Communication Header Channel Width: 3-1/2 inches (90 mm) **OR** 4 inches (102 mm) **OR** 6-1/2 inches (165 mm), **as directed**.
- b. Arrangement: In same plane as **OR** Below, **as directed**, service raceways.
- c. Connections: Arranged to connect with service raceways at single-level **OR** two-level, **as directed**, junction boxes.

C. Flush, Flat-Top Underfloor Raceways

1. Description:
 - a. Material: Steel.
 - b. Cross-Section Shape: Rectangular, single channel and multichannel, separated by steel wall(s).
 - c. Listed and labeled for installation with top flush with concrete floor.
 - d. Number of Levels: One.
2. Service Raceways: Fitted with preset inserts.
 - a. Number of Longitudinal Channels per Multichannel Raceway: Two **OR** Three, **as directed**.
 - b. Number of Single-Channel Raceways per Run: One **OR** Two **OR** Three, **as directed**, unless otherwise indicated.
 - c. Nominal Channel Dimensions: 3 inches (76 mm) wide by 1-1/4 inches (32 mm) deep.
 - d. Preset Inserts: Threaded opening with removable steel plug that is flush with top of raceway when screwed in place.
 - 1) Spacing: 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed**, o.c., full length of each service raceway.
 - 2) Arrangement: Stagger insert locations on parallel raceways or channels to accommodate placement of adjacent service fittings.
 - 3) Size: 1-5/8-inch (41-mm) diameter.
3. Header Raceways: Raceways same as service raceways except without preset inserts (blank raceway).
 - a. Nominal Channel Dimensions: Same as service raceways.
 - b. Arrangement: In same plane as service raceways.
 - c. Connections: Arranged to connect with service raceways at junction boxes.

D. Cellular Metal Underfloor Raceways

1. Service Raceways: Fitted with preset inserts.
 - a. Material: Steel.
 - b. Number of Longitudinal Cells: Three, separated by steel walls.
 - c. Nominal Dimensions of Cells:
 - 1) Overall Depth: 1-1/4 inches (32 mm) unless otherwise indicated.
 - 2) Cross-Sectional Area of Cells: Power cells: 5-1/2 sq. in. (35.5 sq. cm); communication system cells: 16 sq. in. (103 sq. cm).
 - d. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.
 - e. Preset Inserts: Rectangular-shaped metal housing assemblies arranged to provide electrical outlet access to each cell of each raceway designated for service raceway use. Inserts shall be provided throughout the entire length of each such raceway.
 - 1) Spacing: 30 inches (762 mm) **OR** 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed**, o.c.
 - 2) Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-system service fitting.
 - 3) Include mounting and connecting provisions for a surface, single- or multiple-system service fitting.



- 4) Include connecting provisions for a wiring-extension service fitting to feed wall outlets.
 - 5) Equip each insert with a disposable cover plate arranged for installation with top 1/8 inch (3 mm) below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable top.
2. Header Assembly: A junction box and raceway arrangement arranged to feed wires and cables to service raceways.
- a. Three-compartment junction box connecting blank, multicell cellular header raceway (no inserts) with cellular service raceways.
 - 1) Arrange junction box in the center of a 60-inch (152-cm) length of header raceway.
 - 2) Cellular header raceway shall have same dimensions as service raceways.
 - 3) Provide capability for service raceways to be run in both directions from intersection with header raceway.
 - b. Three-compartment junction box preassembled with blank, flat-top, multichannel header raceway (no inserts) and fitted to connect with cellular service raceway at right angles to header raceway.
 - 1) Arrange junction box in the center of a 60-inch (152-cm) length of header raceway.
 - 2) Provide capability for service raceways to be run in both directions from intersection with header raceway.
- E. Trench-Type Underfloor Raceways
1. Trench: Steel, shop or factory welded and fabricated to indicated sizes. Include the following features:
 - a. Slab Depth Adjustment: Minimum of minus 1/8 inch (3 mm) to plus 5/8 inch (16 mm) before and during concrete placement.
 - b. Cover Supports: Height adjustable, with leveling screws to rigidly support cover assembly.
 - c. Screed Strip: Extruded aluminum along both edges at proper elevation without requiring shim material.
 - d. Trim Strip: Select to accommodate floor finish material.
 - e. Partitions: Arranged to separate channels and isolate wiring of different systems.
 - f. Grommeted openings in active floor cells or service raceways.
 - g. Manufacturer's standard corrosion-resistant finish, applied after fabrication.
 2. Cover Plates: Removable, steel plates, 1/4 inch (6 mm) thick, each weighing 60 lb (27 kg) or less with full gasket attached to side units. Fabricate intermediate supports to limit unsupported spans to 15 inches (380 mm) or less. Fabricate covers with appropriate depth recess to receive indicated floor finish.
- F. Electrical Connection Components For Cellular Steel Floor Deck
1. Preset Inserts: Rectangular metal-housing assemblies.
 - a. Spacing: 30 inches (762 mm) **OR** 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed**, o.c.
 - b. Size: As required to provide electrical outlet access to each cell of each group of three cells that is designated for electrical service raceway use.
 - c. Equip each insert with a disposable cover arranged for installation with top 1/8 inch (3 mm) below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable cover.
 - d. Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-system service fitting.
 - e. Include mounting and connecting provisions for a surface, single-, double-, or triple-system service fitting.
 - f. Include connecting provisions for a wiring-extension service fitting to feed wall outlets.
- G. Electrical Connection Components For Cellular Concrete Floor Deck
1. Afterset Inserts: Round metal-nipple assembly with internal and external threading, arranged to screw into plug driven into 1-7/8-inch (48-mm) hole drilled through floor fill, where present, and deck-cell wall into floor raceway cell.



- a. Inserts shall be compatible with floor-mounting service fittings.
 - b. Inserts shall provide wiring path from cell to power **OR** communication **OR** power and communication, **as directed**, wall and ceiling outlets.
 - c. Inserts shall provide wiring path from cell to header raceway.
- H. Supports, Fittings, And Hardware
1. Supports, fittings, and hardware shall be compatible with raceway and outlet system and shall be listed for use with raceway systems and components specified.
 2. Supports: Adjustable for height and arranged to maintain alignment and spacing of raceways during concrete placement. Include hold-down straps.
 3. Raceway Fittings: Couplings, expansion-joint sleeves, cross-under offsets, vertical and horizontal elbows, grounding screws, adapters, end caps, and other fittings suitable for use with basic components to form a complete installation.
- I. Junction Boxes
1. Description: Manufacturer's standard enclosure for indicated type, quantity, arrangement, and configuration of raceways at each raceway junction, intersection, and access location. Include the following accessories and features:
 - a. Mounting brackets.
 - b. Escutcheons and holders to accommodate surrounding floor covering.
 - c. Means for leveling and height adjustment more than 3/8 inch (10 mm) before and after concrete is placed.
 - d. Raceway Openings: For underfloor raceways and conduits arranged to accommodate raceway layout.
 - e. Covers shall have appropriate depth recess to receive specific floor finish material.
 - f. Partitions to separate wiring of different systems.
- J. Service Fittings
1. Exposed Parts Finish: Brass **OR** Brushed Aluminum, **as directed**.
 2. Flush, Single-System Service Fitting for Round Inserts: Include mounting and cover to support and provide access to single connector, jack, or receptacle device; mounted flush with floor within body of insert.
 - a. Connector, Jack, and Receptacle Devices: Single modular type; complying with Division 26 Section(s) "Wiring Devices" AND Division 27 Section(s) "Communications Horizontal Cabling".
 - b. Power Receptacle Outlet: Suitable for 20-A device.
 3. Flush, Single- or Multiple-System Service Fitting for Rectangular Inserts: Include mounting, hinged cover, and trim to support and provide access to connector, jack, or receptacle devices mounted flush with floor within insert.
 - a. Connector, Jack, and Receptacle Devices: Modular type; complying with Division 26 Section(s) "Wiring Devices" AND Division 27 Section(s) "Communications Horizontal Cabling".
 - b. Power Receptacle Rating: 20 A, 120 V unless otherwise indicated.
 4. Recess-Mounted Service Fitting: Modular fittings compatible with preset inserts and shall include covers; provisions for receptacles, jacks, and connectors; and associated device plates for indicated systems. Include hinged flush handhole covers with recessed depth to match thickness of floor finish material. Provide for internally mounted receptacle- and communication-jack and connector assemblies complying with requirements in Division 26 Section(s) "Wiring Devices" AND Division 27 Section(s) "Communications Horizontal Cabling".
 - a. Duplex receptacle.
 - b. Duplex telephone-data jacks.
 - c. Double duplex receptacles.
 - d. Duplex receptacle and duplex telephone-data jacks.
 - e. Double duplex telephone-data jacks, Category 5 **OR** Category 5e **OR** Category 6, **as directed**.



- f. Fiber-optic cable connector.
- 5. Surface-Mounted Service Fitting: Modular pedestal type, with locking attachment matched to insert floor opening.
 - a. Power-outlet, double-faced, surface-mounted unit for duplex receptacle on both sides.
 - b. Power-outlet, single-faced, surface-mounted unit for duplex receptacle on one side.
 - c. Communication-outlet, double-faced, surface-mounted unit.
 - 1) Include bushed openings on both sides; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
 - 2) Include provisions for modular dual fiber-optic connector assembly on both sides.
 - 3) Include provisions for modular dual jack-connector assembly, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**, on both sides.
 - d. Communication-outlet, single-faced, surface-mounted unit with bushed opening on one side; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
 - e. Combination surface-mounted unit for duplex receptacle on one side and with communication cable connection provision on opposite side.
 - 1) Communication Side: Include bushed opening; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
 - 2) Communication Side: Include provisions for modular dual fiber-optic connector assembly.
 - 3) Communication Side: Include provisions for modular dual jack-connector assembly, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**.
- 6. Flush-Mounted Service Fittings: Modular fittings compatible with preset inserts and shall include covers, provisions for receptacles jacks and connector assemblies and wiring extensions to wall-mounted outlets, and associated device plates for indicated systems. Include flush handhole covers, recessed to suit floor finish material. Internally mounted, modular, receptacle, jack and connector assemblies shall comply with requirements in Division 26 Section(s) "Wiring Devices" AND Division 27 Section(s) "Communications Horizontal Cabling".
 - a. Duplex convenience receptacle.
 - b. Duplex telephone-data outlets.
 - c. Double duplex convenience receptacles.
 - d. Duplex convenience receptacle and duplex telephone-data outlets.
 - e. Double duplex telephone-data outlets.
 - f. Duplex communication jack, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**.
 - g. Duplex fiber-optic communication connector.
 - h. Wiring-Extension Service Fittings: Arrangement of brackets and mountings to support, and provide access to wiring or cabling of a cell, and to connect the cable or raceway that extends the system to an individual wall outlet. Provide for connection of FMC **OR** ENT **OR** Type MC cable, **as directed**, for power extensions, and FMC **OR** ENT **OR** optical fiber/communication cable raceway, **as directed**, for communication system extensions.

1.3 EXECUTION

A. Installation

- 1. Install raceways aligned and leveled and, unless otherwise indicated, parallel or perpendicular to building walls.
- 2. Provide a concrete base for support of cellular metal raceway.
- 3. Arrange supports to attain proper elevation, alignment, and spacing of raceways. Install supports securely at ends and at intervals not to exceed 60 inches (1500 mm), to prevent movement during concrete pour.
- 4. Level raceway components with finished slab and make adjustments for floor finishes.
- 5. Adjust supports to maintain a 1/16- to 3/8-inch (1.6- to 10-mm) finished concrete cover over preset inserts.
- 6. Remove burrs, sharp edges, dents, and mechanical defects.
- 7. Cap or plug boxes, insert- and service-fitting openings, and open ends of raceways.



8. Seal raceways, cells, junction boxes, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill. Tape joints, or seal with compound, as recommended in writing by underfloor raceway manufacturer.
9. Junction Boxes: Install tops level and flush with finished floor. Install blank closure plates or plugs to close unused junction-box openings. Grout boxes in place to prevent movement during construction. Place top covers in inverted position during construction to prevent damage to surface of cover. Reinstall covers in proper position prior to final acceptance of Work.
10. Afterset Inserts: Cut, hole saw, and drill slab and raceways to allow for installation.
11. Ground underfloor raceway components.
12. Install a marker at the center of the last insert of each cell and channel of each straight run of metal underfloor service raceway to locate the insert and identify the system.
 - a. Install markers at last inserts on both sides of permanent walls and at first inserts adjacent to each junction box.
 - b. Install markers flush at screed line before pouring slab or placing fill. Extend marker with grommited screw when floor covering is placed. Do not extend through carpet.
 - c. Use slotted-head screw to identify electrical power; use Phillips-head screw to identify conventional communications.
 - d. Use another distinctive screw head to identify third system such as special-purpose wiring.
13. Level raceway components with finished slab and make adjustments in raceway component elevation to accommodate indicated floor finishes.

B. Field Quality Control

1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Perform visual inspection of interior of each junction box **OR** section of trench raceway, **as directed**, to verify absence of dirt, dust, construction debris, and moisture. Replace damaged and malfunctioning components.
 - b. Perform point-to-point tests of ground continuity and resistance of ground path between the most remote accessible fitting on each branch of each underfloor raceway system and the main electrical distribution grounding system.
 - 1) Determine cause and perform correction of any point-to-point resistance value that exceeds 0.05 ohms.
 - 2) Comply with NETA Acceptance Testing Specifications about safety, suitability of test equipment, test instrument calibration, and test report and records.

C. Cleaning

1. Clean and swab out underfloor raceways, inserts, and junction boxes after finish has been applied to floor slab, and remove foreign material, dirt, and moisture. Leave interiors clean and dry.

END OF SECTION 26 05 19 13



Task	Specification	Specification Description
26 05 19 13	26 05 13 00a	Undercarpet Cables



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SECTION 26 05 19 16 - COMMON WORK RESULTS FOR COMMUNICATIONS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for communications. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Communications equipment coordination and installation.
 - b. Sleeves for pathways and cables.
 - c. Sleeve seals.
 - d. Grout.
 - e. Common communications installation requirements.

C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

D. Submittals

1. Product Data: For sleeve seals.

1.2 PRODUCTS

A. Sleeves For Pathways And Cables

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - a. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - 2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

B. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

C. Grout



1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

1.3 EXECUTION

A. Common Requirements For Communications Installation

1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

B. Sleeve Installation For Communications Penetrations

1. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
7. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
11. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

C. Sleeve-Seal Installation

1. Install to seal exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve



seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Firestopping

1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping".

END OF SECTION 26 05 19 16



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**SECTION 26 05 19 16a - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for electronic safety and security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Electronic safety and security equipment coordination and installation.
 - b. Sleeves for raceways and cables.
 - c. Sleeve seals.
 - d. Grout.
 - e. Common electronic safety and security installation requirements.

C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

D. Submittals

1. Product Data: For sleeve seals.

1.2 PRODUCTS

A. Sleeves For Raceways And Cables

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - a. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - 2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

B. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

C. Grout



1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

1.3 EXECUTION

A. Common Requirements For Electronic Safety And Security Installation

1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

B. Sleeve Installation For Electronic Safety And Security Penetrations

1. Electronic safety and security penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
7. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
11. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

C. Sleeve-Seal Installation

1. Install to seal exterior wall penetrations.



2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- D. Firestopping
1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping".

END OF SECTION 26 05 19 16a



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SECTION 26 05 19 16b - ELECTRICAL RENOVATION

1.1 DESCRIPTION OF WORK

- A. This specification covers the furnishing and installation of materials for electrical renovation. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 GENERAL

A. Quality Assurance

1. Regulatory Requirements: Comply with following:
 - a. Electrical: National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code (NEC).
 - b. Accessibility:
 - 1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
 - a) Uniform Federal Accessibility Standards (UFAS).
 - 2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
 - 3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
 - 4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).

B. Project Conditions

1. Existing Conditions: Buildings will be occupied during construction. See Division 1 Section "Summary of Work." Do not interfere with use of occupied portions of building. Maintain free and safe passage to and from occupied areas.

C. Scheduling And Sequencing

1. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.

D. Alterations, Cutting And Protection

1. Protection: Protect existing finishes, equipment, utilities and adjacent work, which is scheduled to remain, from damage.
2. Existing Operating Facilities: Confine operations to immediate vicinity of new work and do not interfere with or obstruct ingress or egress to and from adjacent facilities.

1.3 PRODUCTS

A. Materials

1. Electrical Materials and Devices: Comply with NFPA 70 (NEC):
 - a. Boxes: Galvanized steel, not less than 1.6 mm (0.0625 inch) thickness (NEC 370-20) grounded in accordance with NEC, Article 250, suitable for recess mounting.
 - 1) Provide boxes of appropriate shape and size for intended purpose.
 - b. Devices:
 - 1) Duplex Receptacles: 15 A or 20 A 115 V, UL Listed with screw side connections and corrugated bearing pads.
 - a) GFIC Outlets: 115 V, 60 Hz, 15/20 A rating, UL Listed.
 - 2) Switches: 15 A, 115 V, single pole, single throw switch, UL Listed, with side screw connections and corrugated bearing pads.



- a) Garbage Disposal: Heavy duty, 120/277 VAC, 60 Hz, single pole, single throw, 20 A rate, UL listed and CSA certified.
- 3) Cover Plates: Smooth plastic in color to match existing.
- c. Wiring: Insulated wire, Type NM 600 V with ground wire, sized as appropriate for intended purpose and in accordance with NEC.
 - 1) Aluminum Wire: Not allowed unless existing wiring is aluminum.
 - 2) Provide necessary fittings in accordance with NEC.

1.4 EXECUTION

A. Examination

1. Units, Spaces and Areas to be Renovated: Inspect to become familiar with existing conditions and to take measurements which are necessary for renovation work to be completed in accordance with contract requirements.
 - a. Carefully inspect condition of existing spaces including, but not limited to walls, floors, plumbing, electrical, etc. as essential to successful completion of renovation work.
 - b. Survey each space and verify dimensions for work.

B. Preparation

1. Building Occupation: Carry out renovation work to cause as little inconvenience to occupants as possible. See Division 1 Section "Summary of Work."
2. Protection: Protect and be responsible for existing buildings, facilities, utilities, and improvements within areas of construction operations.
 - a. Tenant's Property: Be responsible for any damage or loss to residents' property and to other work. Replace any material, which, in opinion of the Owner, has become damaged to extent that it could not be restored to its original condition.
 - b. Take precautions to protect residents and public from injury from construction operations.

C. Laying Out Work

1. Discrepancies: Verify dimensions and elevations indicated in layout of existing work.
 - a. Prior to commencing work, carefully compare and check Drawings (if any), for discrepancies in locations or elevations of work to be executed.
 - b. Refer discrepancies among Drawings (if any), Specifications and existing conditions to the Owner for adjustment before work affected is performed.
 - 1) Failure to make such notification shall place responsibility on Contractor to carry out work in satisfactory, workmanlike manner.
2. Contractor: Responsible for location and elevation of construction contemplated by Construction Documents.

D. Location Of Equipment And Piping

1. Drawings (if any) indicating location of equipment, piping, ductwork, etc. are diagrammatic and job conditions shall not always permit their installation in location shown. When this situation occurs, bring condition to the Owner's attention immediately. Relocation will be determined in joint conference.
2. Contractor: Do not relocate any items without first obtaining the Owner's acceptance. Remove and relocate such relocated items at own expense if so directed.

E. Electrical Work

1. General: Install boxes, wiring, and devices as indicated and required to connect and control electrical devices in accordance with NFPA 70 (NEC).
 - a. Boxes: Solidly anchor to framing or blocking.
2. Removing Electrical Switch or Duplex Outlet (Non-Hazardous Locations):
 - a. Box to Remain:
 - 1) Remove electrical device; cap hot and neutral with set-screw wire connectors.



- 2) Attach ground wire to remaining box with solid screw attachment.
 - 3) Provide and install natural finish aluminum blank cover plate with screw fasteners integral to match size of box remaining.
 - b. Box to be removed:
 - 1) Remove electrical device and box and pull wire out of wall back to first circuit panel, disconnecting from circuit panel.
 - 2) Patch and repair hole in partition to match existing.
 3. Garbage Disposal Electrical Hook-up: See Section "Plumbing." Comply with NFPA 70 (NEC):
 - a. Wiring: Install from disposal through concealed spaces to house panel, anchoring wire, and providing necessary fittings.
 - b. Switch: Install above counter top backsplash.
 4. Range Hood Electrical Hook-up: See Section "Residential Appliances." Comply with NFPA 70 (NEC):
 - a. Electric service: Install insulated wire from range hood through concealed spaces to house panel, anchoring wire, and providing necessary fittings.
 5. Water Heater Electrical Hook-up: See Division 15 Section "Domestic Water Heaters." Comply with NFPA 70 (NEC).
 6. Furnace Electrical Hook-up: See Section "Furnaces." Comply with NFPA 70 (NEC).
 7. Smoke Detector Electrical Hook-up: See "Fire Alarm." Comply with NFPA 70 (NEC).
- F. Integrating Existing Work
1. Protection: Protect existing improvements from damage.
 - a. Where new work is to be connected to existing work, exercise special care not to disturb or damage existing work more than necessary.
 - b. Damaged Work: Replace, repair and restored to its original condition at no cost to the Owner.

END OF SECTION 26 05 19 16b



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SECTION 26 05 19 16c - COMMUNICATIONS EQUIPMENT ROOM FITTINGS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for communications equipment room fittings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Telecommunications mounting elements.
 - b. Backboards.
 - c. Telecommunications equipment racks and cabinets.
 - d. Telecommunications service entrance pathways.
 - e. Grounding.

C. Definitions

1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. BICSI: Building Industry Consulting Service International.
3. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel not exceeding 6 inches (152 mm) in width.
4. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
5. LAN: Local area network.
6. RCDD: Registered Communications Distribution Designer.
7. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of a bottom without ventilation openings within integral or separate longitudinal side rails.
8. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.

D. Performance Requirements

1. Seismic Performance: Floor-mounted cabinets and cable pathways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 - c. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.
3. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
4. Seismic Qualification Certificates: For floor-mounted cabinets, accessories, and components, from manufacturer.



- a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
- c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Quality Assurance

1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - a. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD **OR** RCDD/NTS **OR** Commercial Installer, Level 2, **as directed**.
 - b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.
 - c. Field Inspector: Currently registered by BICSI as RCDD **OR** Commercial Installer, Level 2, **as directed**, to perform the on-site inspection.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
4. Grounding: Comply with ANSI-J-STD-607-A.

G. Project Conditions

1. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

H. Coordination

1. Coordinate layout and installation of communications equipment with the Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
 - a. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and the Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 - b. Record agreements reached in meetings and distribute them to other participants.
 - c. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
 - d. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
2. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

1.2 PRODUCTS

A. Pathways

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
 - a. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.



- b. Support brackets with cable tie slots for fastening cable ties to brackets.
 - c. Lacing bars, spools, J-hooks, and D-rings.
 - d. Straps and other devices.
3. Cable Trays:
- a. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inch (0.055 mm) thick, **as directed**.
 - 1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
 - 2) Trough Cable Trays: Nominally 6 inches (150 mm) wide.
 - 3) Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
 - 4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
 - 5) Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with **OR** without, **as directed**, solid covers.
4. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used.
- a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
- B. Backboards
- 1. Backboards: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry".
- C. Equipment Frames
- 1. General Frame Requirements:
 - a. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - b. Module Dimension: Width compatible with EIA 310 standard, 19-inch (480-mm) panel mounting.
 - c. Finish: Manufacturer's standard, baked-polyester powder coat.
 - 2. Floor-Mounted Racks: Modular-type, steel **OR** aluminum, **as directed**, construction.
 - a. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip, **as directed**.
 - b. Baked-polyester powder coat finish.
 - 3. Modular Freestanding Cabinets:
 - a. Removable and lockable side panels.
 - b. Hinged and lockable front and rear doors.
 - c. Adjustable feet for leveling.
 - d. Screened ventilation openings in the roof and rear door.
 - e. Cable access provisions in the roof and base.
 - f. Grounding bus bar.
 - g. Rack **OR** Roof, **as directed**, -mounted, 550-cfm (260-L/s) fan with filter.
 - h. Power strip.
 - i. Baked-polyester powder coat finish.
 - j. All cabinets keyed alike.
 - 4. Modular Wall Cabinets:
 - a. Wall mounting.
 - b. Steel **OR** Aluminum, **as directed**, construction.
 - c. Treated to resist corrosion.
 - d. Lockable front and rear doors.



- e. Louvered side panels.
 - f. Cable access provisions top and bottom.
 - g. Grounding lug.
 - h. Rack **OR** Roof, **as directed**, -mounted, 250-cfm (118-L/s) fan.
 - i. Power strip.
 - j. All cabinets keyed alike.
5. Cable Management for Equipment Frames:
- a. Metal, with integral wire retaining fingers.
 - b. Baked-polyester powder coat finish.
 - c. Vertical cable management panels shall have front and rear channels, with covers.
 - d. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

D. Power Strips

1. Power Strips: Comply with UL 1363.
 - a. Rack mounting.
 - b. Six, 15-A, 120-V ac, NEMA WD 6, Configuration 5-15R **OR** 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R, **as directed**, receptacles.
 - c. LED indicator lights for power and protection status.
 - d. LED indicator lights for reverse polarity and open outlet ground.
 - e. Circuit Breaker and Thermal Fusing:
 - 1) When protection is lost, circuit opens and cannot be reset.

OR

 Unit continues to supply power if protection is lost.
 - f. Close-coupled, direct plug-in **OR** Cord connected with 15-foot (4.5-m), **as directed**, line cord.
 - g. Rocker-type on-off switch, illuminated when in on position.
 - h. Peak Single-Impulse Surge Current Rating: 33 **OR** 26 **OR** 13, **as directed**, kA per phase.
 - i. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.

E. Grounding

1. Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems" for grounding conductors and connectors.
2. Telecommunications Main Bus Bar:
 - a. Connectors: Mechanical type, cast silicon bronze, solderless compression **OR** exothermic, **as directed**, -type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 - b. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
 - c. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
3. Comply with ANSI-J-STD-607-A.

F. Labeling

1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

1.3 EXECUTION

A. Entrance Facilities

1. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
2. Install underground **OR** buried **OR** aerial, **as directed**, pathways complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Article.



- a. Install underground **OR** buried, **as directed**, entrance pathway complying with Division 26 Section "Raceway And Boxes For Electrical Systems".
- B. Installation
1. Comply with NECA 1.
 2. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
 3. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
 4. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- C. Firestopping
1. Comply with requirements in Division 07 Section "Penetration Firestopping".
 2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
 3. Comply with BICSI TDMM, "Firestopping Systems" Article.
- D. Grounding
1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
 2. Comply with ANSI-J-STD-607-A.
 3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
 4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
 - a. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.
- E. Identification
1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
 2. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
 3. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 **OR** Class 3 **OR** Class 4, **as directed**, level of administration including optional identification requirements of this standard, **as directed**.
 4. Labels shall be preprinted or computer-printed type.

END OF SECTION 26 05 19 16c



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SECTION 26 05 19 16d - COMMUNICATIONS BACKBONE CABLING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for communications backbone cabling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pathways.
 - b. UTP cable.
 - c. 50/125 and 62.5/125-micrometer, optical fiber cabling.
 - d. Coaxial cable.
 - e. Cable connecting hardware, patch panels, and cross-connects.
 - f. Cabling identification products.

C. Definitions

1. BICSI: Building Industry Consulting Service International.
2. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
3. EMI: Electromagnetic interference.
4. IDC: Insulation displacement connector.
5. LAN: Local area network.
6. RCDD: Registered Communications Distribution Designer.
7. UTP: Unshielded twisted pair.

D. Backbone Cabling Description

1. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
2. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

E. Performance Requirements

1. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

F. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings:
 - a. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by the Owner.
 - b. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - c. Cabling administration drawings and printouts.
 - d. Wiring diagrams to show typical wiring schematics including the following:
 - 1) Cross-connects.
 - 2) Patch panels.
 - 3) Patch cords.



- e. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
- f. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements.
3. Qualification Data: For Installer, **as directed**, qualified layout technician, installation supervisor, and field inspector.
4. Source quality-control reports.
5. Field quality-control reports.
6. Maintenance Data.
7. Software and Firmware Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - c. Device address list.
 - d. Printout of software application and graphic screens.

G. Quality Assurance

1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - a. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
 - b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.
2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
5. Grounding: Comply with ANSI-J-STD-607-A.

H. Delivery, Storage, And Handling

1. Test cables upon receipt at Project site.
 - a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
 - b. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
 - c. Test each pair of UTP cable for open and short circuits.

I. Software Service Agreement

1. Technical Support: Beginning with Final Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Pathways

1. General Requirements: Comply with TIA/EIA-569-A.



2. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - a. Support brackets with cable tie slots for fastening cable ties to brackets.
 - b. Lacing bars, spools, J-hooks, and D-rings.
 - c. Straps and other devices.
 3. Cable Trays:
 - a. Cable Tray Material: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inches (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inches (0.055 mm) thick, **as directed**.
 - 1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
 - 2) Trough Cable Trays: Nominally 6 inches (150 mm) wide.
 - 3) Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
 - 4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
 - 5) Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with **OR** without, **as directed**, solid covers.
 4. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used.
 - a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
- B. Backboards
1. Backboards: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.
- C. UTP Cable
1. Description: 100-ohm, 100-pair UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket and overall metallic shield.
 - a. Comply with ICEA S-90-661 for mechanical properties.
 - b. Comply with TIA/EIA-568-B.1 for performance specifications.
 - c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
 - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - 1) Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
 - 2) Communications, Plenum Rated: Type CMP or MPP, **as directed**, complying with NFPA 262.
 - 3) Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, **as directed**, complying with UL 1666.
 - 4) Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
 - 5) Multipurpose: Type MP or MPG; or MPP or MPR, **as directed**.
 - 6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
 - 7) Multipurpose, Riser Rated: Type MPR or MPP, **as directed**, complying with UL 1666.
- D. UTP Cable Hardware
1. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.



2. Connecting Blocks: 110-style IDC for Category 5e **OR** 110-style IDC for Category 6 **OR** 66-style IDC for Category 5e, **OR** 110-style IDC for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
3. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - a. Number of Terminals per Field: One for each conductor in assigned cables.
4. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 - a. Number of Jacks per Field: One for each four-pair UTP cable indicated **OR** conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria, **as directed**.
5. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
6. Patch Cords: Factory-made, 4-pair cables in 36-inch (900-mm) **OR** 48-inch (1200-mm), **as directed**, lengths; terminated with 8-position modular plug at each end.
 - a. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
 - b. Patch cords shall have color-coded boots for circuit identification.

E. Optical Fiber Cable

1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
 - a. Comply with ICEA S-83-596 for mechanical properties.
 - b. Comply with TIA/EIA-568-B.3 for performance specifications.
 - c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
 - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - 1) General Purpose, Nonconductive: Type OFN or OFNG, or OFNR, OFNP, **as directed**.
 - 2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - 3) Riser Rated, Nonconductive: Type OFNR or OFNP, **as directed**, complying with UL 1666.
 - 4) General Purpose, Conductive: Type OFC or OFCG; or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
 - 5) Plenum Rated, Conductive: Type OFCP or OFNP, **as directed**, complying with NFPA 262.
 - 6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **as directed**, complying with UL 1666.
 - e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
 - f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
 - g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
2. Jacket:
 - a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
 - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
 - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Optical Fiber Cable Hardware

1. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
 - a. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.



2. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.
 3. Cable Connecting Hardware:
 - a. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
 - b. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
 - c. Type SFF connectors may be used in termination racks, panels, and equipment packages.
- G. Coaxial Cable
1. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
 2. RG-11/U: NFPA 70, Type CATV.
 - a. No. 14 AWG, solid, copper-covered steel conductor.
 - b. Gas-injected, foam-PE insulation.
 - c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
 - d. Jacketed with sunlight-resistant, black PVC or PE.
 - e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
 3. RG59/U: NFPA 70, Type CATVR.
 - a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
 - b. Gas-injected, foam-PE insulation.
 - c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
 - d. Color-coded PVC jacket.
 4. RG-6/U: NFPA 70, Type CATV or CM.
 - a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
 - c. Jacketed with black PVC or PE.
 - d. Suitable for indoor installations.
 5. RG59/U: NFPA 70, Type CATV.
 - a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
 - c. PVC jacket.
 6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
 - a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
 - b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
 - c. Copolymer jacket.
 7. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
 - a. CATV Cable: Type CATV, or CATVP or CATVR, **as directed**.
 - b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
 - c. CATV Riser Rated: Type CATVR; or CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
 - d. CATV Limited Rating: Type CATVX.
- H. Coaxial Cable Hardware
1. Coaxial-Cable Connectors: Type BNC, 75 ohms.
- I. Grounding
1. Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems" for grounding conductors and connectors.
 2. Comply with ANSI-J-STD-607-A.



- J. Identification Products
 - 1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- K. Source Quality Control
 - 1. Testing Agency: Engage a qualified testing agency to evaluate cables.
 - 2. Factory test cables on reels according to TIA/EIA-568-B.1.
 - 3. Factory test UTP cables according to TIA/EIA-568-B.2.
 - 4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
 - 5. Cable will be considered defective if it does not pass tests and inspections.
 - 6. Prepare test and inspection reports.

1.3 EXECUTION

- A. Entrance Facilities
 - 1. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.
- B. Wiring Methods
 - 1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
 - a. Install plenum cable in environmental air spaces, including plenum ceilings.
 - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
 - 2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - 3. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- C. Installation Of Pathways
 - 1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.
 - 2. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings". Drawings indicate general arrangement of pathways and fittings.
 - 3. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
 - 4. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
 - 5. Install manufactured conduit sweeps and long-radius elbows whenever possible.
 - 6. Pathway Installation in Communications Equipment Rooms:
 - a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - b. Install cable trays to route cables if conduits cannot be located in these positions.
 - c. Secure conduits to backboard when entering room from overhead.
 - d. Extend conduits 3 inches (76 mm) above finished floor.
 - e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
 - 7. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.



- D. Installation Of Cables
1. Comply with NECA 1.
 2. General Requirements for Cabling:
 - a. Comply with TIA/EIA-568-B.1.
 - b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - c. Install 110-style IDC termination hardware unless otherwise indicated.
 - d. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - e. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - f. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - g. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
 - h. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - i. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - j. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
 - k. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
 3. UTP Cable Installation:
 - a. Comply with TIA/EIA-568-B.2.
 - b. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
 4. Optical Fiber Cable Installation:
 - a. Comply with TIA/EIA-568-B.3.
 - b. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
 5. Open-Cable Installation:
 - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - b. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
 - c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
 6. Installation of Cable Routed Exposed under Raised Floors:
 - a. Install plenum-rated cable only.
 - b. Install cabling after the flooring system has been installed in raised floor areas.
 - c. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.
 7. Outdoor Coaxial Cable Installation:
 - a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
 - b. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
 8. Group connecting hardware for cables into separate logical fields.
 9. Separation from EMI Sources:
 - a. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:



- 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
- c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
- 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
- d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
- 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
- e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
- f. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).
- E. Firestopping
1. Comply with requirements in Division 07 Section "Penetration Firestopping".
 2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
 3. Comply with BICSI TDMM, "Firestopping Systems" Article.
- F. Grounding
1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
 2. Comply with ANSI-J-STD-607-A.
 3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
 4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
- G. Identification
1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
 - a. Administration Class: **1 OR 2 OR 3 OR 4, as directed.**
 - b. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
 2. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
 3. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 **OR** Class 3 **OR** Class 4, **as directed**, level of administration including optional identification requirements of this standard.
 4. Comply with requirements in Division 27 Section "Communications Horizontal Cabling" for cable and asset management software.
 5. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.



6. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
7. Cable and Wire Identification:
 - a. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - b. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - c. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
 - d. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - 1) Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
 - 2) Label each unit and field within distribution racks and frames.
 - e. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
8. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:
 - a. Cables use flexible vinyl or polyester that flexes as cables are bent.

H. Field Quality Control

1. Tests and Inspections:
 - a. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
 - b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - c. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - d. Optical Fiber Cable Tests:
 - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 2) Link End-to-End Attenuation Tests:
 - a) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
 - b) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.



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2. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
 3. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
 4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
 5. Prepare test and inspection reports.

END OF SECTION 26 05 19 16d



SECTION 26 05 19 16e - COMMUNICATIONS HORIZONTAL CABLING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for communications horizontal cabling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pathways.
 - b. UTP cabling.
 - c. 50/125 and 62.5/125-micrometer, optical fiber cabling.
 - d. Coaxial cable.
 - e. Multiuser telecommunications outlet assemblies.
 - f. Cable connecting hardware, patch panels, and cross-connects.
 - g. Telecommunications outlet/connectors.
 - h. Cabling system identification products.
 - i. Cable management system.

C. Definitions

1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. BICSI: Building Industry Consulting Service International.
3. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel.
4. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
5. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
6. EMI: Electromagnetic interference.
7. IDC: Insulation displacement connector.
8. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
9. LAN: Local area network.
10. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.
11. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
12. RCDD: Registered Communications Distribution Designer.
13. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom without ventilation openings.
14. Trough or Ventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom having openings for the passage of air.
15. UTP: Unshielded twisted pair.

D. Horizontal Cabling Description

1. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.
 - a. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.



- b. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
 - c. Bridged taps and splices shall not be installed in the horizontal cabling.
 - d. Splitters shall not be installed as part of the optical fiber cabling.
2. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.
 3. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) in the horizontal cross-connect.
- E. Performance Requirements
1. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.
- F. Submittals
1. Product Data: For each type of product indicated.
 2. Shop Drawings:
 - a. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by the Owner.
 - b. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - c. Cabling administration drawings and printouts.
 - d. Wiring diagrams to show typical wiring schematics, including the following:
 - 1) Cross-connects.
 - 2) Patch panels.
 - 3) Patch cords.
 - e. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
 - f. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements.
 3. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration and faceplates for color selection and evaluation of technical features.
 4. Qualification Data: For Installer, **as directed**, qualified layout technician, installation supervisor, and field inspector.
 5. Source quality-control reports.
 6. Field quality-control reports.
 7. Maintenance Data.
 8. Software and Firmware Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - c. Device address list.
 - d. Printout of software application and graphic screens.
- G. Quality Assurance
1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - a. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
 - b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.
 2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.



- b. Smoke-Developed Index: 50 **OR** 450, **as directions**, or less.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
5. Grounding: Comply with ANSI-J-STD-607-A.

H. Delivery, Storage, And Handling

1. Test cables upon receipt at Project site.
 - a. Test optical fiber cables to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
 - b. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
 - c. Test each pair of UTP cable for open and short circuits.

I. Software Service Agreement

1. Technical Support: Beginning with Final Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Pathways

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - a. Support brackets with cable tie slots for fastening cable ties to brackets.
 - b. Lacing bars, spools, J-hooks, and D-rings.
 - c. Straps and other devices.
3. Cable Trays:
 - a. Cable Tray Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inch (0.055 mm) thick, **as directed**.
 - 1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
 - 2) Trough Cable Trays: Nominally 6 inches (150 mm) wide.
 - 3) Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
 - 4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
 - 5) Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with **OR** without, **as directed**, solid covers.
4. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used.
 - a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

B. Backboards



1. Backboards: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.

C. UTP Cable

1. Description: 100-ohm, 4-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.
 - a. Comply with ICEA S-90-661 for mechanical properties.
 - b. Comply with TIA/EIA-568-B.1 for performance specifications.
 - c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
 - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - 1) Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
 - 2) Communications, Plenum Rated: Type CMP or MPP, **as directed**, complying with NFPA 262.
 - 3) Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, **as directed**, complying with UL 1666.
 - 4) Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
 - 5) Multipurpose: Type MP or MPG; or MPP or MPR, **as directed**.
 - 6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
 - 7) Multipurpose, Riser Rated: Type MPR or MPP, **as directed**, complying with UL 1666.

D. UTP Cable Hardware

1. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
2. Connecting Blocks: 110-style IDC for Category 5e **OR** 110-style IDC for Category 6 **OR** 66-style IDC for Category 5e, **OR** 110-style IDC for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
3. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - a. Number of Terminals per Field: One for each conductor in assigned cables.
4. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 - a. Number of Jacks per Field: One for each four-pair UTP cable indicated **OR** conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria, **as directed**.
5. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
6. Patch Cords: Factory-made, four-pair cables in 36-inch (900 mm) **OR** 48-inch (1200-mm), **as directed**, lengths; terminated with eight-position modular plug at each end.
 - a. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
 - b. Patch cords shall have color-coded boots for circuit identification.

E. Optical Fiber Cable

1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**, -micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
 - a. Comply with ICEA S-83-596 for mechanical properties.
 - b. Comply with TIA/EIA-568-B.3 for performance specifications.



- c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
 - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - 1) General Purpose, Nonconductive: Type OFN or OFNG, or OFNR, OFNP, **as directed**.
 - 2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - 3) Riser Rated, Nonconductive: Type OFNR or OFNP, **as directed**, complying with UL 1666.
 - 4) General Purpose, Conductive: Type OFC or OFCG; or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
 - 5) Plenum Rated, Conductive: Type OFCP or OFNP, **as directed**, complying with NFPA 262.
 - 6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **as directed**, complying with UL 1666.
 - e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
 - f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
 - g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
 - 2. Jacket:
 - a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
 - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
 - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).
- F. Optical Fiber Cable Hardware
- 1. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
 - a. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
 - 2. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.
 - 3. Cable Connecting Hardware:
 - a. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
 - b. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
 - c. Type SFF connectors may be used in termination racks, panels, and equipment packages.
- G. Coaxial Cable
- 1. Cable Characteristics: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
 - 2. RG-11/U: NFPA 70, Type CATV.
 - a. No. 14 AWG, solid, copper-covered steel conductor.
 - b. Gas-injected, foam-PE insulation.
 - c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
 - d. Jacketed with sunlight-resistant, black PVC or PE.
 - e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
 - 3. RG59/U: NFPA 70, Type CATVR.
 - a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
 - b. Gas-injected, foam-PE insulation.
 - c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
 - d. Color-coded PVC jacket.
 - 4. RG-6/U: NFPA 70, Type CATV or CM.



- a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
 - c. Jacketed with black PVC or PE.
 - d. Suitable for indoor installations.
5. RG59/U: NFPA 70, Type CATV.
- a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
 - c. PVC jacket.
6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
- a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
 - b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
 - c. Copolymer jacket.
7. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
- a. CATV Cable: Type CATV or CATVP or CATVR, **as directed**.
 - b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
 - c. CATV Riser Rated: Type CATVR; or CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
 - d. CATV Limited Rating: Type CATVX.
- H. Coaxial Cable Hardware
1. Coaxial-Cable Connectors: Type BNC, 75 ohms.
- I. Consolidation Points
1. Description: Consolidation points shall comply with requirements for cable connecting hardware.
 - a. Number of Terminals per Field: One for each conductor in assigned cables.
 - b. Number of Connectors per Field:
 - 1) One for each four-pair UTP cable indicated.
 - 2) One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
 - c. Mounting: Recessed in ceiling **OR** Wall **OR** Desk **OR** Furniture, **as directed**.
 - d. NRTL listed as complying with UL 50 and UL 1863.
 - e. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.
- J. Multiuser Telecommunications Outlet Assembly (MUTOA)
1. Description: MUTOAs shall meet the requirements for cable connecting hardware.
 - a. Number of Terminals per Field: One for each conductor in assigned cables.
 - b. Number of Connectors per Field:
 - 1) One for each four-pair UTP cable indicated.
 - 2) One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
 - c. Mounting: Recessed in ceiling **OR** Wall **OR** Desk **OR** Furniture, **as directed**.
 - d. NRTL listed as complying with UL 50 and UL 1863.
 - e. Label shall include maximum length of work area cords, based on TIA/EIA-568-B.1.
 - f. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.
- K. Telecommunications Outlet/Connectors
1. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.
 2. Workstation Outlets: Two **OR** Four, **as directed**,-port-connector assemblies mounted in single or multigang faceplate.



- a. Plastic Faceplate: High-impact plastic. Coordinate color with Division 26 Section "Wiring Devices".
 - b. Metal Faceplate: Stainless steel **OR** Brass, **as directed**, complying with requirements in Division 26 Section "Wiring Devices".
 - c. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
 - 1) Flush mounting jacks, positioning the cord at a 45-degree angle.
 - d. Legend:
 - 1) Factory labeled by silk-screening or engraving for stainless steel **OR** brass, **as directed**, faceplates.
OR
Machine printed, in the field, using adhesive-tape label.
OR
Snap-in, clear-label covers and machine-printed paper inserts.
- L. Grounding
1. Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems" for grounding conductors and connectors.
 2. Comply with ANSI-J-STD-607-A.
- M. Identification Products
1. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
 2. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
- N. Cable Management System
1. Description: Computer-based cable management system, with integrated database and graphic, **as directed**, capabilities.
 2. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.
 3. Information shall be presented in database view, schematic plans, or technical drawings.
 - a. Microsoft Visio Professional or AutoCAD drawing software shall be used as drawing and schematic plans software.
 4. System shall interface with the following testing and recording devices:
 - a. Direct upload tests from circuit testing instrument into the personal computer.
 - b. Direct download circuit labeling into labeling printer.
- O. Source Quality Control
1. Testing Agency: Engage a qualified testing agency to evaluate cables.
 2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
 3. Factory test UTP cables according to TIA/EIA-568-B.2.
 4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
 5. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
 6. Cable will be considered defective if it does not pass tests and inspections.
 7. Prepare test and inspection reports.
- 1.3 EXECUTION
- A. Entrance Facilities
1. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.
- B. Wiring Methods



1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
 - a. Install plenum cable in environmental air spaces, including plenum ceilings.
 - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

C. Installation Of Pathways

1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
2. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings". Drawings indicate general arrangement of pathways and fittings.
3. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
4. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
5. Install manufactured conduit sweeps and long-radius elbows whenever possible.
6. Pathway Installation in Communications Equipment Rooms:
 - a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - b. Install cable trays to route cables if conduits cannot be located in these positions.
 - c. Secure conduits to backboard when entering room from overhead.
 - d. Extend conduits 3 inches (76 mm) above finished floor.
 - e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
7. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

D. Installation Of Cables

1. Comply with NECA 1.
2. General Requirements for Cabling:
 - a. Comply with TIA/EIA-568-B.1.
 - b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - c. Install 110-style IDC termination hardware unless otherwise indicated.
 - d. MUTOA shall not be used as a cross-connect point.
 - e. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
 - 1) Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - 2) Locate consolidation points for UTP at least 49 feet (15 m) from communications equipment room.
 - f. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - g. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - h. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.



- i. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 - j. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - k. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - l. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
 - m. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
3. UTP Cable Installation:
 - a. Comply with TIA/EIA-568-B.2.
 - b. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
 4. Optical Fiber Cable Installation:
 - a. Comply with TIA/EIA-568-B.3.
 - b. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
 5. Open-Cable Installation:
 - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - b. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
 - c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
 6. Installation of Cable Routed Exposed under Raised Floors:
 - a. Install plenum-rated cable only.
 - b. Install cabling after the flooring system has been installed in raised floor areas.
 - c. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.
 7. Outdoor Coaxial Cable Installation:
 - a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
 - b. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
 8. Group connecting hardware for cables into separate logical fields.
 9. Separation from EMI Sources:
 - a. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
 - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
 - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:



- 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
- e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
 - f. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).
- E. Firestopping
1. Comply with requirements in Division 07 Section "Penetration Firestopping".
 2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
 3. Comply with BICSI TDMM, "Firestopping Systems" Article.
- F. Grounding
1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
 2. Comply with ANSI-J-STD-607-A.
 3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
 4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
- G. Identification
1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
 - a. Administration Class: **1 OR 2 OR 3 OR 4, as directed.**
 - b. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
 2. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
 3. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
 4. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 **OR** Class 3 **OR** Class 4, **as directed**, level of administration, including optional identification requirements of this standard.
 5. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
 6. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by the Owner.
 7. Cable and Wire Identification:
 - a. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.



- b. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - c. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
 - d. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - 1) Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
 - 2) Label each unit and field within distribution racks and frames.
 - e. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
 - f. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.
8. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.
- a. Cables use flexible vinyl or polyester that flex as cables are bent.

H. Field Quality Control

- 1. Tests and Inspections:
 - a. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
 - b. Visually confirm Category 5e **OR** Category 6, **OR** Category 6e **as directed**, marking of outlets, cover plates, outlet/connectors, and patch panels.
 - c. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - d. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - e. Optical Fiber Cable Tests:
 - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 2) Link End-to-End Attenuation Tests:
 - a) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
 - b) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
 - f. UTP Performance Tests:
 - 1) Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
 - a) Wire map.
 - b) Length (physical vs. electrical, and length requirements).
 - c) Insertion loss.



- d) Near-end crosstalk (NEXT) loss.
 - e) Power sum near-end crosstalk (PSNEXT) loss.
 - f) Equal-level far-end crosstalk (ELFEXT).
 - g) Power sum equal-level far-end crosstalk (PSELFEXT).
 - h) Return loss.
 - i) Propagation delay.
 - j) Delay skew.
- g. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.3.
 - h. Coaxial Cable Tests: Conduct tests according to Division 27 Section "Master Antenna Television System".
 - i. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.
 - 1) Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
 - 2) Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- 2. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
 - 3. End-to-end cabling will be considered defective if it does not pass tests and inspections.
 - 4. Prepare test and inspection reports.

END OF SECTION 26 05 19 16e

**SECTION 26 05 19 16f - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY****1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for conductors and cables for electronic safety and security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. UTP cabling.
 - b. 50/125 and 62.5/125-micrometer, multimode optical fiber cabling.
 - c. Coaxial cabling.
 - d. RS-232 cabling.
 - e. RS-485 cabling.
 - f. Low-voltage control cabling.
 - g. Control-circuit conductors.
 - h. Fire alarm wire and cable.
 - i. Identification products.

C. Definitions

1. BICSI: Building Industry Consulting Service International.
2. EMI: Electromagnetic interference.
3. IDC: Insulation displacement connector.
4. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
5. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
6. RCDD: Registered Communications Distribution Designer.

D. Performance Requirements

1. Seismic Performance: Pathways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated.
 - a. For coaxial cable, include the following installation data for each type used:
 - 1) Nominal OD.
 - 2) Minimum bending radius.
 - 3) Maximum pulling tension.
2. Shop Drawings: Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to side of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
3. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
4. Seismic Qualification Certificates: For pathways, accessories, and components, from manufacturer.



- a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Source quality-control reports.
 6. Field quality-control reports.
 7. Operation and Maintenance Data: For wire and cable to include in operation and maintenance manuals. Include the following:
 - a. Allowable pulling tension of cable.
 - b. Cable connectors and terminations recommended by the manufacturer.

F. Quality Assurance

1. Testing Agency Qualifications: An NRTL.
 - a. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Delivery, Storage, And Handling

1. Test cables upon receipt at Project site.
 - a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical-fiber flashlight or optical loss test set.
 - b. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
 - c. Test each pair of UTP cable for open and short circuits.

H. Project Conditions

1. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
 - a. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.
2. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.2 PRODUCTS

A. Pathways

1. Support of Open Cabling: NRTL labeled for support of Category 5e **OR** Category 6, **OR** Category 6e **as directed**, cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - a. Support brackets with cable tie slots for fastening cable ties to brackets.
 - b. Lacing bars, spools, J-hooks, and D-rings.
 - c. Straps and other devices.
2. Cable Trays:



- a. Cable Tray Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M Grade 0.55, not less than 0.002165 inch (0.055 mm) thick, **as directed**.
 - 1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep, **as directed**. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
 - 2) Trough Cable Trays: Nominally 6 inches (150 mm), **as directed**, wide.
 - 3) Ladder Cable Trays: Nominally 18 inches (455 mm), **as directed**, wide, and a rung spacing of 12 inches (305 mm), **as directed**.
 - 4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm), **as directed**, wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
 - 5) Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm), **as directed**, wide. Provide with **OR** without, **as directed**, solid covers.
 3. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways and Boxes." Flexible metal conduit shall not be used, **as directed**.
 4. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
- B. Backboards
1. Backboards: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry".
- C. UTP Cable
1. Description: 100-ohm, 4-pair UTP, covered with a blue thermoplastic jacket.
 - a. Comply with ICEA S-90-661 for mechanical properties.
 - b. Comply with TIA/EIA-568-B.1 for performance specifications.
 - c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
 - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - 1) Communications, General Purpose: Type CM or CMG; **OR** MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
 - 2) Communications, Plenum Rated: Type CMP **OR** MPP, **as directed**, complying with NFPA 262.
 - 3) Communications, Riser Rated: Type CMR; **OR** MPP, CMP, or MPR, **as directed**, complying with UL 1666.
 - 4) Communications, Limited Purpose: Type CMX; **OR** MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
 - 5) Multipurpose: Type MP or MPG; **OR** MPP or MPR, **as directed**.
 - 6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
 - 7) Multipurpose, Riser Rated: Type MPR **OR** MPP, **as directed**, complying with UL 1666.
- D. UTP Cable Hardware
1. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
 2. Connecting Blocks: 110-style for Category 5e **OR** 110-style for Category 6 **OR** 66-style for Category 5e, **OR** 110-style for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25, **as directed**, percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- E. Optical Fiber Cable
1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, **as directed**, nonconductive, **as directed**, tight buffer, optical fiber cable.



- a. Comply with ICEA S-83-596 for indoor cable OR ICEA S-87-640 for outside plant, as directed, for mechanical properties.
 - b. Comply with TIA/EIA-568-B.3 for performance specifications.
 - c. Comply with TIA-492AAAB **OR** TIA-492AAAA-A, **as directed**, for detailed specifications.
 - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - 1) General Purpose, Nonconductive: Type OFN or OFNG, **OR** OFNR, OFNP, **as directed**.
 - 2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - 3) Riser Rated, Nonconductive: Type OFNR or OFNP, complying with UL 1666.
 - 4) General Purpose, Conductive: Type OFC or OFCG; **OR** OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
 - 5) Plenum Rated, Conductive: Type OFCP or OFNP, complying with NFPA 262.
 - 6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **asa directed**, complying with UL 1666.
 - e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
 - f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
 - g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
2. Jacket:
- a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
 - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
 - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Optical Fiber Cable Hardware

1. Cable Connecting Hardware: Meet the Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
 - a. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
 - b. Type SFF connectors may be used in termination racks, panels, and equipment packages.

G. Coaxial Cable

1. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
2. RG-11/U: NFPA 70, Type CATV.
 - a. No. 14 AWG, solid, copper-covered steel conductor.
 - b. Gas-injected, foam-PE insulation.
 - c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
 - d. Jacketed with sunlight-resistant, black PVC or PE.
 - e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
3. RG59/U: NFPA 70, Type CATVR.
 - a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
 - b. Gas-injected, foam-PE insulation.
 - c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
 - d. Color-coded PVC jacket.
4. RG-6/U: NFPA 70, Type CATV or CM.
 - a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
 - c. Jacketed with black PVC or PE.



- d. Suitable for indoor installations.
 5. RG59/U: NFPA 70, Type CATV.
 - a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
 - c. PVC jacket.
 6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
 - a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
 - b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
 - c. Copolymer jacket.
 7. NFPA and UL Compliance: Coaxial cables shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655, and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
 - a. CATV Cable: Type CATV, **OR** CATVP or CATVR, **as directed**.
 - b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
 - c. CATV Riser Rated: Type CATVR; **OR** CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
 - d. CATV Limited Rating: Type CATVX.
- H. Coaxial Cable Hardware
1. Coaxial-Cable Connectors: Type BNC, 75 ohms.
- I. RS-232 Cable
1. Standard Cable: NFPA 70, Type CM.
 - a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - b. Polypropylene insulation.
 - c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 - d. PVC jacket.
 - e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - f. Flame Resistance: Comply with UL 1581.
 2. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - b. Plastic insulation.
 - c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 - d. Plastic jacket.
 - e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - f. Flame Resistance: Comply with NFPA 262.
- J. RS-485 Cable
1. Standard Cable: NFPA 70, Type CM **OR** CMG, **as directed**.
 - a. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1581.
 2. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. Flame Resistance: NFPA 262, Flame Test.
- K. Low-Voltage Control Cable



1. Paired Cable: NFPA 70, Type CMG.
 - a. 1 pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1581.
 2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. 1 pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with NFPA 262.
- L. Control-Circuit Conductors
1. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway **OR** Type XHHN, complying with UL 44, in raceway, **as directed**.
 2. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway **OR** power-limited cable, complying with UL 83, concealed in building finishes **OR** power-limited tray cable, complying with UL 83, in cable tray **OR** Type XHHN, complying with UL 44, in raceway, **as directed**.
 3. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.
- M. Fire Alarm Wire And Cable
1. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
 2. Signaling Line Circuits: Twisted, shielded pair, not less than **OR** No. 18 AWG **OR** size as recommended by system manufacturer, **as directed**.
 - a. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.
 3. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - a. Low-Voltage Circuits: No. 16 AWG, minimum.
 - b. Line-Voltage Circuits: No. 12 AWG, minimum.
 - c. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket, **as directed**, with red identifier stripe, NRTL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.
- N. Identification Products
1. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
 2. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
- O. Source Quality Control
1. Testing Agency: Engage a qualified testing agency to evaluate cables.
 2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
 3. Factory test UTP cables according to TIA/EIA-568-B.2.
 4. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.



5. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
6. Cable will be considered defective if it does not pass tests and inspections.
7. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation Of Pathways

1. Cable Trays: Comply with NEMA VE 2 and TIA-569-B.
2. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.
3. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
4. Install manufactured conduit sweeps and long-radius elbows whenever possible.
5. Pathway Installation in Equipment Rooms:
 - a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - b. Install cable trays to route cables if conduits cannot be located in these positions.
 - c. Secure conduits to backboard when entering room from overhead.
 - d. Extend conduits 3 inches (75 mm) above finished floor.
 - e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
6. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

B. Installation Of Hangers And Supports

1. Comply with requirements in Division 26 Section "Hangers And Supports For Electrical Systems" for installation of supports for pathways, conductors and cables.

C. Wiring Method

1. Install wiring in metal raceways and wireways. Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 3/4 inch (21 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
2. Install wiring in raceways except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 3/4 inch (21 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
3. Install cable, concealed in accessible ceilings, walls, and floors when possible.
4. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Installation Of Conductors And Cables

1. Comply with NECA 1.
2. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
3. General Requirements for Cabling:
 - a. Comply with TIA/EIA-568-B.1.
 - b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."



- c. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
 - d. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - e. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 - f. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - g. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - h. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
4. UTP Cable Installation: Install using techniques, practices, and methods that are consistent with Category 5e **OR** Category 6, **OR** Category 6e **as directed**, rating of components and that ensure Category 5e **OR** Category 6, **OR** Category 6e **as directed**, performance of completed and linked signal paths, end to end.
 - a. Comply with TIA/EIA-568-B.2.
 - b. Install 110-style IDC termination hardware unless otherwise indicated.
 - c. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
 5. Optical Fiber Cable Installation:
 - a. Comply with TIA/EIA-568-B.3.
 - b. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
 6. Outdoor Coaxial Cable Installation:
 - a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
 - b. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
 7. Open-Cable Installation:
 - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - b. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
 - c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
 8. Installation of Cable Routed Exposed under Raised Floors:
 - a. Install plenum-rated cable only.
 - b. Install cabling after the flooring system has been installed in raised floor areas.
 - c. Coil cable 72 inches (1830 mm) long shall be neatly coiled not less than 12 inches (300 mm) in diameter below each feed point.
 9. Separation from EMI Sources:
 - a. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).



- c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
 - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
 - e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
 - f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).
- E. Fire Alarm Wiring Installation
1. Comply with NECA 1 and NFPA 72.
 2. Wiring Method: Install wiring in metal raceway according to Division 26 Section "Raceway And Boxes For Electrical Systems".
 - a. Install plenum cable in environmental air spaces, including plenum ceilings.
 - b. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
 3. Wiring Method:
 - a. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 - b. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is **OR** is not, **as directed**, permitted.
 - c. Signaling Line Circuits: Power-limited fire alarm cables may **OR** shall not, **as directed**, be installed in the same cable or raceway as signaling line circuits.
 4. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
 5. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
 6. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
 7. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.
 8. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.
- F. Power And Control-Circuit Conductors
1. 120-V Power Wiring: Install according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables" unless otherwise indicated.
 2. Minimum Conductor Sizes:
 - a. Class 1 remote-control and signal circuits, No. 14 AWG.



- b. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
- c. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

G. Connections

1. Comply with requirements in Division 28 Section "Perimeter Security Systems" for connecting, terminating, and identifying wires and cables.
2. Comply with requirements in Division 28 Section "Intrusion Detection" for connecting, terminating, and identifying wires and cables.
3. Comply with requirements in Division 28 Section "Access Control" for connecting, terminating, and identifying wires and cables.
4. Comply with requirements in Division 28 Section "Video Surveillance" for connecting, terminating, and identifying wires and cables.
5. Comply with requirements in Division 28 Section "Plc Electronic Detention Monitoring And Control Systems" for connecting, terminating, and identifying wires and cables.
6. Comply with requirements in Division 28 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System", **as directed**, for connecting, terminating, and identifying wires and cables.
7. Comply with requirements in Division 28 Section "Refrigerant Detection And Alarm" for connecting, terminating, and identifying wires and cables.

H. Firestopping

1. Comply with requirements in Division 07 Section "Penetration Firestopping".
2. Comply with TIA-569-B, "Firestopping" Annex A.
3. Comply with BICSI TDMM, "Firestopping Systems" Article.

I. Grounding

1. For communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
2. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

J. Identification

1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".

K. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
 - b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - c. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
 - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - d. Optical Fiber Cable Tests:



- 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- 2) Link End-to-End Attenuation Tests:
 - a) Multimode Link Measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526-14-A, Method B, One Reference Jumper.
 - b) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
- e. Coaxial Cable Tests: Comply with requirements in Division 27 Section "Master Antenna Television System".
3. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 26 05 19 16f



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Task	Specification	Specification Description
26 05 19 16	01 22 16 00	No Specification Required
26 05 19 16	26 05 00 00	Common Work Results for Electrical
26 05 19 16	26 05 13 00	Conductors And Cables
26 05 19 16	26 05 13 00a	Undercarpet Cables
26 05 19 16	26 05 13 00b	Medium-Voltage Cables



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SECTION 26 05 19 23 - MONORAILS WITH ELECTRIC POWERED HOISTS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for monorails with electric powered hoists. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. System Description

1. Provide a monorail system with electric powered hoist(s) and plain type (hand operated) **OR** hand chain operated **OR** electric powered, **as directed**, trolley(s) complete, tested and ready for operation. Monorails, hoist(s), trolley(s), equipment, materials, installation, examination, inspection, and workmanship shall be in accordance with the applicable requirements of NFPA 70, ASME/ANSI B30.11, ASME/ANSI B30.16, ASME HST-1M, ANSI/ASME HST-4M, and MMA MH27.1, with modifications specified herein. Reference in these publications to the "authority having jurisdiction" shall be interpreted to mean the "the Owner."

C. Submittals

1. Shop Drawings: Monorail system
2. Product Data: Monorail track system including switches, suspension system and other components; Electric wire rope hoist; Electric chain hoist; Trolley; Pendant pushbutton station; Electrification.
3. Design Data: Load and sizing calculations.
4. Test Reports
5. Certificates
6. Operation and Maintenance Data

D. Delivery, Storage, and Handling

1. Delivery and Storage: Inspect materials delivered to site for damage; unload and store with minimum handling. Store materials on-site in enclosures or under protective coverings. Protect materials not suitable for outdoor storage to prevent damage during periods of inclement weather, including subfreezing temperatures, precipitation, and high winds. Store materials susceptible to deterioration by direct sunlight under cover and avoid damage due to high temperatures. Do not store materials directly on ground. When special precautions are required, prominently and legibly stencil instructions for such precautions on outside of equipment or its crating.
2. Handling: Handle materials in such a manner as to ensure delivery to final location in undamaged condition. Make repairs to damaged materials at no cost to the Owner.

E. Quality Assurance

1. Certificates: Overload Test Certificate: Submit a statement that the monorail system can be periodically load tested to 125 percent (plus 5 minus 0) of rated load.
2. Drawings: Monorail System: Show the general arrangement of all components, clearances and principal dimensions, assemblies of hoist, trolley, track, track suspension system, and electrical schematic drawings.
3. Design Data: Load and Sizing Calculations: Submit calculations verifying the sizing of any track, track suspension device and additional supports which are not the monorail system manufacturer's standard cataloged product.

1.2 PRODUCTS



- A. Overhead Monorail System: Provide overhead monorail system conforming to MMA MH27.1, Class C, for indoor **OR** outdoor, **as directed**, service, with an electric wire rope or chain hoist mounted on a movable trolley. Trolley shall be plain type (hand operated) **OR** hand chain operated **OR** motor operated, **as directed**. Monorail system shall operate on AC voltage as required to meet project requirements, 60 Hz, single **OR** three, **as directed**, phase power source.
1. Capacity: The monorail system shall have a minimum rated capacity as required to meet project requirements. Mark the hoist capacity in pounds (kg) on both sides of the hoist or load block.
 2. Speeds: The hoist shall have two operating speeds, **unless directed otherwise**, and shall be capable of hoisting and lowering the rated load at a high speed of 20 feet per minute (fpm) (100 mm/s). The trolley shall have two operating speeds, **unless directed otherwise**, and shall be capable of moving the rated load at a high speed of 50 fpm **OR** 100 fpm, **as directed**, (250 mm/s **OR** 500 mm/s, **as directed**,). Low speed(s) shall be one quarter to one third of high speed(s). Actual speed(s) shall be within plus or minus 15 percent of those specified.
 3. Material Limitations: Shafts, keys, couplings, sprockets, and chains shall be steel. All gears shall be steel except for worm gears, which shall be bronze or steel. Cast iron and aluminum used to support components of the hoist power transmission train shall be ductile.
 4. Safety: Comply with the mandatory and advisory safety requirements of ASME/ANSI B30.11, ASME/ANSI B30.16, and 29 CFR 1910.179.
- B. Monorail Track System: MMA MH27.1. Track beams shall be patented track sections fabricated by a manufacturer regularly engaged in production of this type of beam.
1. Track Suspension System: Monorail suspension shall be flexible **OR** rigid, **as directed**, type. Make bolted connections to supporting structure, excluding hanger rods, with ASTM A 325/A 325M bolts, ASTM A 563/A 563M nuts, and ASTM F 959/F 959M load indicator washers. ASTM A 325/A 325M bolts shall be fully pre-tensioned in accordance with AISC S329. Support monorail track system from the structural members shown. Provide additional supports as required to carry monorail track system loads to the structural members shown. Materials for additional supports shall conform to the material requirements contained in Division 05 Section "Structural Steel Framing".
- C. Electric Wire Rope Hoist: ANSI/ASME HST-4M, Class H3, except as modified herein. Hoist shall be double reeved, **unless directed otherwise**.
1. Hoisting Ropes: FS RR-W-410, improved or extra improved plow steel, regular lay, uncoated, 6 by 37 class construction, with an independent wire rope core. Provide proof of wire rope breaking strength test report.
 2. Sheaves: Sheaves shall be steel or ductile cast iron. Pitch diameter of running sheaves shall not be less than 16 times the rope diameter. Pitch diameter of non running sheaves shall not be less than 12 times the rope diameter.
 3. Drum: Drum shall be steel or ductile cast iron. Pitch diameter of the drum shall not be less than 18 times the rope diameter. Not less than two dead wraps of the hoisting rope shall remain on each anchorage when the hook is in its extreme low position.
- D. Electric Chain Hoist: ASME HST-1M, Class H3, except as modified herein. Provide load chain proof test.
- E. Trolley: Trolley shall meet all applicable requirements of MMA MH27.1, ASME HST-1M and ANSI/ASME HST-4M. Trolley shall have elastomeric bumpers to engage runway stops.
- F. Motors: NEMA MG 1. Hoist motor shall be single **OR** two, **as directed**, speed AC squirrel cage induction type. Trolley motor shall be single **OR** two, **as directed**, speed AC squirrel cage induction type. Motor insulation shall be Class B minimum. Provide totally enclosed non-ventilated (TENV) motor enclosures. Maximum motor speed shall not exceed 1800 RPM.



- G. Controls: Provide single **OR** two, **as directed**, speed magnetic control for the hoist. Provide single **OR** two, **as directed**, speed magnetic controls for the trolley. Provide reduced voltage starting, acceleration and deceleration for the trolley drive.
- H. Limit Switches: Provide upper and lower limit switches which de-energize the hoist motor.
- I. Brakes: Provide hoist with an electro-mechanical holding brake and a mechanical load brake, each capable of holding 130 percent of the rated hoist capacity. Hoist holding brake shall be capable of being released to test the load brake. Provide trolley with an electro-mechanical brake. Provide trolley brake with a minimum torque rating of 100 percent (for outdoor monorails) or 50 percent (for indoor monorails) of the drive motor rated torque. Trolley brake torque shall be adjustable down to 85 percent of its torque rating.
- J. Load Block And Hook: Construct load blocks of steel. Provide forged steel, swivel type hook, with hook nut keyed to hook shank by means of a setscrew installed in a plane parallel to the longitudinal axis of the hook shank, or other similar easily removable securing device. Hook throat opening shall not be less than as required to meet project requirements. Provide hook with spring loaded steel safety latch for closing the hook throat opening. The hook and hook nut shall be unpainted. Permanently mark hook and hook nut with an identification number.
1. Hook and Hook Nut Magnetic Particle Inspection: Magnetic particle inspect the hook and nut over the entire area in accordance with ASTM A 275/A 275M. Acceptance standard shall be no defects. A defect is defined as a linear indication that is greater than 1/8 inch (3 mm) long whose length is equal to or greater than three times its width.
- K. Bearings: All bearings except those subject to a small rocker motion shall be anti-friction type. Bearings not considered lifetime lubricated by the manufacturer shall be provided with a means for lubrication.
- L. Pendant Pushbutton Station: Hoist and trolley, **unless directed otherwise**, shall be controlled from a pendant pushbutton station. Arrange pushbuttons in accordance with ASME/ANSI B30.11 recommendations. Locate station 4 feet (1.2 m) above the finished floor
- M. Electrification: Runway electrification shall be of the flat festooned type **OR** enclosed safety bar type, **as directed**, with four continuous copper conductors. Provide electrical work for the monorail system in accordance with NFPA 70.
- N. Identification Plates: Provide identification plates of noncorrosive metal with clearly legible permanent lettering giving the manufacturer's name, model number, capacity in pounds, and other essential information or identification.
- O. Painting System: Painting shall be manufacturer's standard. Provide a primer and a finish coat. For outdoor monorail systems, blast clean all components prior to painting and prime with inorganic zinc type primer; finish coat shall be an epoxy formulated for marine environments. Paint coats shall be smooth and even, free of runs, sags, orange peel, or other defects.
- 1.3 EXECUTION:
- A. Erection And Installation: Erect and install the monorail system, complete in accordance with the approved submittals and in condition to perform the operational and acceptance tests.
- B. Erection Services: Provide supervisory erection services from the monorail system manufacturer.
- C. Field Quality Control
1. Post-Erection Inspection: After erection, the Contractor and the the Owner shall jointly inspect the monorail and hoist systems and components to determine compliance with specifications and



- approved submittals. The Contractor shall notify the the Owner 3 days before the inspection. Provide a report of the inspection indicating the monorail system is considered ready for operational tests
2. **Operational Tests:** After erection and inspection, test the hoist, and trolley as specified herein. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacturer, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the monorail system is operational. The Contractor shall furnish loads for testing, operating personnel, instruments, and all other necessary apparatus. The the Owner will furnish loads for testing; the Contractor shall receive and transport the loads from a location not more than 100 miles (161 km) from the job site and shall return them to that location after the tests have been completed.
 3. **Test Data:** Record test data on appropriate test record forms suitable for retention for the life of the monorail system. Record operating and startup current measurements for electrical equipment (motors and coils) using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) shall be justified or appropriate adjustments performed. In addition, high temperatures or abnormal operation of any equipment or machinery shall be noted, investigated, and corrected. Record hoist and trolley speeds during each test cycle.
 4. **Hook Test:** Measure hook for hook throat spread before and after load test. Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus 1/64 inch (0.4 mm)). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening by more than 5 percent from the base measurement shall be cause for rejection.
 5. **No-Load Test**
 - a. **Hoist:** Raise the load hook the full operating lift distance and verify satisfactory operation of hoist, upper limit switch, lower limit switch, and the hoisting and lowering speeds. Operate the hoist at low and high speed in both directions.
 - b. **Trolley:** Operate trolley assembly the full length of the monorail in both directions. Operate trolley at low and high speed in each direction. Verify satisfactory operation and verify trolley speed. Operate all rail switches.
 6. **Load Test: 125 Percent (plus 5 percent minus 0) of rated capacity**
 - a. **Hoist Static Test:** Raise test load approximately one foot above the floor and hold for 10 minutes. Observe load lowering that may occur which will indicate malfunction of hoisting component or brake. Lower the test load to the floor until the hoist line is slack.
 - b. **Hoist Dynamic Test:** Raise the test load to approximately 5 feet (1.5 m) above the floor using both speed points in the process. Lower the load back to the floor using both speed points. Stop the test load at least once while lowering at high speed and observe proper brake operation. Wait 5 minutes, then repeat the above cycle.
 - c. **Load Brake Test:** Raise test load approximately 5 feet (1.5 m). With the hoist controller in the neutral position, release the holding brake. The load brake should hold the test load. Again with the holding brake in the released position, start the test load down at low speed and return the controller to off position as the test load lowers. The load brake should prevent the test load from accelerating. NOTE: It is not necessary for the load brake to halt the downward motion of the test load.
 - d. **Loss of Power Test:** Raise the test load approximately 3 feet (1 m) and while lowering test load at low speed, cut main power to hoist. Load should stop.
 - e. **Trolley Test:** With test load hoisted to a height of one foot (300 mm) above the floor, operate trolley the full distance of the monorail in both directions using both speed points in the process. Observe for any malfunctioning of the trolley assembly and monorail system. Operate all rail switches.
 - f. **Rated Load Speed Test:** With the hoist loaded to rated capacity, raise and lower the load verifying that the hoisting and lowering speeds are provided as specified. With the hoist loaded to rated capacity, operate trolley along the monorail beam verifying that the trolley



speed is provided as specified. Further, verify that the trolley stops in each direction within a distance (in feet) equal to 10 percent of rated capacity high speed (in feet per minute) when initially travelling at high speed and carrying the rated capacity load. Record voltage, amperage, hoisting and lowering speeds, trolley travel speed, and motor speed for each motor.

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**SECTION 26 05 19 23a - CRANES, OVERHEAD ELECTRIC, UNDERRUNNING (UNDER 20,000 POUNDS)**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for underrunning overhead electric cranes (under 20,000 pounds). Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definitions

1. Bridge: That part of an overhead crane consisting of girder, end trucks, and drive mechanism which carries the trolley/hoist and travels in a direction parallel to the runway. (An auxiliary girder may be required to support over-hanging loads.)
2. Dead Loads: The loads on a structure which remain in a fixed position relative to the structure.
3. Girder: The principal horizontal beam of the crane bridge which supports the trolley/hoist and is supported by the end trucks.
4. Live Load: A load which moves relative to the structure under consideration.
5. Patented Track: A generic term referring to crane and monorail track built in accordance with MMA MH27.1 utilizing a composite track section incorporating a proprietary bottom flange shape.
6. Rated Load: For the purpose of this specification the rated load is defined as the maximum working load suspended under the load hook. Load block and ropes are not included in the rated load.
7. Runway: The track, beams, hangar rods, and structural supports on which the crane operates.
8. Standard Commercial Product: A product which is currently being sold, or previously has been sold, in substantial quantities to the general public, industry or Government in the course of normal business operations. Nominal quantities, such as models, samples, prototypes or experimental units do not meet this definition.
9. Trolley/Hoist: A combined unit consisting of a trolley, a wheeled mechanism which provides horizontal motion along the bridge girder, and a hoist, a machinery unit, suspended from the trolley, used for lifting and lowering a freely suspended load.
10. Underrunning (Underhung) Crane: An electric overhead traveling crane having the end trucks supported on runway.

C. Submittals

1. Shop Drawings
 - a. Submit shop drawings in the Contractor's standard format and show the general arrangement of all components in plan, elevation, and end views; clearances, hook approaches on all four sides, and principal dimensions, demonstrating compliance with the clearances indicated; assemblies of hoists, trolley, and bridge drives; and electrical schematic wiring diagrams. Provide panel wiring diagrams and interconnection diagrams, include an integral "Bill of Materials" on each drawing. Provide weights of major components. Provide maximum wheel loads (without impact) and spacings that will be imparted to the runway track beams.
 - b. Submit erection drawings showing all match-marked details of field joints, erection procedures, alignment procedures and tolerances, lifting points, and any special precautions to be observed during crane erection.
 - c. Submit lubrication drawing showing all lubrication points, the type of lubricant to be used, and the frequency of lubrication. Provide a table on each drawing for documentation of future revisions.
2. Product Data: Submit data for standard items including trolley/hoist, controllers, couplings, push-button station, electrification, bridge motors and brakes.

Cranes, Overhead Electric, Underrunning (Under 20,000 Pounds)



3. Design Data: Submit calculations demonstrating compliance with all specification requirements.
4. Test Reports.
5. Operation and Maintenance Data.

D. Quality Assurance

1. Structural Steel Fabrication: Fabricate structural steel free of kinks and sharp bends. Shear and chip neatly and accurately. Provide square and true corners. Straighten material by methods that will not change material properties or cause fabrication scars.
2. Flame Cutting: Flame cutting, using a tip suitable for the thickness of metal, may be used instead of shearing or sawing. Grind or machine flame-cut surfaces sufficiently to remove slag, objectionable notches, and all evidence of cooling checks.
3. Forming: Make bends of major character with metal dies or fixtures to ensure uniformity of size and shape. Perform cold-forming operations with material temperature below 600 degrees F (310 degrees C). Perform hot-forming operations with material temperature over 1100 degrees F (590 degrees C).
4. Welding: AWS D14.1, including preweld and postweld heat treatments; however, the minimum classification of electrodes shall be the E70 series.
5. Castings: Make castings sound and free from warping, misplaced coring, or other defects which might render the casting defective. Perform weld repairs of castings to correct dimensions or other defects only after approval of such repairs is obtained from the the Owner. Make weld repairs items of permanent record.
6. Structural and Weldment Machining: Machine flat all mounting surfaces for electric motors, brakes, gear reducers, and other mechanical components. Finish mounting surfaces to 250 micro-inches (6 micrometers) or finer. Machine seats for travel wheel bearings, bearing housings, or pillow blocks with one set-up on a milling or boring machine.
7. Hook and Hook Nut Inspection
 - a. Magnetic-particle inspect the entire surface area in accordance with ASTM A 275/A 275M. Acceptance standard shall be no defects. A defect is defined as a linear indication that is greater than 1/8 inch (3 mm) long whose length is equal to or greater than three times its width.
 - b. Each hook, including shank and hook nut, shall be inspected over the entire surface areas by magnetic particle inspection. If hook nut is not used, any device that functions the same as the hook nut shall be inspected by magnetic particle inspection.
 - 1) Procedure: Magnetic particle inspection shall be conducted in accordance with ASTM A 275/A 275M. This inspection shall be conducted at the factory of the hook manufacturer or hoist manufacturer. Alternately, a recognized independent testing lab may conduct the inspections if equipped and competent to perform such a service, and if approved by the the Owner.
 - 2) Acceptance Criteria: Defects found on the hook or hook nut shall result in rejection of defective items for use on furnished hoist. For this inspection, a defect is defined as a linear or non-linear indication for which the largest dimension is greater than 1/8 inch (3 mm). Weld repairs for defects on hook or hook nut will not be permitted.
 - 3) Test Report: A test report of the magnetic particle inspection of each hook and hook nut provided shall be submitted to and approved by the the Owner prior to final acceptance of hoist installation. Test reports shall be certified by the testing organization.
 - 4) Weld Repair: Weld repairs for defects on hooks or hook nuts will not be acceptable.
8. Shop Structural Alignment: Accurately align girders and end trucks for squareness and parallelism prior to punching, drilling, and reaming bolt holes. Install bridge and trolley travel wheels with their respective axles parallel and in line side-to-side.
9. Structural Bolted Connections: Accurately punch, drill, and ream (as necessary) bolt holes, and remove burrs. Install ASTM A 325/A 325M bolts in accordance with AISC S329.
10. Machine Work (Structural and Mechanical Parts): Fabricate machined parts to the tolerances, surface finishes, and fits indicated on the approved drawings. Any surface indications of



- improper metal cutting or removal (such as tearing, glazing, smearing, or gouging) will be cause for rejection. Flaws such as scratches, ridges, holes, peaks, cracks, or checks which degrade the quality or suitability of a part, will be cause for rejection of such a part.
11. Mechanical Assembly: Accurately align (within coupling tolerances) and positively secure mechanical components to maintain the alignment. Shim gaps in excess of 0.001 inch (0.025 mm) under base-mounted components. A maximum of two shims per corner will be permitted. Do not force parts into position to obtain apparent alignment. Tighten bolts, nuts, and screws. Secure fasteners or parts which might become loosened by vibration, shock, or crane operation with suitable locking devices. Friction shall not be relied upon for retention of parts.
 12. Priming and Painting: The primer coats and the finish coat of paint shall be smooth, even, free of runs, sags, orange peels, or other defects. Care shall be taken to preclude painting over the hook, equipment information or name plates, lubrication fittings, stainless steel or aluminum, or mating surfaces of structural bolted connections. Paint, coatings, or galvanizing on the following items or areas will not be acceptable: hoist wire ropes, hook nuts, or areas on sheaves or rope drums in contact with the wire ropes.
 13. Electrical Installation: Install electrical wiring, conduit and components in accordance with the requirements of NFPA 70.
 14. Design Data
 - a. Girders
 - 1) For load Cases 1 and 2 (defined in CMAA 74) and load Cases 3 and 4 (defined herein), provide the following analyses:
 - a) Normal stress at mid-span including that due to warping;
 - b) Shear stress (including that due to torsion) at end notches;
 - c) Weld stresses;
 - d) Buckling (flange and web); and
 - e) Local flange bending (due to wheel loads).
 - 2) For Cases 1 and 2, provide fatigue analysis (welds and structural bolting and girder connections). Consider only unaltered ASTM A 325/A 325M bolts in this analysis.
 - 3) Using trolley load and lifting load, provide:
 - a) Calculation of mid-span deflection; and
 - b) Calculation of camber.
 - b. End Trucks: For each of the four load cases, provide the following analyses:
 - 1) Normal stresses;
 - 2) Shear stresses (including that due to torsion); and
 - 3) Weld stresses.
 - c. Structural Bolting at Girder Connections: For each of the four load cases, provide combined shear and tension stress calculations for girder-to-end truck connections.
 15. Test Reports: Requirements: Provide original mill test reports. Proof testing report of the hook as addressed in ASME/ANSI B30.10. Bolts shall meet requirements of ASTM A 325/A 325M. Nuts shall meet requirements of ASTM A 194/A 194M or ASTM A 563/A 563M. Submit complete heat treating records, mechanical test reports, and inspection test reports.

1.2 PRODUCTS

A. General

1. Provide underrunning overhead electric crane with electrically operated bridge, trolley/hoist, controlled by a pendent pushbutton station suspended from a festooning system along the bridge. The crane shall, as a minimum, be in accordance with the requirements of this specification and shall be the manufacturer's standard commercial product. Include in the crane being furnished additional or better features which are not specifically prohibited by this specification, but which are a part of the manufacturer's standard commercial product. The crane shall operate in an indoor **OR** outdoor, **as directed**, environment. Maximum crane wheel loads (without impact) due to dead and live loads, with the trolley in any position, shall not cause a more severe loading



condition in the runway support structure than that produced by the design wheel loads and spacings indicated.

- a. Crane Safety: Comply with the mandatory and advisory safety requirements of ASME/ANSI B30.11, ASME/ANSI B30.16, and ANSI/ASME HST-4M.
 - b. Power Characteristics: The crane shall operate from AC voltage as required to meet project requirements, 60 Hz three phase power source.
- B. Capacity: The crane shall have a minimum rated capacity of 1/2 to 10 tons (one ton equals 2000 pounds) (1/2 to 10 metric tons), as required to meet project requirements.
- C. Speeds: The crane shall have the following rated load speeds (plus or minus 15 percent):
1. Hoist - high speed of 10 feet per minute (fpm) (50 mm/s), unless otherwise directed.
 2. Trolley - high speed of 50 fpm (250 mm/s).
 3. Bridge - high speed of 50 fpm (250 mm/s).
- D. Crane Design And Fabrication
1. Bridge: CMAA 74, Class C (Moderate Service) or MMA MH27.1, Class C (Moderate Service), except as modified herein. Provide a patented track for the girder.
 2. Trolley: ANSI/ASME HST-4M, Class H3 or MMA MH27.1, Class C (Moderate Service), except as modified herein.
 3. Hoist: ANSI/ASME HST-4M, Class H3, except as modified herein.
 4. Structural Design: Design the crane in accordance with CMAA 74, except as modified herein. However, fabricate the girder from patented track conforming to MMA MH27.1.
 - a. Additional Load Combinations: In addition to load Case 1, "Crane in Regular Use Under Principal Loading" and Case 2, "Crane in Regular Use Under Principal and Additional Loading" of CMAA 74, also consider the following load combination(s):
 - 1) Test Loads: The crane will be periodically tested up to 130 percent of rated capacity. Calculate combined stresses for the following load combination to ensure structural adequacy during testing:

Case 3: Test Loads (Stress Level 3)
DL (DLFB) + TL (DLFT) + LL (1 + HLF) + IFD + SK

Note: LL = 1.3 x rated capacity
Test and extraordinary loads shall not be considered in the fatigue analysis
 - 2) Seismic Forces (SF): Consider seismic forces in the design of the crane. Locate the concentrated load in the same positions as when calculating vertical shears and bending moments. Consider twisting moments due to the horizontal forces acting eccentric to the horizontal neutral axis of the girder in the shear and combined stress calculations. Do not consider seismic forces in the fatigue analysis. Calculate combined stresses due to seismic forces for the following load combination:

Case 4:

Seismic Loading (1.33 x Stress Level 1)
DL (DLFB) + TL (DLFT) + LL (1 + HLF) + SF

Note: Factor for SF to be as required to meet project requirements.

Note: SF = [_____] DL (distributed) + [_____] TL (concentrated)
 - b. Welding: AWS D14.1 for welding design and procedures.
 - c. Structural Bolted Connections: Attach girder to end truck with friction type connections and fasten with unaltered ASTM A 325/A 325M high-strength bolts. (Galvanized or coated



- bolts and ASTM A 490 bolts shall not be used.) Make structural bolted connections not referenced above with ASTM A 325/A 325M or ASTM A 307 bolts.
- d. Girder: Provide a patented track for the girder. The summation of all normal stresses on a girder section under analysis shall not exceed the allowable stress for tension or compression.
5. Mechanical Design: Provide crane bridge drive in accordance with MMA MH27.1. The hoist shall be trolley suspended and shall be in accordance with ANSI/ASME HST-4M and other requirements specified herein. Lift limiting and overload limiting devices which use a clutch to stop motion shall not be furnished with the hoist.
- a. Trolley Drive: Provide motor-driven type hoist trolley.
- b. Threaded Fastener: Fasten base-mounted and flange-mounted components and all mechanical connections subjected to calculable loads with ASTM A 325/A 325M bolts or SAE J 429, Grade 5, screws with properly torqued matched nuts. Bolts and screws may be installed into tapped holes only in heat treated steel with a minimum hardness of 195 BHN.
- c. Load Block: Construct the load block entirely of steel. The design shall preclude the wire rope from being cut, pinched, crushed, or chafed in case of two-blocking. Provide load block with a trunnion separate from the sheave pin. Bore the trunnion for swivel mounting of the hook and securely retain in the block side plates. The trunnion shall rotate about its horizontal axis in holes bored in the side plates. Construct the load block so that the hook and hook nut may be removed from the load block without disassembly of the block. Forge the hook from steel conforming to ASTM A 668/A 668M; the hook shall be unpainted. Provide the hook with a safety latch. Provide the equalizer bar or sheave perpendicular to the running sheaves. Mark hoist capacity in pounds on both sides of the load blocks. Hook and hook nut shall be capable of complete disassembly that enables access to all surfaces of hook, including shank and hook nut for inspection purposes. Provision shall be made for the hook nut, or other hook-to-block fastener, to be keyed to hook shank by means of a set screw or similar, easily removable, securing device. Paint the lower load block yellow, with one inch (25 mm) wide diagonal black stripes located on 2 inch (50 mm) centers.
- d. Hoisting Rope: FS RR-W-410, improved or extra improved plow steel, regular lay, uncoated, 6 by 37 class construction, with an independent wire rope core. Provide double reeved reeving arrangement. Connect hoisting rope dead end to equalizer bars (if used) by means of zinc-speltered sockets or swaged fittings installed in a manner which develops the full breaking strength of the hoisting rope. Anchor hoisting rope ends on the drum by means of swaged fittings or by clamping. Neatly and securely seize hoisting rope ends with corrosion resistant wire, except where terminated in zinc-speltered sockets or swaged fittings. Provide wire rope minimum safety factor of 5 to 1 based on the ratio of actual minimum wire rope breaking load to the calculated load on rope when hoist is assumed loaded to rated capacity. Certification from rope manufacturer verifying provided wire rope breaking strength, shall be submitted to the Owner and approved prior to final acceptance of hoist. No paint or coatings will be allowed on the wire rope. Minimum length of the wire rope shall enable the load hook to operate through its full hook lift range and still have a minimum of two full wraps of wire rope around the rope drum.
- e. Sheaves: Provide steel sheaves. Machine or grind the grooves to contour and rim toughen or flame or induction harden to not less than 320 BHN. Provide minimum pitch diameters of running sheaves of not less than 24 (for custom design load block with trunnion) or 16 (otherwise) times the rope diameter. Provide sheave groove depth of not less than 1.15 times the hoisting rope diameter.
- f. Drum: Provide drum with turned helical grooves cut right and left hand to receive, in a single layer, the full winding length of the rope plus not less than two dead wraps on each end.
- 1) The drum shall be of steel construction. Design drum so that not less than two dead wraps of hoisting rope will remain on each anchorage when the hook is in its extreme low position. Drum grooving shall be right and left hand. Minimum drum



- groove depth, shall be 0.375 times the rope diameter. Minimum drum groove pitch shall be either 1.14 times the rope diameter, or the rope diameter plus 1/8 inch (3 mm), whichever is smaller. Minimum drum pitch diameter shall be 16 **OR** 18, **as directed**, times the rope diameter. The surface of the drum which comes in contact with wire rope shall not be painted, coated, or galvanized.
- g. Hoist Brake: Provide electro-mechanical holding brake and mechanical load brake.
 - h. Trolley Brake: Provide trolley drive with an electro-mechanical brake. Provide brake with a minimum torque rating of 100 percent (for outdoor crane) or 50 percent (for indoor crane) of the drive motor rated torque and adjustable down to 85 percent of its torque rating. Select disc brake (if applicable) having housing which permits easy access for wear and setting inspection of the friction discs.
 - i. Bridge Brake: Provide bridge drive with an electro-mechanical brake. Provide brake a minimum torque rating of 100 percent (for outdoor crane) or 50 percent (for indoor crane) of the drive motor rated torque and adjustable down to 85 percent of its torque rating. Select disc brake (if applicable) having housing which permits easy access for wear and setting inspection of the friction discs.
 - j. Bridge Drive: MMA MH27.1.
 - k. Bumpers: Provide elastomeric type bumpers on the trolley. Provide spring or elastomeric type bumpers, if bridge speed is 50 fpm (250 mm/s), or otherwise provide hydraulic type bumpers on bridge end trucks.
 - l. Surface Finishes: Finish mechanical components to 125 micro-inches (3 micrometers) or finer. Provide finer finishes as required by the component manufacturers.
 - m. Antifriction Bearings: Provide antifriction type bearings, except where bushings are specifically permitted or required. Provide grease lubricated bearings with means for relubrication through easily accessible lubrication fittings or provide permanently lubricated and sealed bearings.
 - n. Bushings: Provide manufacturer's standard bronze alloy bushings and thrust washers. Provide means for relubrication of grease lubricated bushings through easily accessible lubrication fittings or provide oil impregnated type bushings.
 - o. Shims: ASTM A 666, Type 304 corrosion resistant steel, pre-cut, slotted, and with the thickness stamped on an insert tab. Shim shape shall resemble a U and the slot width shall approximate the mounting bolt diameter.
6. Electrical Design: The design, selection, rating, and installation of the electrical portions of the crane and its accessories shall conform to the requirements of NEMA ICS 3, CMAA 74, ANSI/ASME HST-4M, and NFPA 70, and other requirements specified herein. Control each motion of the crane by a suitable controller. Design crane to operate on VAC rating as required to meet project requirements, 3-phase, 60-Hertz power. The crane manufacturer shall furnish and install all electrical equipment on the crane, including motors, electrically released brakes, switches, controllers, panels, operating station, wiring system, cables, and bridge-to-trolley electrification, and the runway electrification. Installation of the runway electrification includes providing conductors between the electrification system and the Owner installed junction box indicated. Provide NEMA Type 1 for indoor crane or Type 3 for outdoor crane, as defined by NEMA 250, enclosures for control panels, for pendent pushbutton station, and for auxiliary devices and mount along the bridge.
- a. Wiring System: Provide the wiring system, with all of its associated hardware, fittings, and devices, in accordance with NFPA 70. Provide type RHW, TFE, XHHW, or Z conductors in raceways and type SIS conductors on control panels. Provide type TFE or Z insulation for conductors connected to, or routed above, resistors. Provide ferrous rigid metal conduit raceways suitable for wet locations; where flexible connections are necessary, provide liquidtight flexible metal conduit. Provide an equipment grounding conductor, sized in accordance with Section 250-95 of NFPA 70, with all ungrounded conductors. Provide No. 4 AWG (25 mm²) minimum for leads from the runway contact conductors. Number or tag wiring at connection points.



- b. Motors: NEMA MG 1. Provide two speed (if magnetic controls are specified) or single speed (if electronic controls are specified) AC squirrel cage induction type motors for the bridge and trolley drives. Provide two speed, AC squirrel cage induction type motor for the hoist. Motor insulation shall be Class F. Provide totally enclosed non-ventilated (TENV) motor enclosures.
- c. AC Controls:
- 1) OPTION 1: Provide two-speed magnetic controls for the bridge drive, trolley drive, and hoist motors. Ensure that an energized drive motor initially rotates only in the direction selected by the operator by depressing the corresponding pushbutton; i.e., is not overhauled. Feed control circuits from a single phase, air cooled, double wound transformer with a grounded metal screen between the primary and secondary windings of the transformer.
 - a) Bridge and Trolley Control: Provide bridge drive and trolley drive motor control systems with resistive or reactive reduced voltage starting, acceleration, and deceleration utilizing, for each, separate banks of voltage reducing resistors or reactors and timing relays. On deceleration, insert the resistors or reactors into the motor's high speed leads prior to de-energization of the high speed contactor. Ensure smooth acceleration and deceleration. Provide bridge drive and trolley drive motor control systems with a drift point between OFF and the first speed control point in each direction.
 - b) Plugging Protection: Provide plugging protection for the bridge and trolley drives. Provide time delay relays, which will prevent the plugging of bridge and trolley drive motors, in the control circuit; arrange the controls to set the associated drive's brake if attempts are made to plug.

OR

OPTION 2: Provide two-speed magnetic controls for the hoist motor; provide four-speed adjustable frequency controls for the bridge and trolley drive motors. Ensure that an energized drive motor initially rotates only in the direction selected by the operator by depressing the corresponding pushbutton; i.e., is not overhauled.

- c) Bridge and Trolley Control: Provide static reversing, dynamic braking, adjustable frequency (achieved by sinusoidal pulse width modulation), constant torque controllers for the bridge and trolley drive motors. Size each of the controllers so as to provide sufficient starting torque to initiate motion of that crane drive from standstill with rated load under the hook. The acceleration time and the deceleration time shall be independently adjustable from 2 to 20 seconds; initially, set acceleration at 5 seconds and deceleration at 2 seconds. In each direction, provide a drift point between OFF and the first running speed point; provide four running speed points, namely 10, 33, 67, and 100 percent of rated speed. The motor shall run smoothly, without torque pulsations at the lowest speed, and shall be energized at a frequency not exceeding 60 Hz at the highest speed. Include with the controller a full wave rectifier and a three-phase inverter. Select diodes and power transistors so that their current ratings are not less than 200 percent of full load motor current. Provide motor overload protection utilizing a thermal sensitive device embedded in its windings.

Energize each crane drive's electro-mechanical brake by a dedicated contactor controlled directly by the pushbuttons on the pendent pushbutton station; i.e., when both of the pushbuttons for a drive are in the OFF position the brake shall be set and when either of them is in any drift or speed point position the brake shall be released. Provide dynamic braking. Connect resistors to the controller's DC bus whenever motor regeneration causes the DC voltage to rise to a predetermined unacceptable level. Provide resistors continuously rated at a minimum of 125 percent of the full load motor current.



- d) Hoist Control: Feed control circuit from a single phase, air cooled, double wound transformer with a grounded metal screen between the primary and secondary windings of the transformer.
- d. Protection: Not less than that required by NEMA ICS 3, CMAA 74, ANSI/ASME HST-4M, MMA MH27.1, and NFPA 70. Provide enclosed type circuit breaker for crane disconnect. The main line contactor shall be the floor operated disconnect.
- e. Operating Station: Control crane from a pendent pushbutton station. Suspend pendent pushbutton station, from a festooning system along the bridge, by a small cord strain lead 1/8 inch (3 mm) (minimum), 7 by 19 construction, made from corrosion resistant steel, and conforming to FS RR-W-410. Provide Type SO cable for pendent cable with a minimum of 20 percent of its conductors reserved as spares at the time of crane acceptance. On the pushbutton station, provide a blue pilot light to indicate that the main line contactor is energized and a white pilot light to indicate that power is available on the load side of the crane disconnect means. Energize the white pilot light by a separate, fused transformer. Assign cardinal points to bridge and trolley pushbuttons.
- f. Resistors: Provide resistors rated for continuous duty operation based upon the motor nameplate amperes (unless electronic controls are specified, in which case use 125 percent of the motor nameplate amperes) and fabricated of corrosion resistant metal; the use of "wire wound" type resistors is prohibited for segments of 8 ohms or less. Mount resistors in substantial, ventilated enclosures constructed entirely of non-combustible materials. Provide resistors with terminals fitted in the coolest position in the enclosure.
- g. Reactors: Provide reactors rated for continuous duty operation based upon the motor nameplate amperes. Select reactors for 60 Hz operation and having taps for field adjustment of inductance so as to permit achievement of the optimum acceleration characteristics for the drive. Secure the cores and the coils of the reactors to prevent any permanent change in the relative position of the parts. Ground the core to the case or make electrically accessible, except for toroidal coils and nonmetallic cores such as ferrities.
- h. Limit Switches: Provide upper and lower limit switches which de-energize the hoist motor. Lift limiting and overload limiting devices which use a clutch to stop motion shall not be furnished with the hoist.
- i. Electrification: For runway electrification provide four continuous copper conductors enclosed in a solid plastic cover; no splices of the conductors will be permitted. Provide two sets of current collectors for each conductor. For bridge-to-trolley provide festooned type electrification utilizing flat cables suspended from carriers riding on an I-beam. Suspend pendent pushbutton station from a festooning system similar to that specified for the bridge-to-trolley electrification system. Provide cables in the festooning system so that a minimum of 20 percent of the conductors are spares at the time of crane acceptance. Do not extend the festooned cable loops below the high hook position.
7. Surface Preparation and Painting: Blast clean all portions of the crane to be painted to the requirements of SSPC SP 6. As soon as practical after blasting, but before any evidence of rust, coat all surfaces with a zinc molybdate primer, applied to a minimum dry film thickness of 2.0 mils (0.05 mm) but not exceeding 4.0 mils (0.1 mm). Apply finish coat of high gloss silicone alkyd copolymer enamel, applied to a minimum dry film thickness of 1.5 mils (0.04 mm) but not exceeding 3.0 mils (0.08 mm). Coat faying surfaces of bolted connections with a zinc molybdate primer, but do not apply finish paint. The color of the finish coat shall be brilliant yellow; the load block shall be brilliant yellow with black diagonal striping. Factory paint electrical and mechanical equipment in accordance with the manufacturer's best standard practice (for the specified environment), except that electrical equipment doors, which expose current-carrying electrical conductors when opened, shall be orange.
8. Identification Plates: Furnish and install identification plates. The identification plates shall be of noncorrosive metal with clearly legible permanent lettering giving the manufacturer's name, model number, capacity in both kilogram and pound units printed in different colors, and other essential information or identification.



9. Markings: Markings shall include trolley motion direction arrows on both sides of trolley and hoist rated capacity on both sides of the hoist or hoist load lock. Markings shall be visible from push button station and from the loading point and shall correspond to the push button labeling on the station.
- E. Patented Track: Provide specially designed beam, i.e., patented track beam, constructed from welded steel components. Provide patented track fabricated by a manufacturer regularly engaged in the production of this type of beam. The lower flange (T-rail) of the beam section shall have flat wheel treads; minimum lower flange width of 3.25 inches (81 mm); chemical composition of 0.45 to 0.60 percent carbon content, 0.60 to 1.1 percent manganese content; and wheel treads shall be hardened to a minimum hardness of 225 BHN. The upper flange and web of the beam section shall be structural steel, provided as one monolithic piece rolled to shape or fabricated from two pieces with the flange and web continuously fillet welded on both sides. The joint between the web and the T-rail shall be continuously welded from both sides. Provide shop drawings and calculations for the strength design and deflection of the bridge beams for approval by the the Owner. Size beam, as a minimum, to withstand all expected forces and the load combinations specified herein.
- F. Runway System: Provide flexible suspension type runway system including runway track beams, hanger rods, suspension fittings, lateral and longitudinal sway bracing, various structural supports (as required), and necessary hardware. Provide patented track runway track beams designed and fabricated as specified herein. Deliver patented track square, without excessive warpage, and meeting or exceeding the dimensional requirements of AWS D14.1. Select runway suspension hanger rods fabricated from alloy steel with rolled threads. Provide threads of sufficient length to permit at least 1.0 inch of vertical adjustment (up or down) after runway installation. Provide rods with self-aligning gimbal or ball-and-socket joints at each end which allow at least 5.0 degrees of deflection from the vertical. Provide not more than two rods per suspension point and in such cases consider the unequal loads induced in the rods; fluid-filled load equalizing cells are not acceptable.
- G. High-Strength Bolts, Nuts, And Washers: Provide high-strength bolts and nuts of U.S. manufacture, plain (non-coated), and permanently marked (by embossing or indentation) with the ASTM or SAE designation, grade, and manufacturer's identification. Make structural connection of girder to end truck with ASTM A 325/A 325M plain (non-coated) bolts; appropriate ASTM A 194/A 194M or ASTM A 563/A 563M plain nuts; and ASTM F 436/F 436M plain, through hardened, flat, circular washers. Match bolt and nut threads (oversize tapping is not permitted); bolt and nut threads shall conform to ASME/ANSI B18.2.2 and ASME B1.1. Make mechanical connections with ASTM A 325/A 325M bolts, as described above, or with SAE J 429, Grade 5 bolts and SAE J 995, Grade 5 nuts.
- H. Source Quality Control: Inspect and test bolts according to the "Production Lot Method" described in ASTM A 325/A 325M. Process bolts so that the identity and integrity of each production lot, from raw material selection through all processing operations and treatments to final packing and shipment are maintained. Bolts will not be acceptable unless positive traceability of the bolts is established.

1.3 EXECUTION

- A. Erection: Shop assemble crane and crane components to the maximum extent to facilitate erection and minimize field labor. Size each assembly so that it can be transported by common carrier without disassembly insofar as shipping clearances are concerned. Protect parts and equipment delivered to the site from weather, damage, abuse, and loss of identification. Ensure that the crane is erected without initial stresses, forced or improvised fits, misalignments, stress-raising welds, and rough burrs. Solvent-clean wire ropes to remove all preservative and grease-lubricate in accordance with wire rope manufacturer's recommendations prior to reeving. Erect crane within 30 days of the initial delivery of components. After the crane is erected, clean and retouch damaged painted surfaces.
- B. Erection Services: The crane manufacturer shall provide supervisory erection services.

Cranes, Overhead Electric, Underrunning (Under 20,000 Pounds)



C. Field Quality Control

1. Post-Erection Inspection: After erection, the Contractor and the the Owner shall jointly inspect the crane bridge and hoist systems and components to determine compliance with specifications and approved shop drawings and manufacturer's data. The Contractor shall notify the the Owner 3 days before the inspection.
2. Operational Tests: After erection and inspection, test the hoist, bridge, and trolley as specified herein. The 125 percent rated load test shall be made with the bridge and trolley located to obtain maximum loads on the runway and bridge girders. The systems shall be tested in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. The Contractor shall rectify all deficiencies disclosed by testing and retest the system or component to prove the crane is operational. The Contractor shall furnish operating personnel, instruments, and all other necessary apparatus. The the Owner will furnish loads and rigging gear to be used for testing.
3. Test Data:
 - a. Record crane test data on appropriate test record forms suitable for retention for the life of the crane. Include in the test records:
 - 1) Test date
 - 2) Crane identification number
 - 3) Weather conditions (temperature, humidity, barometric pressure, dew point, prevailing wind direction and velocity, and crane orientation)
 - 4) Identification of each test performed
 - 5) Results of each test performed
 - 6) Data collected during testing
 - 7) Remarks
 - b. Record operating and startup current and motor terminal voltage measurements for electrical equipment (motors) using appropriate instrumentation (e.g., clamp-on ammeters). Recorded values shall be compared with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) shall be justified or appropriate adjustments performed. In addition, high temperatures or abnormal operation of any equipment or machinery shall be noted, investigated, and corrected. Record hoist, trolley, and bridge speeds during each test cycle.
4. Hook: Measure hook for hook throat spread before and after load test. Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus 1/64 inch (0.4 mm)). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening by more than one percent from the base measurement shall be cause for rejection.
5. No-Load Test: Raise and lower the hook through the full range of normal travel at rated speed for three complete cycles. Then raise and lower the hook through the full range of normal travel in slow speed. Verify proper operation of hoist limit switches. Operate the bridge and trolley in each direction the full distance between end stops; bring bumpers into contact with bumper stops at each end of travel. Perform one complete cycle in each speed point and verify proper brake operation.
6. Load Tests
 - a. Hoist: Perform the following tests, as specified, with test loads of 50, 100 and 125 percent (plus 5 minus 0) of rated load.
 - 1) Static Load Test (125 percent only): Check entire structure, holding brake and hoisting components as follows: Raise the test load approximately one foot. Hold the load for 10 minutes. Rotate load and hook to check bearing operation. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes
 - 2) Dynamic Load Test (50 percent, 100 percent, and 125 percent): Raise and lower the test load through the full lift in each speed point. Lower the load to the floor, wait



- 5 minutes, then raise and lower the load through two more cycles, one in each speed point. In addition, repeat the dynamic test of test load sequence number 2 (100 percent of rated load) for 10 cycles at rated speed, in order to demonstrate proper operation and repeatability of all functions without component overheating or malfunction. Completely stop the machinery at least once in each direction during each cycle to ensure proper brake operation. Stop the hoist for not more than 15 seconds prior to commencing the next cycle.
- 3) Hoist Load Brake (125 percent only): Raise test load approximately 5 feet (1500 mm). With neither pushbutton depressed, release (by hand) the holding brake. The load brake shall hold the test load. Again with the holding brake in the released position, start the test load down (first point) and then release the pushbutton as the test load lowers. The load brake shall prevent the test load from accelerating.
 - 4) Hoist Loss of Power Test (125 percent only): Raise the test load to approximately 8 feet (2400 mm). While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.
- b. Trolley/Hoist: Operate the trolley/hoist the full distance of the bridge rails in each direction with a test load of 125 percent of rated load on the hook (one cycle). Check proper functioning of all drive speed control points. Verify proper brake action.
 - c. Bridge: With a test load of 125 percent of rated load on the hook, operate the bridge for the full length of the runway in one direction with the trolley/hoist at the extreme end of the bridge, and in the opposite direction with the trolley at the opposite extreme end of the bridge (one cycle). Check proper functioning of all drive speed control points. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.
 - d. Rated Travel Tests: Repeat travel tests for trolley/hoist and bridge with a test load of 100 percent of rated load. Repeat the test for 5 cycles (at least one cycle in each speed point) to demonstrate proper operation and repeatability of all functions without the overheating or malfunction of any components. Completely stop the machinery at least once in each direction during each cycle to ensure proper brake action. Stop the machinery for not more than 15 seconds prior to commencing the next cycle.

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SECTION 26 05 23 00 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of control-voltage electrical power cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. UTP cabling.
 - b. 50/125 **OR** 62.5/125, **as directed**,-micrometer, multimode optical fiber cabling.
 - c. RS-232 cabling.
 - d. RS-485 cabling.
 - e. Low-voltage control cabling.
 - f. Control-circuit conductors.
 - g. Identification products.

C. Definitions

1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.
3. EMI: Electromagnetic interference.
4. IDC: Insulation displacement connector.
5. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
6. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
7. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
8. RCDD: Registered Communications Distribution Designer.
9. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.
10. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
11. UTP: Unshielded twisted pair.

D. Submittals

1. Product Data: For each type of product indicated.
2. Field quality-control reports.
3. Maintenance data.

E. Quality Assurance

1. Testing Agency Qualifications: Member company of an NRTL.
 - a. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.



3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Delivery, Storage, And Handling

1. Test cables upon receipt at Project site.
 - a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight **OR** optical loss test set, **as directed**.
 - b. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
 - c. Test each pair of UTP cable for open and short circuits.

1.2 PRODUCTS

A. Pathways

1. Support of Open Cabling: NRTL labeled for support of Category 5e **OR** Category 6, **as directed**, cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - a. Support brackets with cable tie slots for fastening cable ties to brackets.
 - b. Lacing bars, spools, J-hooks, and D-rings.
 - c. Straps and other devices.
2. Cable Trays:
 - a. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inch (0.055 mm) thick, **as directed**.
 - 1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
 - 2) Trough or Ventilated Cable Trays: Nominally 6 inches (150 mm) wide.
 - 3) Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
 - 4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
 - 5) Solid-Bottom or Nonventilated Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with **OR** without, **as directed**, solid covers.
3. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used, **as directed**.
 - a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

B. Backboards

1. Description: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry".

C. UTP Cable

1. Description: 100-ohm, four-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket, **as directed**.
 - a. Comply with ICEA S-90-661 for mechanical properties.
 - b. Comply with TIA/EIA-568-B.1 for performance specifications.
 - c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **as directed**.
 - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:



- 1) Communications, General Purpose: Type CM or Type CMG; or Type MPP, Type CMP, Type MPR, Type CMR, Type MP, or Type MPG, **as directed**.
- 2) Communications, Plenum Rated: Type CMP or Type MPP, **as directed**, complying with NFPA 262.
- 3) Communications, Riser Rated: Type CMR; or Type MPP, Type CMP, or Type MPR, **as directed**; complying with UL 1666.
- 4) Communications, Limited Purpose: Type CMX; or Type MPP, Type CMP, Type MPR, Type CMR, Type MP, Type MPG, Type CM, or Type CMG, **as directed**.
- 5) Multipurpose: Type MP or Type MPG; or Type MPP or Type MPR, **as directed**.
- 6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
- 7) Multipurpose, Riser Rated: Type MPR or Type MPP, **as directed**, complying with UL 1666.

D. UTP Cable Hardware

1. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
2. Connecting Blocks: 110 style for Category 5e **OR** 110 style for Category 6 **OR** 66 style for Category 5e, **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare; integral with connector bodies, including plugs and jacks where indicated.

E. Optical Fiber Cable

1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
 - a. Comply with ICEA S-83-596 for mechanical properties.
 - b. Comply with TIA/EIA-568-B.3 for performance specifications.
 - c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
 - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - 1) General Purpose, Nonconductive: Type OFN or OFNG, or Type OFNR or Type OFNP, **as directed**.
 - 2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - 3) Riser Rated, Nonconductive: Type OFNR or Type OFNP, **as directed**, complying with UL 1666.
 - 4) General Purpose, Conductive: Type OFC or Type OFCG; or Type OFNG, Type OFN, Type OFCR, Type OFNR, Type OFCP, or Type OFNP, **as directed**.
 - 5) Plenum Rated, Conductive: Type OFCP or Type OFNP, **as directed**, complying with NFPA 262.
 - 6) Riser Rated, Conductive: Type OFCR; or Type OFNR, Type OFCP, or Type OFNP, **as directed**; complying with UL 1666.
 - e. Conductive cable shall be steel **OR** aluminum, **as directed**,-armored type.
 - f. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
 - g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
2. Jacket:
 - a. Jacket Color: Aqua for 50/125 **OR** Orange for 62.5/125, **as directed**,-micrometer cable.
 - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
 - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Optical Fiber Cable Hardware

1. Cable Connecting Hardware: Comply with the Fiber Optic Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
 - a. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
 - b. Type SFF connectors may be used in termination racks, panels, and equipment packages.



- G. RS-232 Cable
1. Standard Cable: NFPA 70, Type CM.
 - a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Polypropylene insulation.
 - c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 - d. PVC jacket.
 - e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
 - f. Flame Resistance: Comply with UL 1581.
 2. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Plastic insulation.
 - c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 - d. Plastic jacket.
 - e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
 - f. Flame Resistance: Comply with NFPA 262.
- H. RS-485 Cable
1. Standard Cable: NFPA 70, Type CM or Type CMG, **as directed**.
 - a. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1581.
 2. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. Flame Resistance: NFPA 262, Flame Test.
- I. Low-Voltage Control Cable
1. Paired Cable: NFPA 70, Type CMG.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1581.
 2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with NFPA 262.
 3. Paired Cable: NFPA 70, Type CMG.
 - a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1581.
 4. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.



- d. Plastic jacket.
 - e. Flame Resistance: NFPA 262, Flame Test.
- J. Control-Circuit Conductors
- 1. Class 1 Control Circuits: Stranded copper, Type THHN-THWN **OR** Type XHHN, **as directed**, in raceway, complying with UL 83 **OR** UL 44, **as directed**.
 - 2. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway **OR** Type XHHN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**, complying with UL 83 **OR** UL 44, **as directed**.
 - 3. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.
- K. Identification Products
- 1. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
 - 2. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
- L. Source Quality Control
- 1. Testing Agency: Engage a qualified testing agency to evaluate cables.
 - 2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
 - 3. Factory test UTP cables according to TIA/EIA-568-B.2.
 - 4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
 - 5. Cable will be considered defective if it does not pass tests and inspections.
 - 6. Prepare test and inspection reports.

1.3 EXECUTION

- A. Installation Of Pathways
- 1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
 - 2. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
 - 3. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
 - 4. Install manufactured conduit sweeps and long-radius elbows if possible.
 - 5. Pathway Installation in Equipment Rooms:
 - a. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
 - b. Install cable trays to route cables if conduits cannot be located in these positions.
 - c. Secure conduits to backboard if entering room from overhead.
 - d. Extend conduits 3 inches (75 mm) above finished floor.
 - e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
 - 6. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.
- B. Installation Of Conductors And Cables
- 1. Comply with NECA 1.
 - 2. General Requirements for Cabling:
 - a. Comply with TIA/EIA-568-B.1.
 - b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - c. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.



- d. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - e. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 - f. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - g. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - h. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
3. UTP Cable Installation:
 - a. Comply with TIA/EIA-568-B.2.
 - b. Install 110-style IDC termination hardware unless otherwise indicated.
 - c. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
 4. Installation of Control-Circuit Conductors:
 - a. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
 5. Optical Fiber Cable Installation:
 - a. Comply with TIA/EIA-568-B.3.
 - b. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
 6. Open-Cable Installation:
 - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - b. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
 - c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
 7. Installation of Cable Routed Exposed under Raised Floors:
 - a. Install plenum-rated cable only.
 - b. Install cabling after the flooring system has been installed in raised floor areas.
 - c. Coil cable 72 inches (1830 mm) long shall be neatly coiled not less than 12 inches (305 mm) in diameter below each feed point.
 8. Separation from EMI Sources:
 - a. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
 - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (305 mm).
 - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:



- 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
 - e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
 - f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).
- C. Removal Of Conductors And Cables
1. Remove abandoned conductors and cables.
- D. Control-Circuit Conductors
1. Minimum Conductor Sizes:
 - a. Class 1 remote-control and signal circuits, No 14 AWG.
 - b. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
 - c. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.
- E. Firestopping
1. Comply with requirements in Division 07 Section "Penetration Firestopping".
 2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
 3. Comply with BICSI TDMM, "Firestopping Systems" Article.
- F. Grounding
1. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
 2. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".
- G. Identification
- H. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
- I. Field Quality Control
1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
 - b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - c. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross connection.
 - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - d. Optical Fiber Cable Tests:
 - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 2) Link End-to-End Attenuation Tests:
 - a) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.



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- b) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
 3. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
 4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
 5. Prepare test and inspection reports.

END OF SECTION 26 05 23 00



Task	Specification	Specification Description
26 05 23 00	26 05 13 00	Conductors And Cables
26 05 23 00	26 05 13 00a	Undercarpet Cables
26 05 23 00	26 05 13 00b	Medium-Voltage Cables



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SECTION 26 05 26 00 - LIGHTNING PROTECTION**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for lightning protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes lightning protection for structures, structure elements and building site components.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For air terminals and mounting accessories.
 - a. Layout of the lightning protection system, along with details of the components to be used in the installation.
 - b. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
3. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.
4. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.
5. Field quality-control reports.
6. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.
7. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
 - a. Ground rods.
 - b. Ground loop conductor.

D. Quality Assurance

1. Installer Qualifications: Certified by UL or LPI as a Master Installer/Designer, trained and approved for installation of units required for this Project.
2. System Certificate:
 - a. UL Master Label.
OR
LPI System Certificate.
OR
UL Master Label Recertification.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

E. Coordination

1. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
2. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.
3. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.



1.2 PRODUCTS

- A. Lightning Protection System Components
1. Comply with UL 96 and NFPA 780, **as directed**.
 2. Roof-Mounted Air Terminals: NFPA 780, Class I **OR** Class II, **as directed**, aluminum **OR** copper, **as directed**, unless otherwise indicated.
 - a. Air Terminals More than 24 Inches (600 mm) Long: With brace attached to the terminal at not less than half the height of the terminal.
 - b. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in Division 07.
 3. Main and Bonding Conductors: Copper **OR** Aluminum, **as directed**.
 4. Ground Loop Conductor: The same size and type as the main conductor except tinned.
 5. Ground Rods: Copper-clad **OR** Zinc-coated **OR** Stainless, **as directed**, steel, sectional type, **as directed**; 3/4 inch (19 mm) in diameter by 10 feet (3 m) **OR** 5/8 inch (16 mm) in diameter by 96 inches (2400 mm), **as directed**, long.
 6. Heavy-Duty, Stack-Mounted, Lightning Protection Components: Stainless steel **OR** Solid copper **OR** Monel metal **OR** Lead sheathed, **as directed**.

1.3 EXECUTION

- A. Installation
1. Install lightning protection components and systems according to UL 96A and NFPA 780.
 2. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.
 3. Conceal the following conductors:
 - a. System conductors.
 - b. Down conductors.
 - c. Interior conductors.
 - d. Conductors within normal view of exterior locations at grade within 200 feet (60 m) of building.
 4. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.

OR

 Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
 - a. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.
 5. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.
 6. Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to lightning protection components.
 7. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure **OR** area or item indicated, **as directed**.
 - a. Bury ground ring not less than 24 inches (600 mm) from building foundation.
 - b. Bond ground terminals to the ground loop.
 - c. Bond grounded building systems to the ground loop conductor within 12 feet (3.6 m) of grade level.
 8. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot (18-m) intervals.
- B. Corrosion Protection
1. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.



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2. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.
- C. Field Quality Control
1. Notify the Owner at least 48 hours in advance of inspection before concealing lightning protection components.
 2. UL Inspection: Meet requirements to obtain a UL Master Label for system.
OR
LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

END OF SECTION 26 05 26 00



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SECTION 26 05 26 00a - GROUNDING AND BONDING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for grounding and bonding. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes methods and materials for grounding systems and equipment, plus the following special applications, **as directed**:
 - a. Overhead-lines grounding.
 - b. Underground distribution grounding.
 - c. Common ground bonding with lightning protection system.

C. Submittals

1. Product Data: For each type of product indicated.
2. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
 - a. Test wells.
 - b. Ground rods.
 - c. Ground rings.
 - d. Grounding arrangements and connections for separately derived systems.
 - e. Grounding for sensitive electronic equipment.
3. Qualification Data: For qualified testing agency and testing agency's field supervisor.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data", include the following:
 - a. Instructions for periodic testing and inspection of grounding features at test wells **OR** ground rings **OR** grounding connections for separately derived systems, **as directed** based on NETA MTS **OR** NFPA 70B, **as directed**.
 - 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

D. Quality Assurance

1. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with UL 467 for grounding and bonding materials and equipment.

1.2 PRODUCTS

A. Conductors

1. Insulated Conductors: Copper **OR** Tinned-copper, **as directed**, wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
2. Bare Copper Conductors:



- a. Solid Conductors: ASTM B 3.
 - b. Stranded Conductors: ASTM B 8.
 - c. Tinned Conductors: ASTM B 33.
 - d. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - e. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - f. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - g. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
3. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 - a. No. 4 AWG minimum, soft-drawn copper.
 - b. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
 4. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 2 inches (6 by 50 mm), **as directed**, in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

B. Connectors

1. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
2. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - a. Pipe Connectors: Clamp type, sized for pipe.
3. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
4. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression **OR** exothermic-type wire terminals, **as directed**, and long-barrel, two-bolt connection to ground bus bar.

C. Grounding Electrodes

1. Ground Rods: Copper-clad **OR** Zinc-coated **OR** Stainless, **as directed**, steel, sectional type, **as directed**; 3/4 inch by 10 feet (19 mm by 3 m) **OR** 5/8 by 96 inches (16 by 2400 mm), **as directed**, in diameter.
2. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 - a. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 - b. Backfill Material: Electrode manufacturer's recommended material.

1.3 EXECUTION

A. Applications

1. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
2. Underground Grounding Conductors: Install bare copper **OR** tinned-copper, **as directed**, conductor, No. 2/0 AWG minimum. Bury at least 24 inches (600 mm) below grade.
 - a. Bury at least 24 inches (600 mm) below grade.
 - b. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
3. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection,



- with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
4. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - a. Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
 - b. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
 5. Conductor Terminations and Connections:
 - a. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - b. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
 - c. Connections to Ground Rods at Test Wells: Bolted connectors.
 - d. Connections to Structural Steel: Welded connectors.
- B. Grounding Overhead Lines
1. Comply with IEEE C2 grounding requirements.
 2. Install 2 parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.
 3. Drive ground rods until tops are 12 inches (300 mm) below finished grade in undisturbed earth.
 4. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.
 5. Lightning Arrester Grounding Conductors: Separate from other grounding conductors.
 6. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.
 7. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.
- C. Grounding Underground Distribution System Components
1. Comply with IEEE C2 grounding requirements.
 2. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
 3. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
 4. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.
- D. Equipment Grounding
1. Install insulated equipment grounding conductors with all feeders and branch circuits.
 2. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - a. Feeders and branch circuits.
 - b. Lighting circuits.
 - c. Receptacle circuits.



- d. Single-phase motor and appliance branch circuits.
 - e. Three-phase motor and appliance branch circuits.
 - f. Flexible raceway runs.
 - g. Armored and metal-clad cable runs.
 - h. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - i. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
 - j. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
3. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
 4. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
 5. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
 6. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
 7. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - a. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
 - b. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
 8. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

E. Installation

1. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
2. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
3. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
 - a. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.



- b. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
4. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts And Raceways For Electrical Systems" and shall be at least 12 inches (300 mm) deep, with cover.
 - a. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
5. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - a. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - b. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 - c. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
6. Grounding and Bonding for Piping:
 - a. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - b. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - c. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
7. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
8. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
9. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column **OR** indicated item, **as directed**, extending around the perimeter of building **OR** area or item indicated, **as directed**.
 - a. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
 - b. Bury ground ring not less than 24 inches (600 mm) from building foundation.
10. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
 - a. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
 - b. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

F. Labeling

1. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for instruction signs. The label or its text shall be green.
2. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - a. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."



- G. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 2. Tests and Inspections:
 - a. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - b. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
 - 1) Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - 2) Perform tests by fall-of-potential method according to IEEE 81.
 - c. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
 3. Report measured ground resistances that exceed the following values:
 - a. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
 - b. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
 - c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 **OR** 3, **as directed**, ohm(s).
 - e. Substations and Pad-Mounted Equipment: 5 ohms.
 - f. Manhole Grounds: 10 ohms.
 4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify the Owner promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26 00a



Task	Specification	Specification Description
26 05 26 00	01 22 16 00	No Specification Required
26 05 26 00	02 84 33 00	Overhead Electrical Distribution



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SECTION 26 05 29 00 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for hangers and supports for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Hangers and supports for electrical equipment and systems.
 - b. Construction requirements for concrete bases.

C. Definitions

1. EMT: Electrical metallic tubing.
2. IMC: Intermediate metal conduit.
3. RMC: Rigid metal conduit.

D. Performance Requirements

1. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
3. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
4. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

E. Submittals

1. Product Data: For the following:
 - a. Steel slotted support systems.
 - b. Nonmetallic slotted support systems.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
 - a. Trapeze hangers. Include Product Data for components.
 - b. Steel slotted channel systems. Include Product Data for components.
 - c. Nonmetallic slotted channel systems. Include Product Data for components.
 - d. Equipment supports.
3. Welding certificates.

F. Quality Assurance

1. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Comply with NFPA 70.

1.2 PRODUCTS**A. Support, Anchorage, And Attachment Components**



1. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - b. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - d. Channel Dimensions: Selected for applicable load criteria.
 2. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
 - a. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 - b. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
 - c. Rated Strength: Selected to suit applicable load criteria.
 3. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
 4. Conduit and Cable Support Devices: Steel **OR** Steel and malleable-iron, **as directed**, hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
 5. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
 6. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 7. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - a. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - b. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel **OR** stainless steel, **as directed**, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - c. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 - d. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 - e. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - f. Toggle Bolts: All-steel springhead type.
 - g. Hanger Rods: Threaded steel.
- B. Fabricated Metal Equipment Support Assemblies
1. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
 2. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

1.3 EXECUTION

A. Application

1. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
2. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by **OR** scheduled in NECA 1, where its Table 1 lists maximum



- spacings less than stated in, **as directed**, NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
3. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - a. Secure raceways and cables to these supports with two-bolt conduit clamps **OR** single-bolt conduit clamps **OR** single-bolt conduit clamps using spring friction action for retention in support channel, **as directed**.
 4. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.
- B. Support Installation
1. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
 2. Raceway Support Methods: In addition to methods described in NECA 1, EMT **OR** IMC **OR** RMC, **as directed**, may be supported by openings through structure members, as permitted in NFPA 70.
 3. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
 4. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - a. To Wood: Fasten with lag screws or through bolts.
 - b. To New Concrete: Bolt to concrete inserts.
 - c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - d. To Existing Concrete: Expansion anchor fasteners.
 - e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - f. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts **OR** Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 **OR** Spring-tension clamps, **as directed**.
 - g. To Light Steel: Sheet metal screws.
 - h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
 5. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
- C. Installation Of Fabricated Metal Supports
1. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
 2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
 3. Field Welding: Comply with AWS D1.1/D1.1M.
- D. Concrete Bases
1. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.



2. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-place Concrete".
3. Anchor equipment to concrete base.
 - a. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - b. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - c. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

E. Painting

1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
2. Touchup: Comply with requirements in Division 07 OR Division 09 Section(s) "High-performance Coatings" **as directed**, for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
3. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29 00

**SECTION 26 05 29 00a - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for vibration and seismic controls for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Isolation pads.
 - b. Spring isolators.
 - c. Restrained spring isolators.
 - d. Channel support systems.
 - e. Restraint cables.
 - f. Hanger rod stiffeners.
 - g. Anchorage bushings and washers.

C. Definitions

1. The IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. Performance Requirements

1. Seismic-Restraint Loading:
 - a. Site Class as Defined in the IBC: **A OR B OR C OR D OR E OR F, as directed.**
 - b. Assigned Seismic Use Group or Building Category as Defined in the IBC: **I OR II OR III, as directed.**
 - 1) Component Importance Factor: **1.0 OR 1.5, as directed.**
 - 2) Component Response Modification Factor: **1.5 OR 2.5 OR 3.5 OR 5.0, as directed.**
 - 3) Component Amplification Factor: **1.0 OR 2.5, as directed.**
 - c. Design Spectral Response Acceleration at Short Periods (0.2 Second): As required to meet Project requirements.
 - d. Design Spectral Response Acceleration at 1.0-Second Period: As required to meet Project requirements.

E. Submittals

1. Product Data: For the following:
 - a. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - b. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - 1) Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed.**
 - 2) Annotate to indicate application of each product submitted and compliance with requirements.
 - c. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
2. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.



- a. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
 - 1) Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 22 for equipment mounted outdoors.
- b. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
- c. Field-fabricated supports.
- d. Seismic-Restraint Details:
 - 1) Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - 2) Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - 3) Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
3. Welding certificates.
4. Field quality-control test reports.

F. Quality Assurance

1. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
4. Comply with NFPA 70.

1.2 PRODUCTS

A. Vibration Isolators

1. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
 - a. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - b. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - c. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - d. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.



- e. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
 - f. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
3. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
- a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - b. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 - c. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - d. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - e. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - f. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

B. Seismic-Restraint Devices

1. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
3. Restraint Cables: ASTM A 603 galvanized-steel **OR** ASTM A 492 stainless-steel, **as directed**, cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod. Do not weld stiffeners to rods.
5. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.
6. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.
7. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
8. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
9. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

C. Factory Finishes



1. Finish:
 - a. Manufacturer's standard prime-coat finish ready for field painting.
 - b. Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1) Powder coating on springs and housings.
 - 2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
 - 3) Baked enamel or powder coat for metal components on isolators for interior use.
 - 4) Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

1.3 EXECUTION

A. Applications

1. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Seismic-Restraint Device Installation

1. Equipment and Hanger Restraints:
 - a. Install restrained isolators on electrical equipment.
 - b. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
2. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
3. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
4. Drilled-in Anchors:
 - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - e. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.



-
- C. Accommodation Of Differential Seismic Motion
1. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.
- D. Field Quality Control
1. Tests and Inspections:
 - a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - b. Schedule test with the Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - c. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - d. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - e. Test to 90 percent of rated proof load of device.
 - f. Measure isolator restraint clearance.
 - g. Measure isolator deflection.
 - h. Verify snubber minimum clearances.
 - i. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
 2. Remove and replace malfunctioning units and retest as specified above.
 3. Prepare test and inspection reports.
- E. Adjusting
1. Adjust isolators after isolated equipment is at operating weight.
 2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
 3. Adjust active height of spring isolators.
 4. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 05 29 00a



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Task	Specification	Specification Description
26 05 29 00	01 22 16 00	No Specification Required
26 05 29 00	05 12 23 00	Cold-Formed Metal Framing
26 05 29 00	05 50 00 00	Metal Fabrications
26 05 33 13	26 05 00 00	Common Work Results for Electrical
26 05 33 13	26 05 19 16	Common Work Results for Communications
26 05 33 13	26 05 19 16a	Common Work Results for Electronic Safety and Security
26 05 33 13	26 05 19 16b	Electrical Renovation
26 05 33 13	26 05 13 00	Conductors And Cables
26 05 33 13	26 05 19 16c	Communications Equipment Room Fittings
26 05 33 13	26 05 19 16d	Communications Backbone Cabling
26 05 33 13	26 05 19 16e	Communications Horizontal Cabling
26 05 33 13	26 05 19 16f	Conductors and Cables for Electronic Safety and Security



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**SECTION 26 05 33 16 - RACEWAYS AND BOXES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of raceways and boxes. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

C. Definitions

1. EMT: Electrical metallic tubing.
2. ENT: Electrical nonmetallic tubing.
3. EPDM: Ethylene-propylene-diene terpolymer rubber.
4. FMC: Flexible metal conduit.
5. IMC: Intermediate metal conduit.
6. LFMC: Liquidtight flexible metal conduit.
7. LFNC: Liquidtight flexible nonmetallic conduit.
8. NBR: Acrylonitrile-butadiene rubber.
9. RNC: Rigid nonmetallic conduit.

D. Submittals

1. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
2. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - a. Custom enclosures and cabinets.
 - b. For handholes and boxes for underground wiring, including the following:
 - 1) Duct entry provisions, including locations and duct sizes.
 - 2) Frame and cover design.
 - 3) Grounding details.
 - 4) Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
 - 5) Joint details.
3. Samples: For each type of exposed finish required for wireways, nonmetallic wireways and surface raceways, prepared on Samples of size indicated below.
4. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - a. Structural members in the paths of conduit groups with common supports.
 - b. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.
5. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section(s) "Hangers And Supports For Electrical Systems" AND "Vibration And Seismic Controls For Electrical Systems". Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 1) The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."



- b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 6. Qualification Data: For professional engineer and testing agency.
- 7. Source quality-control test reports.

E. Quality Assurance

- 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- 2. Comply with NFPA 70.

1.2 PRODUCTS

A. Metal Conduit And Tubing

- 1. Rigid Steel Conduit: ANSI C80.1.
- 2. Aluminum Rigid Conduit: ANSI C80.5.
- 3. IMC: ANSI C80.6.
- 4. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit **OR** IMC, **as directed**.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch (1 mm), minimum.
- 5. EMT: ANSI C80.3.
- 6. FMC: Zinc-coated steel **OR** Aluminum **OR** Zinc-coated steel or aluminum, **as directed**.
- 7. LFMC: Flexible steel conduit with PVC jacket.
- 8. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - b. Fittings for EMT: Steel **OR** Die-cast, **as directed**, set-screw **OR** compression, **as directed**, type.
 - c. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- 9. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

B. Nonmetallic Conduit And Tubing

- 1. ENT: NEMA TC 13.
- 2. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- 3. LFNC: UL 1660.
- 4. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- 5. Fittings for LFNC: UL 514B.

C. Optical Fiber/Communications Cable Raceway And Fittings

- 1. Description: Comply with UL 2024; flexible type, approved for plenum **OR** riser **OR** general-use, **as directed**, installation.

D. Metal Wireways

- 1. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 **OR** 12 **OR** 3R, **as directed**, unless otherwise indicated.
- 2. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.



3. Wireway Covers: Hinged type **OR** Screw-cover type **OR** Flanged-and-gasketed type **OR** As indicated, **as directed**.
 4. Finish: Manufacturer's standard enamel finish.
- E. Nonmetallic Wireways
1. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.
OR
Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
 2. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- F. Surface Raceways
1. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected **OR** Prime coating, ready for field painting, **as directed**.
 2. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected from manufacturer's standard **OR** custom, **as directed**, colors.
- G. Boxes, Enclosures, And Cabinets
1. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
 2. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy **OR** aluminum, **as directed**, Type FD, with gasketed cover.
 3. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
 4. Metal Floor Boxes: Cast metal **OR** Sheet metal, **as directed**, fully adjustable **OR** semi-adjustable, **as directed**, rectangular.
 5. Nonmetallic Floor Boxes: Nonadjustable, round.
 6. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
 7. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum **OR** galvanized, cast iron, **as directed**, with gasketed cover.
 8. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
 - a. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - b. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint, **as directed**.
 9. Cabinets:
 - a. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - b. Hinged door in front cover with flush latch and concealed hinge.
 - c. Key latch to match panelboards.
 - d. Metal barriers to separate wiring of different systems and voltage.
 - e. Accessory feet where required for freestanding equipment.
- H. Handholes And Boxes For Exterior Underground Wiring
1. Description: Comply with SCTE 77.
 - a. Color of Frame and Cover: Gray **OR** Green **as directed**.
 - b. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed**, bottom, unless otherwise indicated.
 - c. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 - d. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - e. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** as indicated for each service, **as directed**.



- f. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- g. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
2. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.
3. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.
4. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete **OR** reinforced concrete **OR** cast iron **OR** hot-dip galvanized-steel diamond plate **OR** fiberglass, **as directed**.

I. Sleeves For Raceways

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
4. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".

J. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
 - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

K. Source Quality Control For Underground Enclosures

1. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - a. Tests of materials shall be performed by a independent testing agency.
 - b. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - c. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

1.3 EXECUTION

A. Raceway Application

1. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - a. Exposed Conduit: Rigid steel conduit **OR** IMC **OR** RNC, Type EPC-40-PVC **OR** RNC, Type EPC-80-PVC, **as directed**.
 - b. Concealed Conduit, Aboveground: Rigid steel conduit **OR** IMC **OR** EMT **OR** RNC, Type EPC-40-PVC, **as directed**.
 - c. Underground Conduit: RNC, Type EPC-40 **OR** 80, **as directed**, -PVC, direct buried.



- d. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LPMC **OR** LFNC, **as directed**.
- e. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R **OR** 4, **as directed**.
- f. Application of Handholes and Boxes for Underground Wiring:
 - 1) Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete **OR** Fiberglass enclosures with polymer-concrete frame and cover **OR** Fiberglass-reinforced polyester resin, **as directed**, SCTE 77, Tier 15 structural load rating.
 - 2) Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units **OR** Heavy-duty fiberglass units with polymer-concrete frame and cover, **as directed**, SCTE 77, Tier 8 structural load rating.
 - 3) Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
2. Comply with the following indoor applications, unless otherwise indicated:
 - a. Exposed, Not Subject to Physical Damage: EMT **OR** ENT **OR** RNC, **as directed**.
 - b. Exposed, Not Subject to Severe Physical Damage: EMT **OR** RNC identified for such use, **as directed**.
 - c. Exposed and Subject to Severe Physical Damage: Rigid steel conduit **OR** IMC, **as directed**. Includes raceways in the following locations:
 - 1) Loading dock.
 - 2) Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - 3) Mechanical rooms.
 - d. Concealed in Ceilings and Interior Walls and Partitions: EMT **OR** ENT **OR** RNC, Type EPC-40-PVC, **as directed**.
 - e. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LPMC in damp or wet locations.
 - f. Damp or Wet Locations: Rigid steel conduit **OR** IMC, **as directed**.
 - g. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
 - h. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
 - i. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway **OR** Riser-type, optical fiber/communications cable raceway **OR** Plenum-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
 - j. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel **OR** nonmetallic, **as directed**, in damp or wet locations.
3. Minimum Raceway Size: 1/2-inch (16-mm) **OR** 3/4-inch (21-mm), **as directed**, trade size.
4. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - a. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
 - b. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
5. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
6. Do not install aluminum conduits in contact with concrete.

B. Installation

1. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
2. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.



3. Complete raceway installation before starting conductor installation.
4. Support raceways as specified in Division 26 Section(s) "Hangers And Supports For Electrical Systems" AND "Vibration And Seismic Controls For Electrical Systems".
5. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
6. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
7. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
8. Raceways Embedded in Slabs:
 - a. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - b. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - c. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
9. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
10. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
11. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
12. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
 - a. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
 - b. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
 - c. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
13. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - b. Where otherwise required by NFPA 70.
14. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).
 - a. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
 - 1) Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - 2) Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - 3) Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - 4) Attics: 135 deg F (75 deg C) temperature change.
 - b. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.



- c. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.
 15. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures, **as directed**, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - a. Use LFMC in damp or wet locations subject to severe physical damage.
 - b. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
 16. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
 17. Set metal floor boxes level and flush with finished floor surface.
 18. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- C. Installation Of Underground Conduit
1. Direct-Buried Conduit:
 - a. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
 - b. Install backfill as specified in Division 31 Section "Earth Moving"
 - c. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving".
 - d. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

OR

Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - 1) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.

OR

For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
 - e. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of conduit.
- D. Installation Of Underground Handholes And Boxes
1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
 2. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
 3. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
 4. Install handholes and boxes with bottom below the frost line, **<Insert depth of frost line below grade at Project site>** below grade.
 5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.



6. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

E. Sleeve Installation For Electrical Penetrations

1. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both surfaces of walls.
7. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
8. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.
9. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies, **as directed**.
10. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
11. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping".
12. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
13. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
14. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing mechanical sleeve seals.

F. Sleeve-Seal Installation

1. Install to seal underground, exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

G. Firestopping

1. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping".

H. Protection

1. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Final Completion.



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- a. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - b. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33 16



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SECTION 26 05 33 16a - WIRING DEVICES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of wiring devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Receptacles, receptacles with integral GFCI, and associated device plates.
 - b. Twist-locking receptacles.
 - c. Receptacles with integral surge suppression units.
 - d. Wall-box motion sensors.
 - e. Isolated-ground receptacles.
 - f. Hospital-grade receptacles.
 - g. Snap switches and wall-box dimmers.
 - h. Solid-state fan speed controls.
 - i. Wall-switch and exterior occupancy sensors.
 - j. Communications outlets.
 - k. Pendant cord-connector devices.
 - l. Cord and plug sets.
 - m. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

C. Definitions

1. EMI: Electromagnetic interference.
2. GFCI: Ground-fault circuit interrupter.
3. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
4. RFI: Radio-frequency interference.
5. TVSS: Transient voltage surge suppressor.
6. UTP: Unshielded twisted pair.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
3. Samples: One for each type of device and wall plate specified, in each color specified.
4. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Straight Blade Receptacles

1. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.



2. Hospital-Grade, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 Supplement SD.
 3. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - a. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
 4. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - a. Description: Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.
- B. GFCI Receptacles
1. General Description: Straight blade, feed **OR** non-feed, **as directed**,-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
 2. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 3. Hospital-Grade, Duplex GFCI Convenience Receptacles, 125 V, 20 A: Comply with UL 498 Supplement SD.
- C. TVSS Receptacles
1. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 1449, with integral TVSS in line to ground, line to neutral, and neutral to ground.
 - a. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
 - b. Active TVSS Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
 2. Duplex TVSS Convenience Receptacles:
 - a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.
 3. Isolated-Ground, Duplex Convenience Receptacles:
 - a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
 4. Hospital-Grade, Duplex Convenience Receptacles: Comply with UL 498 Supplement SD.
 - a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.
 5. Isolated-Ground, Hospital-Grade, Duplex Convenience Receptacles:
 - a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Comply with UL 498 Supplement SD. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
- D. Hazardous (Classified) Location Receptacles
1. Available Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
- E. Twist-Locking Receptacles
1. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
 2. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
 - a. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw



terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

F. Pendant Cord-Connector Devices

1. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
 - a. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
 - b. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

G. Cord And Plug Sets

1. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 - a. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
 - b. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

H. Snap Switches

1. Comply with NEMA WD 1 and UL 20.
2. Switches, 120/277 V, 20 A:
3. Pilot Light Switches, 20 A:
 - a. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
4. Key-Operated Switches, 120/277 V, 20 A:
 - a. Description: Single pole, with factory-supplied key in lieu of switch handle.
5. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
6. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

I. Wall-Box Dimmers

1. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
2. Control: Continuously adjustable slider **OR** toggle switch **OR** rotary knob, **as directed**; with single-pole or three-way switching. Comply with UL 1472.
3. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
 - a. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF," **as directed**.
4. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

J. Fan Speed Controls

1. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
 - a. Continuously adjustable slider **OR** toggle switch **OR** rotary knob, **as directed**, 5 A **OR** 1.5 A, **as directed**.
 - b. Three-speed adjustable slider **OR** rotary knob, **as directed**, 1.5 A.

K. Occupancy Sensors

1. Wall-Switch Sensors:



- a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
 2. Wall-Switch Sensors:
 - a. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
 3. Long-Range Wall-Switch Sensors:
 - a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).
 4. Long-Range Wall-Switch Sensors:
 - a. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft. (111 sq. m).
 5. Wide-Range Wall-Switch Sensors:
 - a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).
 6. Exterior Occupancy Sensors:
 - a. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot (34-m) detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.
- L. Communications Outlets
1. Telephone Outlet:
 - a. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.
 2. Combination TV and Telephone Outlet:
 - a. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.
- M. Wall Plates
1. Single and combination types to match corresponding wiring devices.
 - a. Plate-Securing Screws: Metal with head color to match plate finish.
 - b. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting **OR** Smooth, high-impact thermoplastic **OR** 0.035-inch- (1-mm-) thick, satin-finished stainless steel **OR** 0.04-inch- (1-mm-) thick, brushed brass with factory polymer finish **OR** 0.05-inch- (1.2-mm-) thick anodized aluminum **OR** 0.04-inch- (1-mm-) thick steel with chrome-plated finish, **as directed**.
 - c. Material for Unfinished Spaces: Galvanized steel **OR** Smooth, high-impact thermoplastic, **as directed**.
 - d. Material for Damp Locations: Thermoplastic **OR** Cast aluminum, **as directed**, with spring-loaded lift cover, and listed and labeled for use in "wet locations."
 2. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum **OR** thermoplastic, **as directed**, with lockable cover.
- N. Floor Service Fittings
1. Type: Modular, flush-type **OR** flap-type **OR** above-floor, **as directed**, dual-service units suitable for wiring method used.
 2. Compartments: Barrier separates power from voice and data communication cabling.
 3. Service Plate: Rectangular **OR** Round, **as directed**, die-cast aluminum **OR** solid brass, **as directed**, with satin finish.
 4. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
 5. Voice and Data Communication Outlet: Blank cover with bushed cable opening **OR** Two modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable, **as directed**.
- O. Poke-Through Assemblies



1. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
 - a. Service Outlet Assembly: Pedestal type with services indicated **OR** Flush type with two simplex receptacles and space for two RJ-45 jacks **OR** Flush type with four simplex receptacles and space for four RJ-45 jacks, **as directed**.
 - b. Size: Selected to fit nominal 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, cored holes in floor and matched to floor thickness.
 - c. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
 - d. Closure Plug: Arranged to close unused 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, cored openings and reestablish fire rating of floor.
 - e. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of two **OR** four, **as directed**, 4-pair, Category 5e voice and data communication cables.

P. Multioutlet Assemblies

1. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
2. Raceway Material: Metal, with manufacturer's standard finish **OR** PVC, **as directed**.
3. Wire: No. 12 AWG.

Q. Service Poles

1. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
 - a. Poles: Nominal 2.5-inch- (65-mm-) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.
 - b. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
 - c. Finishes: Manufacturer's standard painted finish and trim combination **OR** Satin-anodized aluminum, **as directed**.
 - d. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.
 - e. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
 - f. Voice and Data Communication Outlets: Blank insert with bushed cable opening **OR** Two RJ-45 Category 5e jacks **OR** Four RJ-45 Category 5e jacks, **as directed**.

R. Finishes

1. Color: Wiring device catalog numbers in Section Text do not designate device color.
 - a. Wiring Devices Connected to Normal Power System: Almond **OR** Black **OR** Brown **OR** Gray **OR** Ivory **OR** White **OR** As selected, **as directed**, unless otherwise indicated or required by NFPA 70 or device listing.
 - b. Wiring Devices Connected to Emergency Power System: Red.
 - c. TVSS Devices: Blue.
 - d. Isolated-Ground Receptacles: Orange **OR** As specified above, with orange triangle on face, **as directed**.

1.3 EXECUTION

A. Installation

1. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
2. Coordination with Other Trades:



- a. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 - b. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - c. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - d. Install wiring devices after all wall preparation, including painting, is complete.
3. Conductors:
- a. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - b. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - c. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 - d. Existing Conductors:
 - 1) Cut back and pigtail, or replace all damaged conductors.
 - 2) Straighten conductors that remain and remove corrosion and foreign matter.
 - 3) Pigtailing existing conductors is permitted provided the outlet box is large enough.
4. Device Installation:
- a. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
 - b. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - c. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - d. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 - e. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 - f. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 - g. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 - h. Tighten unused terminal screws on the device.
 - i. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
5. Receptacle Orientation:
- a. Install ground pin of vertically mounted receptacles up **OR** down, **as directed**, and on horizontally mounted receptacles to the right **OR** left, **as directed**.
 - b. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
6. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
7. Dimmers:
- a. Install dimmers within terms of their listing.
 - b. Verify that dimmers used for fan speed control are listed for that application.
 - c. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
8. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
9. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.



-
- B. Identification
1. Comply with Division 26 Section "Identification For Electrical Systems".
 - a. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black **OR** white **OR** red, **as directed**,-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 - a. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
 - b. Test Instruments: Use instruments that comply with UL 1436.
 - c. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
 2. Tests for Convenience Receptacles:
 - a. Line Voltage: Acceptable range is 105 to 132 V.
 - b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
 - c. Ground Impedance: Values of up to 2 ohms are acceptable.
 - d. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - e. Using the test plug, verify that the device and its outlet box are securely mounted.
 - f. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
 3. Test straight blade convenience outlets in patient-care areas **OR** hospital-grade convenience outlets, **as directed**, for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

END OF SECTION 26 05 33 16a



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Task	Specification	Specification Description
26 05 33 16	26 05 19 16b	Electrical Renovation
26 05 33 23	26 05 33 16	Raceways And Boxes
26 05 33 23	26 05 19 13	Underfloor Raceways For Electrical Systems



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SECTION 26 05 36 00 - CABLE TRAYS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of cable trays. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes steel, aluminum, stainless-steel, and fiberglass cable trays and accessories.

C. Submittals

1. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
2. Shop Drawings: For each type of cable tray.
 - a. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
 - b. Seismic-Restraint Details, **as directed**: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
 - 1) Design Calculations: Calculate requirements for selecting seismic restraints.
 - 2) Detail fabrication, including anchorages and attachments to structure and to supported cable trays.
3. Field quality-control reports.
4. Operation and Maintenance Data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

E. Delivery, Storage, And Handling

1. Steel cable tray, hot dip galvanized after fabrication, **OR** Aluminum cable tray **OR** Stainless-steel cable tray **OR** Fiberglass cable tray, **as directed** may be stored outside without cover, but shall be loosely stacked, elevated off the ground, and ventilated to prevent staining during storage.
2. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.
3. Steel, mill galvanized **OR** electrogalvanized **OR** factory-primed, **as directed**, cable tray shall be stored in a well-ventilated, dry location. Unpack and dry wet materials before storage.
4. PVC-coated **OR** Field-painted, **as directed**, cable tray shall be stored indoors. Protect cable tray from scratching and marring of finish. Unpack and dry wet materials before storage.

1.2 PRODUCTS

A. Materials And Finishes

1. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.



- a. Factory-standard primer, ready for field painting; with cadmium-plated hardware according to ASTM B 766.
 - b. Mill galvanized before fabrication, complying with ASTM A 653/A 653M, G90 (Z275) coating; with hardware galvanized according to ASTM B 633 **OR** cadmium plated according to ASTM B 766, **as directed**.
 - c. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.
 - d. Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M, Class B2; with chromium-zinc, ASTM F 1136, **OR** Type 316 stainless-steel, **as directed**, hardware.
 - e. PVC coating applied in a fluidized bed or by electrostatic spray; with chromium-zinc, ASTM F 1136 **OR** Type 316 stainless-steel, **as directed**, hardware.
 - f. Epoxy-resin paint over paint manufacturer's recommended primer and corrosion-inhibiting treatment; with cadmium-plated hardware according to ASTM B 766 **OR** Type 316 stainless-steel hardware, **as directed**.
2. Cable Trays, Fittings, and Accessories: Aluminum, complying with NEMA VE 1, Aluminum Association's Alloy 6063-T6 for rails, rungs, and cable trays, and Alloy 5052-H32 or Alloy 6061-T6 for fabricated parts; with chromium-zinc, ASTM F 1136, **OR** Type 316 stainless-steel, **as directed**, splice-plate fasteners, bolts, and screws
 3. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304 **OR** 316, **as directed**, complying with NEMA VE 1.
 4. Cable Trays, Fittings, and Accessories: Fiberglass, complying with NEMA FG 1 and UL 568. Splice-plate fasteners, bolts, and screws shall be fiberglass-encapsulated stainless steel. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.
 5. Sizes and Configurations: Refer to the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
 - a. Center-hanger supports may be used only when specifically indicated.

B. Cable Tray Accessories

1. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
2. Covers: Solid **OR** Louvered **OR** Ventilated-hat **OR** 2-in-3 pitch cover, **as directed**, type of same materials and finishes as cable tray.
3. Barrier Strips: Same materials and finishes as cable tray.
4. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

C. Warning Signs

1. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
2. Materials and fastening are specified in Division 26 Section "Identification For Electrical Systems".

1.3 EXECUTION

A. Cable Tray Installation

1. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.
2. Remove burrs and sharp edges from cable trays.
3. Fasten cable tray supports to building structure and install seismic restraints, **as directed**.



- a. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
 - b. Place supports so that spans do not exceed maximum spans on schedules.
 - c. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
 - d. Support bus assembly to prevent twisting from eccentric loading.
 - e. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
 - f. Locate and install supports according to NEMA FG 1 **OR** NEMA VE 1, **as directed**.
4. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
 5. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA FG 1 **OR** NEMA VE 1, **as directed**. Space connectors and set gaps according to applicable standard.
 6. Make changes in direction and elevation using standard fittings.
 7. Make cable tray connections using standard fittings.
 8. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping".
 9. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
 10. Workspace: Install cable trays with enough space to permit access for installing cables.
 11. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
 12. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.
- B. Cable Installation
1. Install cables only when cable tray installation has been completed and inspected.
 2. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
 3. On vertical runs, fasten cables to tray every 18 inches (457 mm). Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
 4. In existing construction, remove inactive or dead cables from cable tray.
 5. Install covers after installation of cable is completed.
- C. Connections
1. Ground cable trays according to manufacturer's written instructions.
 2. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.
- D. Field Quality Control
1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
 - a. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - b. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
 - c. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.



- d. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - e. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorquer in suspect areas.
 - f. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 - g. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.
2. Report results in writing.

E. Protection

1. Protect installed cable trays.
 - a. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
 - b. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.
 - c. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION 26 05 36 00



Task	Specification	Specification Description
26 05 39 00	26 05 19 13	Underfloor Raceways For Electrical Systems
26 05 43 00	26 05 00 00	Common Work Results for Electrical
26 05 43 00	26 05 19 16	Common Work Results for Communications
26 05 43 00	26 05 19 16a	Common Work Results for Electronic Safety and Security
26 05 43 00	26 05 19 16c	Communications Equipment Room Fittings
26 05 43 00	26 05 19 16d	Communications Backbone Cabling
26 05 43 00	26 05 19 16e	Communications Horizontal Cabling
26 05 43 00	26 05 19 16f	Conductors and Cables for Electronic Safety and Security
26 05 46 00	02 84 33 00	Overhead Electrical Distribution



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SECTION 26 05 53 00 - ELECTRICAL IDENTIFICATION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for electrical identification. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Identification for raceways.
 - b. Identification of power and control cables.
 - c. Identification for conductors.
 - d. Underground-line warning tape.
 - e. Warning labels and signs.
 - f. Instruction signs.
 - g. Equipment identification labels.
 - h. Miscellaneous identification products.

C. Submittals

1. Product Data: For each electrical identification product indicated.
2. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
3. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

D. Quality Assurance

1. Comply with ANSI A13.1 and IEEE C2, **as directed**.
2. Comply with NFPA 70.
3. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
4. Comply with ANSI Z535.4 for safety signs and labels.
5. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.2 PRODUCTS

A. Power Raceway Identification Materials

1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
2. Colors for Raceways Carrying Circuits at 600 V or Less:
 - a. Black letters on an orange field.
 - b. Legend: Indicate voltage and system or service type, **as directed**.
3. Colors for Raceways Carrying Circuits at More Than 600 V:
 - a. Black letters on an orange field.
 - b. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
4. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.



5. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
 6. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
 7. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.
 8. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
 9. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) **OR** 0.015 inch (0.38 mm), **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

OR

Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- B. Armored And Metal-Clad Cable Identification Materials
1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
 2. Colors for Raceways Carrying Circuits at 600 V and Less:
 - a. Black letters on an orange field.
 - b. Legend: Indicate voltage and system or service type, **as directed**.
 3. Colors for Raceways Carrying Circuits at More Than 600 V:
 - a. Black letters on an orange field.
 - b. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
 4. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

OR

Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.
- C. Power And Control Cable Identification Materials
1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
 2. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 3. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
 4. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) **OR** 0.015 inch (0.38 mm), **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

OR

Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
 5. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.



6. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- D. Conductor Identification Materials
1. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
 2. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 3. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
 4. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
 5. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
 6. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) **OR** 0.015 inch (0.38 mm), **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
OR
Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- E. Floor Marking Tape
1. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
- F. Underground-Line Warning Tape
1. Tape:
 - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - c. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 2. Color and Printing:
 - a. Comply with ANSI Z535.1 through ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: **ELECTRIC LINE, HIGH VOLTAGE.**
 - c. Inscriptions for Orange-Colored Tapes: **TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.**
 3. Tag: Type I:
 - a. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Thickness: 4 mils (0.1 mm).
 - c. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
 - d. 3-Inch (75-mm) Tensile According to ASTM D 882: 30 lbf (133.4 N), and 2500 psi (17.2 MPa).
 4. Tag: Type II:
 - a. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Thickness: 12 mils (0.3 mm).
 - c. Weight: 36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).



- d. 3-Inch (75-mm) Tensile According to ASTM D 882: 400 lbf (1780 N), and 11,500 psi (79.2 MPa).
 5. Tag: Type ID:
 - a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Overall Thickness: 5 mils (0.125 mm).
 - c. Foil Core Thickness: 0.35 mil (0.00889 mm).
 - d. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
 - e. 3-Inch (75-mm) Tensile According to ASTM D 882: 70 lbf (311.3 N), and 4600 psi (31.7 MPa).
 6. Tag: Type IID:
 - a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Overall Thickness: 8 mils (0.2 mm).
 - c. Foil Core Thickness: 0.35 mil (0.00889 mm).
 - d. Weight: 34 lb/1000 sq. ft. (16.6 kg/100 sq. m).
 - e. 3-Inch (75-mm) Tensile According to ASTM D 882: 300 lbf (1334 N), and 12,500 psi (86.1 MPa).
- G. Warning Labels And Signs
1. Comply with NFPA 70 and 29 CFR 1910.145.
 2. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
 3. Baked-Enamel Warning Signs:
 - a. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 - b. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - c. Nominal size, 7 by 10 inches (180 by 250 mm).
 4. Metal-Backed, Butyrate Warning Signs:
 - a. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
 - b. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - c. Nominal size, 10 by 14 inches (250 by 360 mm).
 5. Warning label and sign shall include, but are not limited to, the following legends:
 - a. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - b. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."
- H. Instruction Signs
1. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 - a. Engraved legend with black letters on white face.
 - b. Punched or drilled for mechanical fasteners.
 - c. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
 2. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
 3. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.



- I. Equipment Identification Labels
 1. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
 2. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
 3. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
 4. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
 5. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

- J. Cable Ties
 1. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - a. Minimum Width: 3/16 inch (5 mm).
 - b. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 - c. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - d. Color: Black except where used for color-coding.
 2. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - a. Minimum Width: 3/16 inch (5 mm).
 - b. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 - c. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - d. Color: Black.
 3. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
 - a. Minimum Width: 3/16 inch (5 mm).
 - b. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
 - c. UL 94 Flame Rating: 94V-0.
 - d. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
 - e. Color: Black.

- K. Miscellaneous Identification Products
 1. Paint: Comply with requirements in Division 07 for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
 2. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

1.3 EXECUTION

- A. Installation
 1. Verify identity of each item before installing identification products.
 2. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
 3. Apply identification devices to surfaces that require finish after completing finish work.
 4. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
 5. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 6. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot



(15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

7. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
8. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - a. Outdoors: UV-stabilized nylon.
 - b. In Spaces Handling Environmental Air: Plenum rated.
9. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
10. Painted Identification: Comply with requirements in Division 07 for surface preparation and paint application.

B. Identification Schedule

1. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:
 - a. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
 - b. Wall surfaces directly external to raceways concealed within wall.
 - c. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
2. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl **OR** Snap-around, **as directed**, labels. Install labels at 10-foot (3-m) **OR** 30-foot (10-m), **as directed**, maximum intervals.
3. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label **OR** self-adhesive vinyl tape applied in bands, **as directed**. Install labels at 10-foot (3-m) **OR** 30-foot (10-m), **as directed**, maximum intervals.
4. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
 - a. Emergency Power.
 - b. Power.
 - c. UPS.
5. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - a. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - 1) Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - 2) Colors for 208/120-V Circuits:
 - a) Phase A: Black.
 - b) Phase B: Red.
 - c) Phase C: Blue.
 - 3) Colors for 480/277-V Circuits:
 - a) Phase A: Brown.
 - b) Phase B: Orange.
 - c) Phase C: Yellow.
 - 4) Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where



- splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
6. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags **OR** nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation, **as directed**.
 7. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
 8. Conductors to Be Extended in the Future: Attach write-on tags **OR** marker tape, **as directed**, to conductors and list source.
 9. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 - a. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - b. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - c. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
 10. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
 - a. Limit use of underground-line warning tape to direct-buried cables.
 - b. Install underground-line warning tape for both direct-buried cables and cables in raceway.
 11. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
 12. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels **OR** Baked-enamel warning signs **OR** Metal-backed, butyrate warning signs, **as directed**.
 - a. Comply with 29 CFR 1910.145.
 - b. Identify system voltage with black letters on an orange background.
 - c. Apply to exterior of door, cover, or other access.
 - d. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - 1) Power transfer switches.
 - 2) Controls with external control power connections.
 13. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
 14. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer **OR** load shedding, **as directed**.
 15. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - a. Labeling Instructions:
 - 1) Indoor Equipment: Adhesive film label **OR** Adhesive film label with clear protective overlay **OR** Self-adhesive, engraved, laminated acrylic or melamine label **OR** Engraved, laminated acrylic or melamine label, **as directed**. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - 2) Outdoor Equipment: Engraved, laminated acrylic or melamine label **OR** Stenciled legend 4 inches (100 mm) high, **as directed**.



- 3) Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - 4) Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
- b. Equipment to Be Labeled:
- 1) Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved **OR** engraved, **as directed**, laminated acrylic or melamine label.
 - 2) Enclosures and electrical cabinets.
 - 3) Access doors and panels for concealed electrical items.
 - 4) Switchgear.
 - 5) Switchboards.
 - 6) Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - 7) Substations.
 - 8) Emergency system boxes and enclosures.
 - 9) Motor-control centers.
 - 10) Enclosed switches.
 - 11) Enclosed circuit breakers.
 - 12) Enclosed controllers.
 - 13) Variable-speed controllers.
 - 14) Push-button stations.
 - 15) Power transfer equipment.
 - 16) Contactors.
 - 17) Remote-controlled switches, dimmer modules, and control devices.
 - 18) Battery-inverter units.
 - 19) Battery racks.
 - 20) Power-generating units.
 - 21) Monitoring and control equipment.
 - 22) UPS equipment.

END OF SECTION 26 05 53 00



Task	Specification	Specification Description
26 05 83 00	26 05 13 00	Conductors And Cables
26 05 83 00	26 05 13 00a	Undercarpet Cables
26 05 83 00	26 05 13 00b	Medium-Voltage Cables



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SECTION 26 09 23 00 - LIGHTING CONTROLS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for lighting controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes manually operated lighting controls with relays, electrically operated circuit breakers, and control module.
2. This Section includes manually operated, PC-based, digital lighting controls with external signal source, relays, electrically operated circuit breakers, and control module.
3. This Section includes individually addressable lighting control devices communicating with data-entry and -retrieval devices using DALI protocol.

C. Definitions

1. BACnet: A networking communication protocol that complies with ASHRAE 135.
2. BAS: Building automation system.
3. DALI: Digital addressable lighting interface.
4. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
5. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
6. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
7. PC: Personal computer; sometimes plural as "PCs."
8. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.
9. RS-485: A serial network protocol, similar to RS-232, complying with TIA/EIA-485-A.

D. Submittals

1. Product Data: For control modules, power distribution components, DALI network materials, manual switches and plates, and conductors and cables.
2. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on this Project.
 - a. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
 - b. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
 - c. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
3. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 - a. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
 - b. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.



4. Software and Firmware Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 - c. Device address list.
 - d. Printout of software application and graphic screens.
 5. Field quality-control test reports.
 6. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
 7. Operation and maintenance data.
 8. Warranty: Special warranty specified in this Section.
- E. Quality Assurance
1. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.
 2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 3. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
 4. Comply with protocol described in IEC 60929, Annex E, for DALI lighting control devices, wiring, and computer hardware and software.
 5. Comply with NFPA 70.
- F. Coordination
1. Coordinate lighting control components to form an integrated interconnection of compatible components. Match components and interconnections for optimum performance of lighting control functions.
 - a. Coordinate lighting controls with BAS **OR** HVAC controls, **as directed**. Design display graphics showing building areas controlled; include the status of lighting controls in each area.
 - b. Coordinate lighting controls with that in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.
 2. Coordinate lighting control components specified in this Section with components specified in Division 26 Section "Panelboards".
- G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Failure of software input/output to execute switching or dimming commands.
 - 2) Failure of modular relays to operate under manual or software commands.
 - 3) Damage of electronic components due to transient voltage surges.
 - b. Warranty Period: Two years from date of Final Completion.
 - c. Extended Warranty Period Failure Due to Transient Voltage Surges: Eight years.
 - d. Extended Warranty Period for Electrically Held Relays: 10 years from date of Final Completion.
- H. Software Service Agreement (May Not Be Allowed For Publicly Funded Projects)
1. Technical Support: Beginning with Final Completion, provide software support for two years.
 2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revise licenses for use of the software.



- a. Provide 30-day notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment, if necessary.

1.2 PRODUCTS

A. System Requirements

1. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.
2. Performance Requirements (for programmable system that controls manual and automatic operation that is not PC based): Manual switch operation sends a signal to programmable-system control module that processes the signal according to its programming and routes an open or close command to one or more relays **OR** electrically operated circuit breakers, **as directed**, in the power-supply circuits to groups of lighting fixtures or other loads.
3. Performance Requirements (for PC-based programmable system that controls manual and automatic operation): Manual switches, an internal timing and control unit, and external sensors or other control signal sources send a signal to a PC-based programmable-system control module that processes the signal according to its programming and routes an open or close command to one or more relays **OR** electrically operated circuit breakers, **as directed**, in the power-supply circuits, or routes variable commands to one or more dimmers, for groups of lighting fixtures or other loads.
4. Performance Requirements (for DALI-compliant program): Individually addressable devices (such as electronic ballasts, dimmers, and manual switches) are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs). Devices also report status to data-entry and -retrieval devices through the bus.
5. BAS Interface: Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports.
 - a. Hardwired Points:
 - 1) Monitoring: On-off status, <Insert monitoring point>.
 - 2) Control: On-off operation, <Insert control point>.
 - b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor lighting from a BAS operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the BAS.

B. Control Module

1. Control Module Description: (This is a generic, nonproprietary control module that is not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral alphanumeric LCD or LED shall display menu-assisted programming and control.
2. Control Module Description: (These are typical systems developed by time-switch manufacturers as an expansion and refinement of their microprocessor-based, digital, time-switch product lines - controls are not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Unit shall be programmable for control of indicated number of output circuits. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices, all located in other enclosures. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral



alphanumeric LCD shall display manual-control and programming steps. Modules and their associated control panels shall include the following features:

- a. Multichannel output with <Insert number> channels.
OR
 Multiple inputs and multichannel output arranged for <Insert number> channels.
- b. Multiple inputs for indicated occupancy sensors and hand-held programming device.
3. Control Module Description: (These are low-voltage control systems developed by high-end, remote-control dimmer system manufacturers - controls are not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Control units shall be programmable and capable of receiving inputs from indicated sensors and hand-held programmer. Output circuits shall be pilot-duty relays compatible with power switching devices. Output circuits shall include digital circuits arranged to transmit control commands to remote preset dimmers. Modules and their associated control panels shall include the following features:
 - a. Multichannel output with <Insert number> channels.
OR
 Multiple inputs and multichannel output arranged for <Insert number> channels.
 - b. Multiple inputs for occupancy sensors, daylight sensors, and dimming systems with associated daylight sensors.
4. Control Module Description: (This is a low-voltage control system developed around panelboards with electrically operated, molded-case circuit breakers and control module installed in panelboard - controls are not PC based.) Panelboard mounted; comply with UL 916 (CSA C22.2, No. 205); microprocessor based, solid-state, 365-day timing and control unit. Control units shall be programmable and capable of receiving inputs from sensors and other sources. Panelboard shall use low-voltage-controlled, electrically operated, molded-case branch circuit breakers as prime power-circuit switching devices. Circuit breakers and a limited number of digital or analog, low-voltage control-circuit outputs shall be individually controlled by control module. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable. Panelboard shall also comply with Division 26 Section "Panelboards".
5. Control Module Description: (This is a refinement of classic low-voltage control system originally developed for manual, multipoint lighting control using latching-type, single-pole relays to switch 120- and 277-V circuits - controls are not PC based.) Comply with UL 508 (CSA C22.2, No. 14); microprocessor-based, programmable, control unit; mounted in preassembled, modular relay panel. Low-voltage-controlled, latching-type, single-pole lighting circuit relays shall be prime output circuit devices. Where indicated, a limited number of digital or analog, low-voltage control-circuit outputs shall be supported by control unit and circuit boards associated with relays. Control units shall be capable of receiving inputs from sensors and other sources. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable.
6. Control Module Description: (This is a typical PC-based software control system developed to operate panelboards with electrically operated circuit breakers, relay boards with latching-type control relays, and individually addressable DALI-compliant devices. This control scheme is also suitable for integrating one or more of these boards to a PC-based control network (such as BAS, detention monitoring and control system, and HVAC control system) specified in another Section.) Programmable, PC-based unit with 17-inch color video monitor **OR** 15-inch color LCD, **as directed**, and keyboard for graphic display and programming of system status and to override breaker status; and to display status of local override controls and diagnostic information. If the control module is applied to emergency lighting units, control unit shall indicate failure of normal power and that the lighting units are, or are not, powered by the alternate power source.
 - a. Display: Single graphic display for programming lighting control panelboards.
OR
 Display: Separate graphic displays for programming each lighting control panelboard.
 - b. Interoperability: Control module shall be configured to connect with other control systems using RS-485 network to enable remote workstations to use control module functions.

**OR**

Interoperability: Control module shall be configured to connect to LonWorks-compliant **OR** BACnet-compliant, **as directed**, network, resulting in extending control to any network-compliant devices such as occupancy switches.

OR

Interoperability: Lighting control shall be configured to allow individual users to turn lighting on and off with their PCs. Software shall be written for Windows operating system, with Web page as the display and ActiveX controls that can be accessed through an Internet browser. Include at least three levels of password protection. Include an egress lighting option that will provide each user with a lighted path for exiting the building after normal working hours.

OR

Interoperability: Lighting control shall be configured to allow individual users to turn lighting on and off with DALI-compliant, digital-communication devices. Software shall be written for Windows operating system, with the full suite of DALI commands and device parameter settings.

- c. System Memory: Nonvolatile. System shall reboot program and reset time automatically without errors after power outages up to 90 days' duration.
- d. Software: Lighting control software shall be capable of linking switch inputs to relay outputs, retrieving links, viewing relay output status, controlling relay outputs, simulating switch inputs, setting device addresses, and assigning switch input and relay output modes.
- e. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight saving time and shall provide weekly routine and annual holiday scheduling.
- f. Astronomic Control: Automatic adjustment of dawn and dusk switching.
- g. Demand Control: Demand shall be monitored through pulses from a remote meter and shall be controlled by programmed switching of loads. System capability shall include sliding window averaging and programming of load priorities and characteristics. Minimum of two different time-of-day demand schedules shall execute load-management control actions by switching output circuits or by transmitting other types of load-control signals.
- h. Confirmation: Each relay or contactor device operated by system shall have auxiliary contacts that provide a confirmation signal to the system of on or off status of device. On or off status confirmation for each electrically operated circuit breaker shall be provided by an auxiliary contact or by a sensing device at load terminal.
 - 1) Software shall interpret status signals, provide for their display, and initiate failure signals.

OR

Lamp or LED at control module or display panel shall identify status of each controlled circuit.

- i. Remote Communication Capability: Allow programming, data-gathering interrogation, status display, and controlled command override from a PC at a remote location over telephone lines **OR** data links **OR** DALI networks **OR** power line carrier, **as directed**. System shall include modem, communications and control software, and remote computer compatibility verification for this purpose.
- j. Telephone Override Capability: Override programmed lighting shutdown commands by telephoning computer and shall enter a voice-menu-guided, override touch-tone code specific to zone being controlled.
- k. Local Override Capability: Manual, low-voltage control devices shall override programmed shutdown of lighting and shall override other programmed control for intervals that may be duration programmed.
- l. Automatic Control of Local Override: Automatic control shall switch lighting off if lighting has been switched on by local override. Comply with provisions in California Code of Regulations, Title 24, Part 6, **as directed**.
- m. Automatic battery backup shall provide power to maintain program and system clock operation for 90 days' minimum duration when power is off.
- n. Programmed time signals shall change preset scenes and dimmer settings.



- o. Daylight Balancing Dimming Control: Control module shall interpret variable analog signal from photoelectric sensor and shall route dimming signals to dimming fluorescent ballast control circuits. Signal shall control dimming of fixture so illumination level remains constant as daylight contribution varies.
- p. Daylight Compensating Switch Control: Control module shall interpret a preset threshold illumination-level signal from a photoelectric relay and shall activate relays controlling power to selected groups of lighting fixtures to turn them on and off to maintain adjustable minimum illumination level as daylight contribution varies.
- q. Energy Conservation: Bilevel control of special ballasts or dimming circuits to comply with local energy codes.
- r. Flick Warning: Programmable momentary turnoff of lights shall warn that programmed shutoff will occur after a preset interval. Warning shall be repeated after a second preset interval before end of programmed override period.
- s. Diagnostics: When system operates improperly, software shall initiate factory-programmed diagnosis of failure and display messages identifying problem and possible causes.
- t. Additional Programming: In addition to system programming by the PC, individual control modules shall be programmable using data-entry and -retrieval (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs).

C. Power Distribution Components (For DALI-Compliant Networks)

1. Modular Relay Panel: Comply with UL 508 (CSA C22.2, No. 14) and UL 916 (CSA C22.2, No. 205); factory assembled with modular single-pole relays, power supplies, and accessory components required for specified performance.
 - a. Cabinet: Steel with hinged, locking door.
 - 1) Barriers separate low-voltage and line-voltage components.
 - 2) Directory: Mounted on back of door. Identifies each relay as to load groups controlled and each programmed pilot device if any.
 - 3) Control Power Supply: Transformer and full-wave rectifier with filtered dc output.
 - b. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type.
 - 1) Low-Voltage Leads: Plug connector to the connector strip in cabinet and pilot light power where indicated.
 - 2) Rated Capacity (Mounted in Relay Panel): 20 A, 125-V ac for tungsten filaments; 20 A, 277-V ac for ballasts.
 - 3) Endurance: 50,000 cycles at rated capacity.
 - 4) Mounting: Provision for easy removal and installation in relay cabinet.
2. Electrically Operated, Molded-Case Circuit-Breaker Panelboard: Comply with NEMA PB 1 and UL 50 (CSA C22.2, No. 94), UL 67 (CSA C22.2, No. 29), UL 489 (CSA C22.2, No. 65), and UL 916 (CSA C22.2, No. 205).
 - a. Cabinets: In addition to requirements specified below, comply with Division 26 Section "Panelboards".
 - b. Electrically Operated, Molded-Case Circuit Breakers: Bolt-on type.
 - 1) Switching Endurance Ratings: Certified by manufacturer or by a nationally recognized testing laboratory (NRTL) for at least 20,000 open and close operations under rated load at 0.8 power factor.
 - 2) Minimum 30,000 open and close operations with load equal to circuit-breaker trip rating and consisting of 100 percent tungsten filament load.
 - 3) Minimum 30,000 open and close operations with load equal to circuit-breaker trip rating and consisting of 100 percent fluorescent ballasts rated for 10 percent total harmonic distortion.
 - 4) Listed and labeled as complying with UL SWD, HCAR, and HID ratings by a national recognized testing laboratory (NRTL) acceptable to authorities having jurisdiction.
3. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels.

**OR**

Line-Voltage Surge Suppression: Field-mounting surge suppressors that comply with Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" for Category A locations.

OR

Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels or field-mounting surge suppressors that comply with Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" for Category A locations.

D. DALI Network Materials

1. Network Power Supply and Router: Interface device connecting TCP/IP control networks to DALI-compliant network.
 - a. DALI-Compliant Network Power Rating: One full-rated network for **OR** Two full-rated networks, each capable of, **as directed**, powering up to 64 addressable devices for each network; suitable for use with NFPA 70, Class 1 and Class 2 control circuits; and 16 V dc, 250 mA.
 - b. Primary Power: 120 or 277 V, field selectable; 12 VA.
 - c. 10basT Ethernet port.
 - d. LED indicator lights for Ethernet status (link, send, and receive), power-on, and DALI network failure.
2. Lighting Control Software:
 - a. Five-tier hierarchical architecture; high-speed, parallel query; and distributed-logic processing scalable from single rooms to full campuses.
 - b. Automatic backup for all settings and parameters.
 - c. TCP/IP network protocol.
 - d. Interactive with other building management systems at TCP/IP level.
 - e. At least three security levels.
 - f. Support the full suite of DALI commands and device parameter settings.
 - g. Scheduling modules to provide building-wide scene scheduling.
 - h. Billing modules to track energy use for multiple tenants and able to produce monthly billing statements.
 - i. Support load shedding, peak shaving, sweeps with local override, and other energy-conservation measures.
 - j. Able to report individual device status, including inoperative lamps, ballast failure detection, and dimmer position.

E. Manual Switches And Plates

1. Push-Button Switches: Modular, momentary-contact, low-voltage type.
 - a. Match color specified in Division 26 Section "Wiring Devices".
 - b. Integral green LED **OR** neon, **as directed**, pilot light to indicate when circuit is on.
 - c. Internal white LED **OR** neon, **as directed**, locator light to illuminate when circuit is off.
2. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Division 26 Section "Wiring Devices".
3. Wall-Box Dimmers: Comply with Division 26 Section "Wiring Devices".
4. Wall Plates: Single and multigang plates as specified in Division 26 Section "Wiring Devices"
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

F. Conductors And Cables

1. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
2. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG, complying with Division 26 Section "Low-voltage Electrical Power Conductors And Cables".



3. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 **OR** 16 **OR** 18, **as directed**, AWG, complying with Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
4. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e **OR** 6, **as directed**, for horizontal copper cable and with Division 28 Section "Conductors And Cables For Electronic Safety And Security".

1.3 EXECUTION

A. Wiring Installation

1. Comply with NECA 1.
2. Wiring Method: Install wiring in raceways except where installed in accessible ceilings and gypsum board partitions. Comply with Division 26 Section "Low-voltage Electrical Power Conductors And Cables". Minimum conduit size shall be 1/2 inch (13 mm).
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
4. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
5. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
6. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.
7. Identify components and power and control wiring according to Division 26 Section "Identification For Electrical Systems".

B. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
 - a. Test for circuit continuity.
 - b. Verify that the control module features are operational.
 - c. Check operation of local override controls.
 - d. Test system diagnostics by simulating improper operation of several components selected by the Owner.

C. Software Installation

1. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

D. Adjusting

1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting sensors and to assist the Owner's personnel in making program changes to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain lighting controls and software training for PC-based control systems.

END OF SECTION 26 09 23 00



SECTION 26 09 23 00a - LIGHTING CONTROL DEVICES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for lighting control devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following lighting control devices:
 - a. Time switches.
 - b. Outdoor and Indoor photoelectric switches.
 - c. Indoor occupancy sensors.
 - d. Outdoor motion sensors.
 - e. Lighting contactors.
 - f. Emergency shunt relays.

C. Definitions

1. LED: Light-emitting diode.
2. PIR: Passive infrared.

D. Submittals

1. Product Data: For each type of product indicated.
2. Field quality-control test reports.
3. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Time Switches

1. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
 - a. Contact Configuration: SPST **OR** DPST **OR** DPDT, **as directed**.
 - b. Contact Rating: 30-A inductive or resistive, 240-V ac **OR** 20-A ballast load, 120/240-V ac, **as directed**.
 - c. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.
OR
Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.
OR
Programs: channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
OR
Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule with skip-a-day weekly schedule.

**OR**

Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week.

OR

Programs: channels; each channel shall be individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.

OR

Programs: channels; each channel shall be individually programmable with 40 on-off operations per week, plus 4 seasonal schedules that modify the basic program, and an annual holiday schedule that overrides the weekly operation on holidays.

OR

Program: Configuration, as directed by the Owner and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.

- d. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels, **as directed**.
 - e. Astronomic Time: All **OR** Selected, **as directed**, channels.
 - f. Battery Backup: For schedules and time clock.
2. Electromechanical-Dial Time Switches: Type complying with UL 917.
- a. Contact Configuration: SPST **OR** DPST **OR** SPDT **OR** DPDT, **as directed**.
 - b. Contact Rating: 30-A inductive or resistive, 240-V ac **OR** 20-A ballast load, 120/240-V ac, **as directed**.
 - c. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
 - d. Astronomic time dial.
 - e. Eight-Day Program: Uniquely programmable for each weekday and holidays.
 - f. Skip-a-day mode.
 - g. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

B. Outdoor Photoelectric Switches

1. Description: Solid state, with SPST **OR** DPST, **as directed**, dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
 - a. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off, **as directed**.
 - b. Time Delay: 15-second minimum, to prevent false operation.
 - c. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
 - d. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

OR

Description: Solid state, with SPST **OR** DPST, **as directed**, dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

- a. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
- b. Time Delay: 30-second minimum, to prevent false operation.
- c. Lightning Arrester: Air-gap type.
- d. Mounting: Twist lock complying with IEEE C136.10, with base.

C. Indoor Photoelectric Switches



1. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit mounted on luminaire, **as directed**, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
 - a. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 - b. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 - c. Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lx) **OR** 100 to 1000 fc (1080 to 10 800 lx), **as directed**, with an adjustment for turn-on and turn-off levels within that range.
 - d. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
 - e. Indicator: Two LEDs to indicate the beginning of on-off cycles.
 2. Skylight Photoelectric Sensors: Solid-state, light-level sensor; housed in a threaded, plastic fitting for mounting under skylight, facing up at skylight; with separate relay unit mounted on luminaire, **as directed**, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
 - a. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 - b. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 - c. Light-Level Monitoring Range: 1000 to 10,000 fc (10 800 to 108 000 lx), with an adjustment for turn-on and turn-off levels within that range.
 - d. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
 - e. Indicator: Two LEDs to indicate the beginning of on-off cycles.
- D. Indoor Occupancy Sensors
1. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
 - a. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - b. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 - c. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 - d. Mounting:
 - 1) Sensor: Suitable for mounting in any position on a standard outlet box.
 - 2) Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - 3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - e. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 - f. Bypass Switch: Override the on function in case of sensor failure.
 - g. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
 2. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
 - a. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 - b. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.



- c. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.
 3. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
 - a. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 - b. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 - c. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 - d. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 - e. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).
 4. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
 - a. Sensitivity Adjustment: Separate for each sensing technology.
 - b. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 - c. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
- E. Outdoor Motion Sensors (PIR)
 1. Performance Requirements: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as raintight according to UL 773A.
 - a. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - b. Mounting:
 - 1) Sensor: Suitable for mounting in any position on a standard outdoor junction box.
 - 2) Relay: Internally mounted in a standard weatherproof electrical enclosure.
 - 3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - c. Bypass Switch: Override the on function in case of sensor failure.
 - d. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc (11 to 215 lx); keep lighting off during daylight hours.
 2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 3. Detection Coverage: Up to 35 feet (11 m), with a field of view of 90 degrees **OR** Up to 100 feet (30 m), with a field of view of 60 degrees **OR** Up to 35 feet (11 m), with a field of view of 180 degrees **OR** Up to 52.5 feet (16 m), with a field of view of 270 degrees, **as directed**.
 4. Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.
 5. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 - a. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.



- b. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

F. Lighting Contactors

1. Description: Electrically operated and mechanically **OR** electrically, **as directed**, held, combination type with fusible switch **OR** nonfused disconnect, **as directed**, complying with NEMA ICS 2 and UL 508.
 - a. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
 - b. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 - c. Enclosure: Comply with NEMA 250.
 - d. Provide with control and pilot devices as indicated on Drawings **OR** scheduled, **as directed**, matching the NEMA type specified for the enclosure.
2. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.
 - a. Monitoring: On-off status, as directed by the Owner.
 - b. Control: On-off operation, as directed by the Owner.

G. Emergency Shunt Relay

1. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic, **as directed**, switching contacts; complying with UL 924.
 - a. Coil Rating: 120 **OR** 277, **as directed**, V.

H. Conductors And Cables

1. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
2. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
3. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 **OR** 16 **OR** 18, **as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

1.3 EXECUTION

A. Sensor Installation

1. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. Contactor Installation

1. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

C. Wiring Installation

1. Wiring Method: Comply with Division 26 Section "Low-voltage Electrical Power Conductors And Cables". Minimum conduit size shall be 1/2 inch (13 mm).
2. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.



4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

D. Identification

1. Identify components and power and control wiring according to Division 26 Section "Identification For Electrical Systems".
 - a. Identify controlled circuits in lighting contactors.
 - b. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
2. Label time switches and contactors with a unique designation.

E. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
 - a. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - b. Operational Test: Verify operation of each lighting control device, and adjust time delays.
2. Lighting control devices that fail tests and inspections are defective work.

END OF SECTION 26 09 23 00a

**SECTION 26 09 23 00b - ELECTRICAL POWER MONITORING AND CONTROL**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for electrical power monitoring and control. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following for monitoring and control of electrical power system:
 - a. PC-based workstation(s) and software.
 - b. Communication network and interface modules for RS-232; RS-485, Modbus TCP/IP; and IEEE 802.3 data transmission protocols.

C. Definitions

1. Ethernet: Local area network based on IEEE 802.3 standards.
2. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.
3. HTML: Hypertext markup language.
4. I/O: Input/output.
5. KB: Short for kilobyte. When used to describe data storage, "KB" represents 1024 bytes.
6. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.
7. LAN: Local area network; sometimes plural as "LANs."
8. LCD: Liquid crystal display.
9. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.
10. Modbus TCP/IP: An open protocol for exchange of process data.
11. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
12. PC: Personal computer; sometimes plural as "PCs."
13. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
14. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.
15. RS-485: A TIA standard for multipoint communications using two twisted-pairs.
16. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
17. THD: Total harmonic distortion.
18. UPS: Uninterruptible power supply; used both in singular and plural context.
19. WAN: Wide area network.

D. Submittals

1. Product Data: For each type of product indicated.
 - a. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
2. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.
 - a. Outline Drawings: Indicate arrangement of components and clearance and access requirements.



- b. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
 - c. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - d. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
 - e. UPS sizing calculations for workstation.
 3. Software and Firmware Operational Documentation:
 - a. Self-study guide describing the process for setting equipment's network address; setting the Owner's options; procedures to ensure data access from any PC on the network, using a standard Web browser; and recommended firewall setup.
 - b. Software operating and upgrade manuals.
 - c. Software Backup: On a magnetic media or compact disc, complete with the Owner-selected options.
 - d. Device address list and the set point of each device and operator option, as set in applications software.
 - e. Graphic file and printout of graphic screens and related icons, with legend.
 4. Software Upgrade Kit: For the Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.
 5. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.
 6. Field quality-control test reports.
 7. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. Include the following:
 - a. Operating and applications software documentation.
 - b. Software licenses.
 - c. Software service agreement.
 - d. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
 - e. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
 8. Other Informational Submittals:
 - a. System installation and setup guides, with data forms to plan and record options and setup decisions.
- E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Software Service Agreement
1. Technical Support: Beginning with Final Completion, provide software support for two years.
 2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include the operating systems. Upgrade shall include new or revised licenses for use of software.
 - a. Provide 30-day notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.



1.2 PRODUCTS

A. Functional Description

1. Instrumentation and Recording Devices: Monitor and record load profiles and chart energy consumption patterns.
 - a. Calculate and Record the Following:
 - 1) Load factor.
 - 2) Peak demand periods.
 - 3) Consumption correlated with facility activities.
 - b. Measure and Record Metering Data for the Following:
 - 1) Electricity.
 - 2) Domestic water.
 - 3) Natural gas.
2. Software: Calculate allocation of utility costs.
 - a. Automatically Import Energy Usage Records to Allocate Energy Costs for the Following:
 - 1) At least 15 departments.
 - 2) At least 30 tenants.
 - 3) At least five processes.
 - 4) At least five buildings.
 - b. Verify utility bills and analyze alternate energy rates, **as directed**.
3. Power Quality Monitoring: Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters:
 - a. Voltage regulation and unbalance.
 - b. Continuous three-phase rms voltage.
 - c. Periodic max./min./avg. samples.
 - d. Harmonics.
 - e. Voltage excursions.
4. Emergency Load Shedding. Preserve critical loads or avoid total shutdown due to unforeseen loss of power sources according to the following logic:
 - a. Determine system topology.
 - b. Evaluate remaining loads and sources.
 - c. Shed loads in less than 100 ms.
5. Demand Management:
 - a. Peaking or co-generator control.
 - b. Load interlocking.
 - c. Load shedding.
 - d. Load trimming.
6. System: Report equipment status and power system control.

B. System Requirements

1. Monitoring and Control System: Include PC-based workstation **OR** multiple PC-based workstations **OR** multiple PC-based workstations with graphics capability and Web access, **as directed**, with its operating system and application software, connected to data transmission network.
2. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
 - a. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
 - b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.
3. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.



4. BAS Interface: Provide factory-installed hardware and software to enable the BAS to monitor, display, and record data for use in processing reports.
 - a. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor, **as directed**.
OR
 ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely monitor meter information from a BAS operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the BAS.

C. Operating System

1. Software: Configured to run on a portable laptop computer, a single PC, or a palm computer, with capability for accessing a single meter at a time. System is not connected to a LAN. Modbus TCP/IP, RS-232, and RS-485 digital communications.
OR
 Software: Configured to run on a single PC, with capability for accessing multiple devices simultaneously. Modbus TCP/IP, RS-232, and RS-485 digital communications.
OR
 Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Ethernet, Modbus TCP/IP, RS-232, and RS-485 digital communications.
OR
 Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be Web enabled. Workstations and portable computers shall not require any software except for an Internet browser to provide connectivity and full functionality. Include a firewall recommended by manufacturer. 100 Base-T Ethernet, Modbus TCP/IP RS-232, and RS-485 digital communications.
2. Operating System Software: Based on 32-bit, Microsoft Windows workstation operating system. Software shall have the following features:
 - a. Multiuser and multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.
 - b. Graphical user interface to show pull-down menus and a menu tree format.
 - c. Capability for future additions within the indicated system size limits.
3. Peer Computer Control Software: Shall detect a failure of workstation and associated server, **as directed**, and shall cause other workstation and associated server, **as directed**, to assume control of all system functions without interruption of operation. Drivers shall be provided in both central computers to support this mode of operation.

D. Applications Software

1. Basic Requirements:
 - a. Fully compatible with and based on the approved operating system.
 - b. Password-protected operator login and access; three levels, minimum.
 - c. Password-protected setup functions.
 - d. Context sensitive on-line help.
 - e. Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random-ordered record.
 - f. Capability for importing custom icons into graphic views to represent alarms and I/O devices.
 - g. Automatic and encrypted backups for database and history; automatically stored at central control PC **OR** selected workstation, **as directed**, and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
 - h. Operator audit trail for recording and reporting all changes made to user-defined system options.
2. Workstation Server Functions:



- a. Support other client PCs on the LAN and WAN, **as directed**.
- b. Maintain recorded data in databases accessible from other PCs on the LAN and WAN, **as directed**.
3. Data Formats:
 - a. User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.
 - b. Option to convert reports and graphics to HTML format.
 - c. Interactive graphics.
 - d. Option to send preprogrammed or operator designed e-mail reports.
4. Metered Data: Display metered values in real time.
5. Remote Control:
 - a. Display circuit-breaker status and allow breaker control.
 - b. User defined with load-shedding automatically initiated and executed schemes responding to programmed time schedules, set points of metered demands, utility contracted load shedding, or combinations of these.
6. Equipment Documentation: Database for recording of equipment ratings and characteristics; with capability for graphic display on monitors.
7. Graphics: Interactive color-graphics platform with pull-down menus and mouse-driven generation of power system graphics, in formats widely used for such drafting; to include the following:
 - a. Site plan.
 - b. Floor plans.
 - c. Equipment elevations.
 - d. Single-line diagrams.
8. User-Defined Monitoring and Control Events: Display and record with date and time stamps accurate to 0.1 second, and including the following:
 - a. Operator log on/off.
 - b. Attempted operator log on/off.
 - c. All alarms.
 - d. Equipment operation counters.
 - e. Out-of-limit, pickup, trip, and no-response events.
9. Trending Reports: Display data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.
 - a. Spreadsheet functions of sum, delta, percent, average, mean, standard deviation, and related functions applied to recorded data.
 - b. Charting, statistical, and display functions of standard Windows-based spreadsheet.
10. Alarms: Display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.
 - a. Functions requiring user acknowledgment shall run in background during computer use for other applications and override other presentations when they occur.
11. Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event; include the graphic displays of the following, based on user-specified criteria:
 - a. Phase voltages, phase currents, and residual current.
 - b. Overlay of three-phase currents, and overlay each phase voltage and current.
 - c. Waveforms ranging in length from 2 cycles to 5 minutes.
 - d. Disturbance and steady-state waveforms up to 512 points per cycle.
 - e. Transient waveforms up to 83,333 points per cycle on 60-Hz base.
 - f. Calculated waveform on a minimum of four cycles of data of the following:
 - 1) THD.
 - 2) rms magnitudes.
 - 3) Peak values.
 - 4) Crest factors.
 - 5) Magnitude of individual harmonics.
12. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software.
13. Tenant or Activity Billing Software:



- a. Automatically compute and prepare tenant bills **OR** activity demand and energy-use statements, **as directed**, based on metering of energy use and peak demand integrated over user-defined interval.
 - b. Intervals shall be same as used by electric utilities, including current vendor.
 - c. Import metered data from saved records that were generated by metering and monitoring software.
 - d. Maintain separate directory for each tenant's historical billing information.
 - e. Prepare summary reports in user-defined formats and time intervals.
14. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
- a. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.
 - b. Sort and report by device name and by function.
 - c. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.
 - d. Differentiate alarm signals from other indications.
 - e. When system is reset, report reset event with same information concerning device, location, date, and time.
- E. Communication Components And Networks
1. Transient Voltage Surge Suppression and Electromagnetic-Interference Immunity: Include in solid-state equipment. Comply with IEEE C37.90.
 2. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard communication protocol; LANs complying with EIA 485, 100 Base-T Ethernet, and Modbus TCP/IP.
- F. Power Monitors
1. Separately mounted, permanently installed instrument for power monitoring and control.
 - a. Enclosure: NEMA 250, Type 1 **OR** 12, **as directed**.
 2. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - a. Indoor installation in non-air-conditioned **OR** nontemperature-controlled, **as directed**, spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
 3. rms Real-Time Measurements:
 - a. Current: Each phase, neutral, average of three phases, percent unbalance.
 - b. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.
 - c. Power: Per phase and three-phase total.
 - d. Reactive Power: Per phase and three-phase total.
 - e. Apparent Power: Per phase and three-phase total.
 - f. Power Factor: Per phase and three-phase total.
 - g. Displacement Power Factor: Per phase and three-phase total.
 - h. Frequency.
 - i. THD: Current and voltage.
 - j. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
 - k. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
 - l. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
 4. Demand Current Calculations, per Phase, Three-Phase Average and Neutral:
 - a. Present.
 - b. Running average.
 - c. Last completed interval.
 - d. Peak.
 5. Demand Real Power Calculations, Three-Phase Total:



- a. Present.
- b. Running average.
- c. Last completed interval.
- d. Predicted.
- e. Peak.
- f. Coincident with peak kVA demand.
- g. Coincident with kVAR demand.
6. Demand Reactive Power Calculations, Three-Phase Total:
 - a. Present.
 - b. Running average.
 - c. Last completed interval.
 - d. Predicted.
 - e. Peak.
 - f. Coincident with peak kVA demand.
 - g. Coincident with kVAR demand.
7. Demand Apparent Power Calculations, Three-Phase Total:
 - a. Present.
 - b. Running average.
 - c. Last completed interval.
 - d. Predicted.
 - e. Peak.
 - f. Coincident with peak kVA demand.
 - g. Coincident with kVAR demand.
8. Average Power Factor Calculations, Demand Coincident, Three-Phase Total:
 - a. Last completed interval.
 - b. Coincident with kW peak.
 - c. Coincident with kVAR peak.
 - d. Coincident with kVA peak.
9. Power Analysis Values:
 - a. THD, Voltage and Current: Per phase, three phase, and neutral.
 - b. Displacement Power Factor: Per phase, three phase.
 - c. Fundamental Voltage, Magnitude and Angle: Per phase.
 - d. Fundamental Currents, Magnitude and Angle: Per phase.
 - e. Fundamental Real Power: Per phase, three phase.
 - f. Fundamental Reactive Power: Per phase.
 - g. Harmonic Power: Per phase, three phase.
 - h. Phase rotation.
 - i. Unbalance: Current and voltage.
 - j. Harmonic Magnitudes and Angles for Current and Voltages: Per phase, up to 31st **OR** 63rd, **as directed**, harmonic.
10. Power Demand Calculations: According to one of the following calculation methods, selectable by the user:
 - a. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
 - b. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
 - 1) Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
 - 2) Fixed block that calculates demand at end of the interval.
 - 3) Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
 - c. Demand Calculation Initiated by a Synchronization Signal:
 - 1) Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.



- 2) Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
 - 3) Demand can be synchronized with clock in the power meter.
11. Sampling:
 - a. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.
 - b. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on all voltage and current channels in the meter.
12. Minimum and Maximum Values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:
 - a. Line-to-line voltage.
 - b. Line-to-neutral voltage.
 - c. Current per phase.
 - d. Line-to-line voltage unbalance.
 - e. Line-to-neutral voltage unbalance.
 - f. Power factor.
 - g. Displacement power factor.
 - h. Total power.
 - i. Total reactive power.
 - j. Total apparent power.
 - k. THD voltage L-L.
 - l. THD voltage L-N.
 - m. THD current.
 - n. Frequency.
13. Harmonic Calculation: Display and record the following:
 - a. Harmonic magnitudes and angles for each phase voltage and current through 31st **OR** 63rd, **as directed**, harmonic. Calculate for all three phases, current and voltage, and residual current. Current and voltage information for all phases shall be obtained simultaneously from same cycle.
 - b. Harmonic magnitude reported as a percentage of the fundamental or as a percentage of rms values, as selected by user.
14. Current and Voltage Ratings:
 - a. Designed for use with current inputs from standard instrument current transformers with 5-A secondary and shall have a metering range of 0-10 A.
 - b. Withstand ratings shall be not less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.
 - c. Designed for use with voltage inputs from standard instrument potential transformers with a 120-V secondary.
15. Accuracy:
 - a. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters.
 - b. Accuracy from Light to Full Rating:
 - 1) Power: Accurate to 0.25 percent of reading, plus 0.025 percent of full scale.
 - 2) Voltage and Current: Accurate to 0.075 percent of reading, plus 0.025 percent of full scale.
 - 3) Power Factor: Plus or minus 0.002, from 0.5 leading to 0.5 lagging.
 - 4) Frequency: Plus or minus 0.01 Hz at 45 to 67 Hz.
16. Waveform Capture:
 - a. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 31st harmonic of basic 60 Hz.
 - b. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.
17. Input: One digital input signal(s).



- a. Normal mode for on/off signal.
 - b. Demand interval synchronization pulse, accepting a demand synchronization pulse from a utility demand meter.
 - c. Conditional energy signal to control conditional energy accumulation.
18. Outputs:
- a. Operated either by user command sent via communication link, or set to operate in response to user-defined alarm or event.
 - b. Closed in either a momentary or latched mode as defined by user.
 - c. Each output relay used in a momentary contact mode shall have an independent timer that can be set by user.
 - d. One digital KY pulse to a user-definable increment of energy measurement. Output ratings shall be up to 120-V ac, 300-V dc, 50 mA, and provide 3500-V rms isolation.
 - e. One relay output module(s), providing a load voltage range from 20- to 240-V ac or from 20- to 30-V dc, supporting a load current of 2 A.
 - f. Output Relay Control:
 - 1) Relay outputs shall operate either by user command sent via communication link or in response to user-defined alarm or event.
 - 2) Normally open and normally closed contacts, field configured to operate as follows:
 - a) Normal contact closure where contacts change state for as long as signal exists.
 - b) Latched mode when contacts change state on receipts of a pickup signal; changed state is held until a dropout signal is received.
 - c) Timed mode when contacts change state on receipt of a pickup signal; changed state is held for a preprogrammed duration.
 - d) End of power demand interval when relay operates as synchronization pulse for other devices.
 - e) Energy Pulse Output: Relay pulses quantities used for absolute kWh, absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.
 - f) Output controlled by multiple alarms using Boolean-type logic.
19. Onboard Data Logging:
- a. Store logged data, alarms, events, and waveforms in 80 **OR** 800, **as directed**, KB of onboard nonvolatile memory.
 - b. Stored Data:
 - 1) Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 to 52 days of 15-minute interval data, depending on number of quantities selected.
 - 2) Custom Data Logs: One **OR** Three, **as directed**, user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:
 - a) Schedule interval.
 - b) Event definition.
 - c) Configured as "fill-and-hold" or "circular, first-in first-out."
 - 3) Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.
 - 4) Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."
 - c. Default values for all logs shall be initially set at factory, with logging to begin on device power up.
20. Alarms.
- a. User Options:
 - 1) Define pickup, dropout, and delay.
 - 2) Assign one of four severity levels to make it easier for user to respond to the most important events first.
 - 3) Allow for combining up to four alarms using Boolean-type logic statements for outputting a single alarm.



- b. Alarm Events:
 - 1) Over/undercurrent.
 - 2) Over/undervoltage.
 - 3) Current imbalance.
 - 4) Phase loss, current.
 - 5) Phase loss, voltage.
 - 6) Voltage imbalance.
 - 7) Over kW demand.
 - 8) Phase reversal.
 - 9) Digital input off/on.
 - 10) End of incremental energy interval.
 - 11) End of demand interval.
- 21. Control Power: 90- to 457-V ac or 100- to 300-V dc.
- 22. Communications:
 - a. Power monitor shall be permanently connected to communicate via Modbus TCP via a 100 Base-T Ethernet **OR** RS-485 Modbus TCP/IP, **as directed**.
 - b. Local plug-in connections shall be for RS-232 and 100 Base-T Ethernet.
- 23. Display Monitor:
 - a. Backlighted LCD to display metered data with touch-screen **OR** touch-pad, **as directed**, selecting device.
 - b. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
 - c. Display four values on one screen at same time.
 - 1) Current, per phase rms, three-phase average and neutral, **as directed**.
 - 2) Voltage, phase to phase, phase to neutral, and three-phase averages of phase to phase and phase to neutral.
 - 3) Real power, per phase and three-phase total.
 - 4) Reactive power, per phase and three-phase total.
 - 5) Apparent power, per phase and three-phase total.
 - 6) Power factor, per phase and three-phase total.
 - 7) Frequency.
 - 8) Demand current, per phase and three-phase average.
 - 9) Demand real power, three-phase total.
 - 10) Demand apparent power, three-phase total.
 - 11) Accumulated energy (MWh and MVARh).
 - 12) THD, current and voltage, per phase.
 - d. Reset: Allow reset of the following parameters at the display:
 - 1) Peak demand current.
 - 2) Peak demand power (kW) and peak demand apparent power (kVA).
 - 3) Energy (MWh) and reactive energy (MVARh).
- G. Standalone, Web-Enabled Monitoring And Control Instrument
 - 1. Separately mounted, permanently installed instrument for power monitoring and control.
 - a. Enclosure: NEMA 250, Type 1 **OR** 12, **as directed**.
 - 2. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability.
 - a. Indoor installation in non-air-conditioned **OR** nontemperature-controlled, **as directed**, spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
 - 3. Power-Distribution Equipment Monitor: Web enabled, with integral network port and embedded Web server with factory-configured firmware and HTML-formatted Web pages for viewing of power monitoring and equipment status information from connected devices equipped with digital communication ports.



4. LAN Connectivity: Multipoint, RS-485 Modbus serial communication network, interconnecting all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network connected to Ethernet server that functions as a gateway and server, providing data access via 10 Base-T **OR** 100 Base-T **OR** 100 Base-FX, **as directed**, LAN.
5. Communication Devices within the Equipment: Addressed at factory and tested to verify reliable communication with network server.
6. Server Configuration:
 - a. Initial network parameters set using a standard Web browser. Connect via a local operator interface, or an RJ-45 port accessible from front of equipment.
 - b. Network server shall be factory programmed with embedded HTML-formatted Web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using a standard Web browser.
 - c. Login: Password protected; password administration accessible from the LAN using a standard Web browser.
 - d. Operating Software: Suitable for local access; firewall protected.
7. Data Access:
 - a. Network server shall include embedded HTML pages providing real-time information from devices connected to RS-485 network ports via a standard Web browser.
8. Equipment Monitoring Options: Login shall be followed by a main menu for selecting summary Web pages that follow.
9. Summary Web pages shall be factory configured to display the following information for each communicating device within the power equipment lineup:
 - a. User-Configured Custom Home Page: Provide for the lineup, showing status-at-a-glance of key operating values, **as directed**.
 - b. Circuit Summary Page: Circuit name, three-phase average rms current, power (kW), power factor, and breaker status.
 - c. Load Current Summary Page: Circuit name, Phase A, B, and C rms current values.
 - d. Demand Current Summary Page: Circuit name, Phase A, B, and C average demand current values.
 - e. Power Summary Page: Circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
 - f. Energy Summary Page: Circuit name, energy (kWh), reactive energy (kVARh), and time/date of last reset.
 - g. Transformer Status Page: Transformer tag, coil temperatures, and cooling fan status.
 - h. Motor-Control Center Status Page: Circuit name, three-phase average rms current, thermal capacity (percentage), and drive output frequency (Hz) contactor status.
 - i. Specific Device Pages: Each individual communicating device shall display detailed, real-time information, as appropriate for device type.
 - 1) Display historical energy data that shall be logged automatically for each device, as appropriate for device type.
 - 2) Display historical data logged from each device in graphical time-trend plots. Value to be displayed on time-trend plot shall be user selectable. Time interval to be displayed on scale shall be for previous day or week.
 - j. Export historical energy data to a PC or workstation through network using FTP (File Transfer Protocol). Format exported data in a CSV (Comma Separated Variable) file format for importing into spreadsheet applications.
10. Communications:
 - a. Power monitor: Permanently connected to communicate via RS-485 Modbus TCP/IP **OR** Modbus TCP via an 100 Base-T Ethernet, **as directed**.
 - b. Local Plug-in Connections: RS-232 and 100 Base-T Ethernet.
 - c. Monitor Display: Backlighted LCD to display metered data with touch-screen **OR** touch-pad, **as directed**, selecting device.

H. Workstation Hardware



1. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - a. Indoor installation in spaces that have environmental controls to maintain ambient conditions of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
2. Computer: Standard unmodified PC of modular design. CPU word size shall be 32 bytes or larger; CPU operating speed shall be at least 66 MHz **OR** GHz, **as directed**.
 - a. Memory: 256 MB of usable installed memory, expandable to a minimum of 1024 MB without additional chassis or power supplies.
 - b. Real-Time Clock:
 - 1) Accuracy: Plus or minus 1 minute per month.
 - 2) Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; automatic reset by software.
 - 3) Clock shall function for one year without power.
 - 4) Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
 - c. Serial Ports: Two RS-232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
 - d. Parallel Port: Enhanced.
 - e. LAN Adapter Card: 10/100-Mbps PCI bus, internal network interface card.
 - f. Sound Card: For playback and recording of digital WAV sound files associated with audible warning and alarm functions.
 - g. Color Monitor: PC compatible, not less than 18 inches (455 mm), LCD type, with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm.
 - h. Keyboard: Minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
 - i. Mouse: Standard, compatible with installed software.
 - j. Disk Storage: Include the following, each with appropriate controller:
 - 1) Minimum 80-GB hard disk, maximum average access time of 10 ms.
 - 2) Floppy Disk Drive: High density, 3-1/2-inch (90-mm) size.
 - 3) PCMCIA slot with removable 500-MB media.
 - 4) 100-MB Iomega Zip drive.
 - 5) 250-MB Iomega Jaz drive.
 - k. Magnetic Tape System, **as directed**: 4-mm cartridge magnetic tape system with minimum 2 **OR** 4 **OR** 20, **as directed**, -GB formatted capacity per tape. Provide 10 tapes, each in a rigid cartridge with spring-loaded cover and operator-selectable write-protect feature.
 - l. Modem: 56,600 bps, full duplex for asynchronous communications. With error detection, auto answer/autodial, and call-in-progress detection. Modem shall comply with requirements in ITU-T v.34, ITU-T v.42, ITU-T v.42 Appendix VI for error correction, and ITU-T v.42 BIS for data compression standards; and shall be suitable for operating on unconditioned voice-grade telephone lines complying with 47 CFR 68.
 - m. Audible Alarm: Manufacturer's standard.
 - n. CD-ROM Drive:
 - 1) Nominal Storage Capacity: 650 MB.
 - 2) Data Transfer Rate: 1.2 Mbps.
 - 3) Average Access Time: 150 ms.
 - 4) Cache Memory: 256 KB.
 - 5) Data Throughput: 1 MB/second, minimum.
 - o. Report Printer: Minimum resolution 600 dpi laser printer.
 - 1) Connected to central station and designated workstations.
 - 2) RAM: 2 MB, minimum.
 - 3) Printing Speed: Minimum 12 pages per minute.



- 4) Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.
 - p. Interface: Bidirectional parallel and universal serial bus.
 - q. LAN Adapter Card: 10/100-Mbps internal network interface card.
 3. Redundant Central Computer: Connected in a hot standby, peer configuration; automatically maintains copies of system software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant computer in near real-time. If central computer fails, redundant computer shall assume control immediately and automatically.
 4. UPS: Self-contained; complying with requirements in Division 26 Section "Static Uninterruptible Power Supply".
 - a. Size: Provide a minimum of 6 hours of operation of workstation station equipment, including 2 hours of alarm printer operation, **as directed**.
 - b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
 - c. Accessories:
 - 1) Transient voltage suppression.
 - 2) Input-harmonics reduction.
 - 3) Rectifier/charger.
 - 4) Battery disconnect device.
 - 5) Static bypass transfer switch.
 - 6) Internal maintenance bypass/isolation switch.
 - 7) External maintenance bypass/isolation switch.
 - 8) Output isolation transformer.
 - 9) Remote UPS monitoring.
 - 10) Battery monitoring.
 - 11) Remote battery monitoring.
- I. RS-232 ASCII Interface
1. ASCII interface shall allow RS-232 connections to be made between a meter or circuit monitor operating as the host PC and any equipment that will accept RS-232 ASCII command strings, such as local display panels **OR** dial-up modems **OR** alarm transmitters, **as directed**.
 2. Pager System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
 - a. RS-232 output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to paging system. This interface shall support both numeric and alphanumeric pagers.
 3. Alarm System Interface:
 - a. RS-232 output shall be capable of transmitting alarms from other monitoring and alarm systems to workstation software.
 4. Cables:
 - a. PVC-Jacketed, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 1) NFPA 70, Type CM.
 - 2) Flame Resistance: UL 1581, Vertical Tray.
 - b. Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 1) NFPA 70, Type CMP.
 - 2) Flame Resistance: NFPA 262, Flame Test.
- J. LAN Cables
1. Comply with Division 27 Section "Communications Horizontal Cabling".



2. RS-485 Cable:
 - a. PVC-Jacketed, RS-485 Cable: Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
 - b. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket, and NFPA 70, Type CMP.
3. Unshielded Twisted Pair Cables: Category 5e **OR 6, as directed**, as specified for horizontal cable for data service in Division 27 Section "Communications Horizontal Cabling".

K. Low-Voltage Wiring

1. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
 - a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
 - b. Ordinary Switching Circuits: Three conductors, unless otherwise indicated.
 - c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors, unless otherwise indicated.

1.3 EXECUTION

A. Cabling

1. Comply with NECA 1.
2. Install cables and wiring according to requirements in Division 27 Section "Communications Horizontal Cabling".
3. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
OR
Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
4. Install LAN cables using techniques, practices, and methods that are consistent with specified category rating of components and that ensure specified category performance of completed and linked signal paths, end to end.
5. Install cables without damaging conductors, shield, or jacket.

B. Identification

1. Identify components and power and control wiring according to Division 26 Section "Identification For Electrical Systems".
2. Label each power monitoring and control module with a unique designation.

C. Grounding

1. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."

D. Field Quality Control

1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Electrical Tests: Use caution when testing devices containing solid-state components.
 - b. Continuity tests of circuits.
 - c. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by



manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.

- 1) Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.
 - 2) Test LANs according to requirements in Division 27 Section "Communications Horizontal Cabling".
 - 3) System components with battery backup shall be operated on battery power for a period of not less than 10 percent of calculated battery operating time.
 - 4) Verify accuracy of graphic screens and icons.
 - 5) Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.
 - 6) Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.
3. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.
 4. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
 5. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.
 6. Remove and replace malfunctioning devices and circuits and retest as specified above.

E. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain systems.
 - a. Train the Owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 12 hours' training.
 - b. Training Aid: Use approved final versions of software and maintenance manuals as training aids.

END OF SECTION 26 09 23 00b



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SECTION 26 09 23 00c - MOTOR-CONTROL CENTERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for motor-control centers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes MCCs for use with ac circuits rated 600 V and less and having the following factory-installed components:
 - a. Incoming main lugs and OCPDs.
 - b. Full-voltage magnetic controllers.
 - c. Reduced-voltage magnetic controllers.
 - d. Reduced-voltage, solid-state controllers.
 - e. Multispeed controllers.
 - f. VFCs.
 - g. Feeder-tap units.
 - h. TVSS.
 - i. Instrumentation.
 - j. Auxiliary devices.

C. Definitions

1. BAS: Building automation system.
2. CE: Conformance Europeene (European Compliance).
3. CPT: Control power transformer.
4. EMI: Electromagnetic interference.
5. GFCI: Ground fault circuit interrupting.
6. IGBT: Insulated-gate bipolar transistor.
7. LAN: Local area network.
8. LED: Light-emitting diode.
9. MCC: Motor-control center.
10. MCCB: Molded-case circuit breaker.
11. MCP: Motor-circuit protector.
12. NC: Normally closed.
13. NO: Normally open.
14. OCPD: Overcurrent protective device.
15. PCC: Point of common coupling.
16. PID: Control action, proportional plus integral plus derivative.
17. PT: Potential transformer.
18. PWM: Pulse-width modulated.
19. RFI: Radio-frequency interference.
20. SCR: Silicon-controlled rectifier.
21. TDD: Total demand (harmonic current) distortion.
22. THD(V): Total harmonic voltage demand.
23. TVSS: Transient voltage surge suppressor.
24. VFC: Variable-frequency controller.

D. Performance Requirements

1. Seismic Performance: MCCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.



- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of controller and each type of MCC. Include shipping and operating weights, features, performance, electrical ratings, operating characteristics, and furnished specialties and accessories.
2. LEED Submittals:
 - a. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.
3. Shop Drawings: For each MCC, manufacturer's approval, custom and production drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
 - a. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - 1) Each installed unit's type and details.
 - 2) Factory-installed devices.
 - 3) Enclosure types and details.
 - 4) Nameplate legends.
 - 5) Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
 - 6) Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
 - 7) Specified optional features and accessories.
 - b. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
 - c. Nameplate legends.
 - d. Vertical and horizontal bus capacities.
 - e. Features, characteristics, ratings, and factory settings of each installed unit.
4. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible **OR** designated, **as directed**, operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC **OR** at the defined PCC, **as directed**, to specified levels.
5. Standard Drawings: For each MCC, as defined in UL 845.
6. Production Drawings: For each MCC, as defined in UL 845.
7. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
8. Seismic Qualification Certificates: For MCCs, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
9. Qualification Data: For qualified testing agency.
10. Product Certificates: For each MCC, from manufacturer.
11. Source quality-control reports.
12. Field quality-control reports.
13. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. Include the following:



- a. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications and field-assigned wiring identification incorporated during construction by manufacturer, Contractor, or both.
 - b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
 - c. Manufacturer's written instructions for setting field-adjustable overload relays.
 - d. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.
 - e. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - f. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
14. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
 15. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.
 16. Warranty: Sample of special warranty.
- F. Quality Assurance
1. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
 2. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.
 3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 4. Comply with NFPA 70.
 5. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
- G. Delivery, Storage, And Handling
1. Deliver MCCs in shipping splits of lengths that can be moved past obstructions in delivery paths.
 2. Handle MCCs according to the following:
 - a. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."
 - b. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."
 3. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside MCCs; install temporary electric heating, with at least 250 W per vertical section **OR** connect factory-installed space heaters to temporary electrical service, **as directed**.
- H. Project Conditions
1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Less than 0 deg F (minus 18 deg C) or exceeding 104 deg F (40 deg C), with an average value exceeding 95 deg F (35 deg C) over a 24-hour period.
 - b. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
 - c. Humidity: Less than 95 percent (noncondensing).
 - d. Altitude: Exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.
 2. Interruption of Existing Electrical Service or Distribution Systems: Do not interrupt electrical service to, or distribution systems within, a facility occupied by the Owner or others unless



permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

- a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical service.
 - b. Indicate method of providing temporary electrical service.
 - c. Do not proceed with interruption of electrical service without the Owner's written permission.
 - d. Comply with NFPA 70E.
3. Product Selection for Restricted Space: Drawings indicate maximum dimensions for MCCs, including clearances between MCCs and adjacent surfaces and other items.

I. Coordination

1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
2. Coordinate features of MCCs, installed units, and accessory devices with remote pilot devices and control circuits to which they connect.
3. Coordinate features, accessories, and functions of each MCC, each controller, and each installed unit with ratings and characteristics of supply circuits, motors, required control sequences, and duty cycle of motors and loads.

J. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace TVSS **OR** VFCs, **as directed**, that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period: Five years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units

1. General Requirements for MCCs: Comply with NEMA ICS 18 and UL 845, **as directed**.

B. Functional Features

1. Description: Modular arrangement of main units, controller units, control devices, feeder-tap units, instruments, metering, auxiliary devices, and other items mounted in vertical sections of MCC.
2. Controller Units: Combination controller units.
 - a. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
 - b. Equip units in Type B and Type C MCCs with pull-apart terminal strips for external control connections.
3. Feeder-Tap Units: Through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
4. Future Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.
5. Spare Units: Installed in compartments indicated "spare."

C. Incoming Mains

1. Incoming Mains Location: Top and bottom, **as directed**.
2. Main Lugs Only: Conductor connectors suitable for use with conductor material and sizes.
 - a. Material: Tin-plated aluminum **OR** Hard-drawn copper, 98 percent conductivity, **as directed**.
 - b. Main and Neutral Lugs: Compression **OR** Mechanical, **as directed**, type.



3. MCCB: Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
 - a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long- and short-time time adjustments.
 - 4) Ground-fault pickup level, time delay, and I^2t response.
 - d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 - f. MCCB Features and Accessories:
 - 1) Standard frame sizes, trip ratings, and number of poles.
 - 2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.
 - 3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - 4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - 6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."
 - 7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
 - 8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - 10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
4. Insulated-Case Circuit Breaker: 80 **OR** 100, **as directed**, percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
 - a. Fixed **OR** Drawout, **as directed**, circuit-breaker mounting.
 - b. Two-step, stored-energy closing.
 - c. Standard **OR** Full, **as directed**, -function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time time adjustments.
 - 3) Ground-fault pickup level, time delay, and I^2t response.
 - d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - e. Remote trip indication and control.



- f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."
- g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- h. Control Voltage: 40-V dc **OR** 125-V dc **OR** 250-V dc **OR** 120-V ac, **as directed**.

D. Combination Controllers

1. Full-Voltage Controllers:
 - a. General Requirements for Full-Voltage Enclosed Controllers: Comply with NEMA ICS 2, general purpose, Class A.
 - b. Magnetic Controllers: Full voltage, across the line, electrically held.
 - 1) Configuration: Nonreversing and reversing.
2. Reduced-Voltage Magnetic Controllers:
 - a. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed transition; adjustable time delay on transition.
 - b. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
 - 1) Configuration:
 - a) Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
 - b) Part-Winding Controller: Separate START and RUN contactors, field-selectable for one-half or two-thirds winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
 - c) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
3. Reduced-Voltage, Solid-State Controllers:
 - a. General Requirements for Reduced-Voltage, Solid-State Controllers: Comply with UL 508.
 - b. Reduced-Voltage, Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium-induction motors.
 - 1) Configuration: Standard duty **OR** Severe duty, **as directed**; nonreversible **OR** reversible, **as directed**.
 - 2) Starting Mode: Voltage ramping **OR** Current limit **OR** Torque control **OR** Torque control with voltage boost, **as directed**; field selectable, **as directed**.
 - 3) Stopping Mode: Coast to stop **OR** Adjustable torque deceleration **OR** Adjustable braking, **as directed**; field selectable, **as directed**.
 - 4) Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
 - 5) Shorting and Input Isolation, **as directed**, Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors, **as directed**.
 - 6) Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
 - 7) Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
 - 8) SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with **OR** without, **as directed**, external feedback from the motor or driven equipment.



- 9) Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
 - a) Adjusting motor full-load amperes, as a percentage of the controller's rating.
 - b) Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
 - c) Adjusting linear acceleration and deceleration ramps, in seconds.
 - d) Initial torque, as a percentage of the nominal motor torque.
 - e) Adjusting torque limit, as a percentage of the nominal motor torque.
 - f) Adjusting maximum start time, in seconds.
 - g) Adjusting voltage boost, as a percentage of the nominal supply voltage.
 - h) Selecting stopping mode, and adjusting parameters.
 - i) Selecting motor thermal-overload protection class between 5 and 30.
 - j) Activating and de-activating protection modes.
 - k) Selecting or activating communications modes.
 - 10) Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
 - a) Controller Condition: Ready, starting, running, stopping.
 - b) Motor Condition: Amperes, voltage, power factor, power, and thermal state.
 - c) Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.
 - 11) Controller Diagnostics and Protection:
 - a) Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.
 - b) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
 - c) Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.
OR
Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.
 - 12) Remote Output Features:
 - a) All outputs prewired to terminal blocks.
 - b) Form C status contacts that change state when controller is running.
 - c) Form C alarm contacts that change state when a fault condition occurs.
 - 13) Optional Features:
 - a) Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc **OR** 4 to 20-mA dc, **as directed**.
 - b) Additional field-assignable Form C contacts for alarm outputs.
 - c) Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - d) Full-voltage bypass contactor operating automatically **OR** manually, with NORMAL/BYPASS selector switch, **as directed**. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.
4. Multispeed Magnetic Controllers:
- a. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
 - b. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held. Compelling relay to ensure that motor will start only at low speed.
 - 1) Configuration: Nonreversing **OR** Reversing, **as directed**; consequent pole **OR** two winding, **as directed**.



- 2) Compelling relays shall ensure that motor starts only at low speed.
 - 3) Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
 - 4) Decelerating timer relays shall ensure automatically timed deceleration through each speed.
 - 5) Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.
5. Disconnecting Means and OCPDs:
- a. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class L, **as directed**, fuses.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
 - b. MCP Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - 4) NC **OR** NO, **as directed**, alarm contact that operates only when MCP has tripped.
 - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
 - c. MCCB Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - 5) NC **OR** NO, **as directed**, alarm contact that operates only when MCCB has tripped.
 - d. Molded-Case Switch Disconnecting Means:
 - 1) UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
 - 4) NC **OR** NO, **as directed**, alarm contact that operates only when molded-case switch has tripped.
6. Overload Relays:
- a. Melting-Alloy Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - b. Bimetallic Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 4) Ambient compensated.



- 5) Automatic resetting.
 - c. Solid-State Overload Relays:
 - 1) Switch or dial selectable for motor running overload protection.
 - 2) Sensors in each phase.
 - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - a) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - b) Analog communication module.
 - d. NC **OR** NO, **as directed**, isolated overload alarm contact.
 - e. External overload reset push button.
 - 7. Control Power:
 - a. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
- E. VFCS
- 1. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C, **as directed**.
 - 2. Application: Constant torque and variable torque, **as directed**.
 - 3. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
 - a. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
 - b. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 - c. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
 - d. Listed and labeled for single-phase use by an NRTL acceptable to authorities having jurisdiction.
 - 4. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
 - 5. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range **OR** 66 Hz, with torque constant as speed changes, **as directed**; maximum voltage equals input voltage.
 - 6. Unit Operating Requirements:
 - a. Input AC Voltage Tolerance: Plus 10 and minus 10 **OR** 15, **as directed**, percent of VFC input voltage rating.
 - b. Input AC Voltage Unbalance: Not exceeding 3 **OR** 5, **as directed**, percent.
 - c. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
 - d. Minimum Efficiency: 96 **OR** 97, **as directed**, percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: 96 **OR** 98, **as directed**, percent under any load or speed condition.
 - f. Overload Capability: 1.1 **OR** 1.5, **as directed**, times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 - g. Starting Torque: Minimum of 100 percent of rated torque from 3 to 60 Hz.
 - h. Speed Regulation: Plus or minus 5 **OR** 10, **as directed**, percent.
 - i. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.



- j. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- 7. Inverter Logic: Microprocessor based, 16 **OR** 32, **as directed**, bit, isolated from all power circuits.
- 8. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
 - a. Signal: Electrical.
OR
Signal: Pneumatic.
- 9. Internal Adjustability Capabilities:
 - a. Minimum Speed: 5 to 25 percent of maximum rpm.
 - b. Maximum Speed: 80 to 100 percent of maximum rpm.
 - c. Acceleration: 0.1 to 999.9 seconds.
 - d. Deceleration: 0.1 to 999.9 seconds.
 - e. Current Limit: 30 to a minimum of 150 percent of maximum rating.
- 10. Self-Protection and Reliability Features:
 - a. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - b. Loss of Input Signal Protection: Selectable response strategy including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 - c. Under- and overvoltage trips.
 - d. Inverter overcurrent trips.
 - e. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
 - f. Critical frequency rejection, with three selectable, adjustable deadbands.
 - g. Instantaneous line-to-line and line-to-ground overcurrent trips.
 - h. Loss-of-phase protection.
 - i. Reverse-phase protection.
 - j. Short-circuit protection.
 - k. Motor overtemperature fault.
- 11. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- 12. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- 13. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- 14. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- 15. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- 16. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker **OR** NEMA AB 1, molded-case switch, with power fuse block and current-limiting fuses **OR** NEMA AB 1, thermal-magnetic circuit breaker **OR** NEMA KS 1, nonfusible switch, with power fuse block and current-limiting fuses **OR** NEMA KS 1, fusible switch, **as directed**, with pad-lockable, door-mounted handle mechanism.
 - a. Disconnect Rating (for VFCs without bypass systems): Not less than 115 percent of VFC input current rating.
 - b. Disconnect Rating (for VFCs with bypass systems): Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
 - c. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.



- d. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
- e. NC **OR** NO, **as directed**, alarm contact that operates only when circuit breaker has tripped.

F. VFC Controls And Indication

1. Status Lights: Door-mounted LED indicators displaying the following conditions:
 - a. Power on.
 - b. Run.
 - c. Overvoltage.
 - d. Line fault.
 - e. Overcurrent.
 - f. External fault.
2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
 - a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 - b. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - 1) Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
3. Historical Logging Information and Displays:
 - a. Running log of total power versus time.
 - b. Total run time.
 - c. Fault log, maintaining last four faults with time and date stamp for each.
4. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters, including, but not limited to:
 - a. Output frequency (Hz).
 - b. Motor speed (rpm).
 - c. Motor status (running, stop, fault).
 - d. Motor current (amperes).
 - e. Motor torque (percent).
 - f. Fault or alarming status (code).
 - g. PID feedback signal (percent).
 - h. DC-link voltage (V dc).
 - i. Set point frequency (Hz).
 - j. Motor output voltage (V ac).
5. Control Signal Interfaces:
 - a. Electric Input Signal Interface:
 - 1) A minimum of two programmable analog inputs: 0- to 10-V dc **OR** 4- to 20-mA dc **OR** Operator-selectable "x"- to "y"-mA dc, **as directed**.
 - 2) A minimum of six multifunction programmable digital inputs.
 - b. Pneumatic Input Signal Interface: 3 to 15 psig (20 to 104 kPa).
 - c. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
 - 1) 0- to 10-V dc.
 - 2) 4- to 20-mA dc.
 - 3) Potentiometer using up/down digital inputs.
 - 4) Fixed frequencies using digital inputs.
 - d. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc **OR** 4- to 20-mA dc **OR** operator-selectable "x"- to "y"-mA dc, **as directed**), which can be configured for any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).



- 3) DC-link voltage (V dc).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set point frequency (Hz).
 - e. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - 1) Motor running.
 - 2) Set point speed reached.
 - 3) Fault and warning indication (overtemperature or overcurrent).
 - 4) PID high- or low-speed limits reached.
 6. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
 - a. Number of Loops: One **OR** Two, **as directed**.
 7. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage, **as directed**. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.
 - a. Network Communications Ports: Ethernet and RS-422/485.
 - b. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet **OR** Echelon LonWorks **OR** Ethernet TCP/IP **OR** Johnson Metasys N2 **OR** Modbus/Memobus **OR** Siemens System 600 APOGEE, **as directed**; protocols accessible via the communications ports.
- G. VFC Line Conditioning And Filtering
1. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD at input terminals of VFCs to less than 5 **OR** 8, **as directed**, percent and THD(V) to 3 **OR** 5, **as directed**, percent.
 2. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD and THD(V) at the defined PCC per IEEE 519.
 3. Input Line Conditioning: **<Insert requirements>**.
 4. VFC Output Filtering: **<Insert requirements>**.
 5. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.
- H. VFC Bypass Systems
1. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes, and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
 2. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.
OR
Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.
 3. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode, **as directed**.
 - a. Bypass Contactor: Load-break, IEC **OR** NEMA, **as directed**, -rated contactor.
 - b. Output Isolating Contactor: Non-load-break, IEC **OR** NEMA, **as directed**, -rated contactor.
 - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

**OR**

Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier, **as directed**, arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

- a. Bypass Contactor: Load-break, IEC **OR** NEMA, **as directed**, -rated contactor.
 - b. Input and Output Isolating Contactors: Non-load-break, IEC **OR** NEMA, **as directed**, -rated contactors.
 - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
4. Bypass Contactor Configuration: Full-voltage (across-the-line) **OR** Reduced-voltage (autotransformer), **as directed**, type.
- a. NORMAL/BYPASS selector switch.
 - b. HAND/OFF/AUTO selector switch.
 - c. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
 - d. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
 - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - 2) Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - e. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
 - f. CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
5. Overload Relays: NEMA ICS 2.
- a. Melting-Alloy Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - b. Bimetallic Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 4) Ambient compensated.
 - 5) Automatic resetting.
 - c. Solid-State Overload Relays:
 - 1) Switch or dial selectable for motor-running overload protection.
 - 2) Sensors in each phase.
 - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 5) Analog communication module.
 - 6) NC **OR** NO, **as directed**, isolated overload alarm contact.
 - 7) External overload reset push button.
- I. Optional VFC Features
1. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications, when overload protection activates.



- a. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
 - b. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
 - c. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.
2. Damper control circuit with end of travel feedback capability.
 3. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
 4. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
 5. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station **OR** smoke-control fan controller, **as directed**, this password-protected input:
 - a. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
 - b. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
OR
Forces VFC to transfer to Bypass Mode and operate motor at full speed.
 - c. Causes display of Override Mode on the VFC display.
 - d. Reset VFC to normal operation on removal of override signal automatically **OR** manually, **as directed**.
 6. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
 7. Remote digital operator kit.
 8. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.
- J. Feeder-Tap Units
1. MCCB: Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
 - a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long- and short-time time adjustments.
 - 4) Ground-fault pickup level, time delay, and I^2t response.
 - d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 - f. MCCB Features and Accessories:
 - 1) Standard frame sizes, trip ratings, and number of poles.
 - 2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.
 - 3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.



- 4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - 6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring And Control".
 - 7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
 - 8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - 10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
2. Fusible Switch: NEMA KS 1, Type HD, clips to accommodate specified fuses with lockable handle.
 3. Fuses are specified in Division 26 Section "Fuses".

K. Transient Voltage Suppression Devices

1. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, wired-in **OR** plug-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the MCC short-circuit rating, and with the following features and accessories:
 - a. Fuses, rated at 200-kA interrupting capacity.
 - b. Fabrication using bolted compression lugs for internal wiring.
 - c. Integral disconnect switch.
 - d. Redundant suppression circuits.
 - e. Redundant replaceable modules.
 - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - g. LED indicator lights for power and protection status.
 - h. Audible alarm, with silencing switch, to indicate when protection has failed.
 - i. Form-C contacts rated at 5 A and 250-V ac, one NO and one NC, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - j. Four **OR** Six, **as directed**, -digit, transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**, -V, three-phase, four-wire circuits shall be as follows:
 - a. Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - b. Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - c. Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.

OR

Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:



- a. Line to Neutral: 400 V, 800 V from high leg.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

- a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

L. Instrumentation

1. Instrument Transformers (for the Owner metering): IEEE C57.13, NEMA EI 21.1, and the following:
 - a. PTs: IEEE C57.13; 120 V, 60 Hz, single **OR** tapped **OR** double, **as directed**, secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 - b. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound **OR** bushing **OR** bar or window, **as directed**, type; single **OR** double, **as directed**, secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 - c. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.
 - d. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
2. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - a. Listed or recognized by a nationally recognized testing laboratory.
 - b. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
 - c. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:
 - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
 - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - 4) Three-Phase Real Power (Megawatts): Plus or minus 2 percent.
 - 5) Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.
 - 6) Power Factor: Plus or minus 2 percent.
 - 7) Frequency: Plus or minus 0.5 percent.
 - 8) Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - 9) Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
 - 10) Contact devices to operate remote impulse-totalizing demand meter.
 - d. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
 - a. Meters: 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semiflush, with antiparallax 250-degree scale and external zero adjustment.
 - b. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
4. Instrument Switches: Rotary type with off position.
 - a. Voltmeter Switches: Permit reading of all phase-to-phase voltages and phase-to-neutral voltages where a neutral is included.
 - b. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.



5. Feeder Ammeters: 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for feeder circuits, unless otherwise indicated.
 6. Watt-Hour Meters and Wattmeters:
 - a. Comply with ANSI C12.1.
 - b. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
 - c. Suitable for connection to three- and four-wire circuits.
 - d. Potential indicating lamps.
 - e. Adjustments for light and full load, phase balance, and power factor.
 - f. Four-dial clock register.
 - g. Integral demand indicator.

OR

Contact devices to operate remote impulse-totalizing demand meter.

 - h. Ratchets to prevent reverse rotation.
 - i. Removable meter with drawout test plug.
 - j. Semiflush mounted case with matching cover.
 - k. Appropriate multiplier tag.
 7. Impulse-Totalizing Demand Meter:
 - a. Comply with ANSI C12.1.
 - b. Suitable for use with MCC watt-hour meter, including two-circuit totalizing relay.
 - c. Cyclometer.
 - d. Four-dial, totalizing kilowatt-hour register.
 - e. Positive chart drive mechanism.
 - f. Capillary pen holding a minimum of one month's ink supply.
 - g. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
 - h. Capable of indicating and recording five **OR 15 OR 30, as directed**,-minute integrated demand of totalized system.
- M. MCC Control Power
1. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from CPT.
OR
Control Circuits: 120-V ac, supplied from remote branch circuit.
 2. Electrically Interlocked Main and Tie Circuit Breakers: Two CPTs in separate compartments, with interlocking relays, connected to the primary side of each CPT at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
 3. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
 4. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
- N. Enclosures
1. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 1 **OR** Type 1A **OR** Type 2 **OR** Type 12, **as directed**, unless otherwise indicated to comply with environmental conditions at installed location.
 2. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
 - a. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point **OR** Manual switching of branch-circuit protective device, **as directed**.
 - b. Space-Heater Power Source: Transformer, factory installed in MCC **OR** 120-V external branch circuit, **as directed**.
 3. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray **OR** custom color, **as directed**, finish over a rust-inhibiting primer on treated metal surface.



4. Outdoor Enclosures: Type 3R, non-walk-in aisle **OR** Type 3R, with interior-lighted walk-in aisle, **as directed**.
 - a. Finish: Factory-applied finish in manufacturer's standard **OR** custom, **as directed**, color; undersurfaces treated with corrosion-resistant undercoating.
 - b. Enclosure: Flat **OR** Downward, rearward sloping, **as directed**, roof; bolt-on rear covers **OR** rear hinged doors, **as directed**, for each section, with provisions for padlocking.
 - c. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking **OR** cylinder lock, **as directed**.
 - d. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; GFCI duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
 - e. Walk-in Aisle Heating and Ventilating:
 - 1) Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F (5 deg C) with outside design temperature of 104 deg F (40 deg C).
 - 2) Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 100 deg F (38 deg C) with outside design temperature of 23 deg F (minus 5 deg C).
 - 3) Ventilating openings complete with replaceable fiberglass air filters, **as directed**.
 - 4) Thermostat: Single stage; wired to control heat and exhaust fan.
 - f. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a CPT within the switchboard. Supply voltage shall be 120 **OR** 120/240 **OR** 120/208, **as directed**, -V ac.
OR
Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.
 5. Compartments: Modular; individual lift-off, **as directed**, doors with concealed hinges and quick-captive screw fasteners. Interlocks on units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
 6. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
 7. Wiring Spaces:
 - a. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
 - b. Horizontal wireways in bottom **OR** top **OR** bottom and top, **as directed**, of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.
- O. Auxiliary Devices
1. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
 - a. Push Buttons, Pilot Lights, and Selector Switches: Heavy **OR** Standard, **as directed**, -duty, oiltight, **as directed**, type.
 - 1) Push Buttons: Covered **OR** Lockable **OR** Recessed **OR** Shielded **OR** Shrouded **OR** Unguarded, **as directed**, types; maintained **OR** momentary, **as directed**, contact unless otherwise indicated.
 - 2) Pilot Lights: Incandescent **OR** LED **OR** Neon **OR** Resistor **OR** Transformer, **as directed**, types; <Insert color(s)>; push to test, **as directed**.
 - 3) Selector Switches: Rotary type.
 - b. Elapsed-Time Meters: Heavy duty with digital readout in hours; nonresettable **OR** resettable, **as directed**.
 - c. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy with selector switches having an off position.
 2. NC **OR** NO **OR** Reversible NC/NO, **as directed**, contactor auxiliary contact(s).



3. Control Relays: Auxiliary and adjustable pneumatic **OR** solid-state, **as directed**, time-delay relays.
4. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
5. Space heaters, with NC auxiliary contacts, to mitigate condensation in enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
6. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
7. Cover gaskets for Type 1 enclosures.
8. Terminals for connecting power factor correction capacitors to the line **OR** load, **as directed**, side of overload relays.
9. Spare control-wiring terminal blocks; unwired **OR** wired, **as directed**.
10. Spare-Fuse Cabinet: Identified and compartmented steel box **OR** cabinet with hinged lockable door, **as directed**.

P. Characteristics And Ratings

1. Wiring: NEMA ICS 18, Class I **OR** Class I-S, **as directed**, Type A **OR** Type B, for starters above Size 3 **OR** Type B-D, for starter Size 3 and below **OR** Type B-T, for starter Size 3 and below **OR** Type C, **as directed**.
OR
Wiring: NEMA ICS 18, Class II **OR** Class II-S, **as directed**, Type B, for starters above Size 3 **OR** Type B-D, for starter Size 3 and below **OR** Type B-T, for starter Size 3 and below **OR** Type C, **as directed**.
2. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
3. Nominal System Voltage: 480 V, three phase, three wire **OR** 480Y/277 V, three phase, four wire, **as directed**.
OR
Nominal System Voltage: 208 V, three phase, three wire **OR** 208/120 V, three phase, four wire, **as directed**.
4. Short-Circuit Current Rating for Each Unit: Combination series rated **OR** Fully rated, **as directed**; 22 **OR** 42 **OR** 65 **OR** 100, **as directed**, kA.
5. Short-Circuit Current Rating of MCC: Combination series rated **OR** Fully rated, **as directed**, with its main overcurrent device; 22 **OR** 42 **OR** 65 **OR** 100, **as directed**, kA.
6. Environmental Ratings:
 - a. Ambient Temperature Rating: Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C), with an average value not exceeding 95 deg F (35 deg C) over a 24-hour period.
 - b. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
 - c. Humidity Rating: Less than 95 percent (noncondensing).
 - d. Altitude Rating: Not exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.
7. Main-Bus Continuous Rating: 600 **OR** 800 **OR** 1000 **OR** 1200 **OR** 1600 **OR** 2000, **as directed**, A.
8. Vertical-Bus Minimum, **as directed**, Continuous Rating: 300 **OR** 600 **OR** 1200, **as directed**, A.
9. Horizontal and Vertical Bus Bracing (Short-Circuit Current Rating): Match MCC short-circuit current rating.
10. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections. Provide for future extensions from both ends, **as directed**. Brace bus extensions for busway feeder bus, **as directed**.
11. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.



12. Phase- and Neutral-, **as directed**, Bus Material: Hard-drawn copper of 98 percent conductivity, silver **OR** tin, **as directed**, plated.
OR
Phase- and Neutral-, **as directed**, Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy.
 13. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus, **as directed**.
OR
Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus, **as directed**.
 14. Ground Bus: Minimum size required by UL 845, hard-drawn copper of 98 percent conductivity, equipped with mechanical **OR** compression, **as directed**, connectors for feeder and branch-circuit equipment grounding conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run, **as directed**.
 15. Front-Connected, Front-Accessible MCCs:
 - a. Main Devices: Drawout **OR** Fixed, **as directed**, mounted.
 - b. Controller Units: Drawout and fixed, **as directed**, mounted.
 - c. Feeder-Tap Units: Drawout and fixed, **as directed**, mounted.
 - d. Sections front and rear aligned.
 16. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic MCC. Provide service entrance label and necessary applicable service entrance features.
 17. the Owner Metering Compartment: A separate customer metering compartment and section with front hinged door, metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks, **as directed**.
 18. Bus Transition and Incoming Pull Sections: Matched and aligned with basic MCC.
 19. Pull Box on Top of an MCC:
 - a. Adequate ventilation to maintain temperature in pull box within same limits as MCC.
 - b. Set back from front to clear circuit-breaker removal mechanism.
 - c. Removable covers forming top, front, and sides. Top covers at rear easily removable for drilling and cutting.
 - d. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
 - e. Cable supports arranged to facilitate cabling and adequate to support cables, including those for future installation.
 - f. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
 20. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of unit.
 21. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
 22. Fungus Proofing: Permanent fungicidal treatment for OCPDs and other components including instruments and instrument transformers.
- Q. Source Quality Control
1. MCC Testing: Inspect and test MCCs according to requirements in NEMA ICS 18.
 2. VFC Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
 - a. Test each VFC while connected to its specified motor **OR** a motor that is comparable to that for which the VFC is rated, **as directed**.



- b. Verification of Performance: Rate VFCs according to operation of functions and features specified.
3. MCCs will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

1.3 EXECUTION

A. Examination

1. Examine areas and surfaces to receive MCCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.
2. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Harmonic Analysis Study

1. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible **OR** designated, **as directed**, operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at the defined PCC to specified levels.
2. Prepare a harmonic analysis study report complying with IEEE 399 and NETA Acceptance Testing Specification.

C. Installation

1. Coordinate layout and installation of MCCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Floor-Mounting Controllers: Install MCCs on 4-inch (100-mm) nominal thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in each fusible switch.
6. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses".
7. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
8. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
9. Install power factor correction capacitors. Connect to the line **OR** load, **as directed**, side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
10. Comply with NECA 1.

D. Identification

1. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for identification of MCC, MCC components, and control wiring.



- a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - b. Label MCC and each cubicle with engraved nameplate.
 - c. Label each enclosure-mounted control and pilot device.
 - d. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.
2. Operating Instructions: Frame printed operating instructions for MCCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of MCCs.
- E. Control Wiring Installation
1. Install wiring between enclosed controllers **OR** master terminal boards, **as directed**, and remote devices and facility's BAS **OR** and facility's central-control system, **as directed**. Comply with requirements in Division 26 Section "Control-voltage Electrical Power Cables".
 2. Bundle, train, and support wiring in enclosures.
 3. Connect selector switches and other automatic-control selection devices where applicable.
 - a. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
 - b. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.
- F. Connections
1. Comply with requirements for installation of conduit in Division 26 Section "Raceway And Boxes For Electrical Systems". Drawings indicate general arrangement of conduit, fittings, and specialties.
 2. Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".
- G. Field Quality Control
1. Perform tests and inspections.
 2. Acceptance Testing Preparation:
 - a. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
 - b. Test continuity of each circuit.
 3. Tests and Inspections:
 - a. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - b. Test insulation resistance for each enclosed controller element, component, connecting motor supply, feeder, and control circuits.
 - c. Test continuity of each circuit.
 - d. Verify that voltages at controller locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify the Owner before starting the motor(s).
 - e. Test each motor for proper phase rotation.
 - f. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - g. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - h. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
 - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
 - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multipole enclosed controller 11 months after date of Final Completion.



- 3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - i. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 - j. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.
 4. Enclosed controllers will be considered defective if they do not pass tests and inspections.
 5. Prepare test and inspection reports, including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- H. Startup Service
1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
- I. Adjusting
1. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
 2. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
 3. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify the Owner before increasing settings.
 4. Set the taps on reduced-voltage autotransformer controllers at 50 **OR** 65 **OR** 80, **as directed**, percent.
 5. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.
 6. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Final Completion.
 7. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".
- J. Protection
1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
 2. Replace controllers whose interiors have been exposed to water or other liquids prior to Final Completion.
- K. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage, solid-state controllers, **as directed**.

END OF SECTION 26 09 23 00c



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SECTION 26 09 23 00d - CENTRAL DIMMING CONTROLS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for central dimming controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes microprocessor-based central dimming controls with the following components:
 - a. Control network.
 - b. Master-control stations.
 - c. Partitioned-space master-control stations.
 - d. Wall stations.
 - e. Dimmer cabinets.
 - f. Manual switches and plates for controlling dimmers.

C. Definitions

1. Fade Override: The ability to temporarily set fade times to zero for all lighting scenes.
2. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
3. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.
4. Low Voltage: As defined in NFPA 70, term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.
5. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
6. SCR: Silicon-controlled rectifier.
7. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

D. Submittals

1. Product Data: For each type of product indicated.
 - a. For central dimming controls; include elevation, features, characteristics, and labels.
 - b. For dimmer panels; include dimensions, features, dimmer characteristics, ratings, and directories.
 - c. Device plates, plate color, and material.
 - d. Ballasts and lamp combinations compatible with dimmer controls.
 - e. Sound data including results of operational tests of central dimming controls.
 - f. Operational documentation for software and firmware.
2. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
 - a. Include elevation views of front panels of control and indicating devices and control stations.
 - b. Wiring Diagrams: Power, signal, and control wiring.
3. Samples: For master-control stations, partitioned-space master-control stations, wall stations, dimmer cabinets, and faceplates with factory-applied color finishes and technical features.
 - a. Operation and Maintenance Data: For central dimming controls with remote-mounting dimmers to include in emergency, operation, and maintenance manuals.
4. Warranty: Special warranty specified in this Section.



- E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 2. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.
 3. Comply with NFPA 70.
- F. Warranty
1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of central dimming controls that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Damage from transient voltage surges.
 - b. Warranty Period: Cost to repair or replace any parts for two years from date of Final Completion.
 - c. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.
- G. Software Service Agreement
1. Services in this Article may not be allowed for publicly funded projects.
 2. Technical Support: Beginning with Final Completion, provide software support for two years.
 3. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

- A. General System Requirements
1. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.
 2. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state dimmers and control panels.
 - a. Alternative Line-Voltage Surge Suppression: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" for Category A **OR** B, **as directed**, locations.
 3. Dimmers and Dimmer Modules: Comply with UL 508.
 - a. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
 - b. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.
- B. System Description
1. Description: Microprocessor-based, solid-state controls consisting of control stations and a separately mounted dimmer cabinet.
 - a. Operation: Change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a rocker switch **OR** pushbutton **OR** slider, **as directed**, is operated.
 - b. System control shall include master station(s), wall stations, and dimmer panels.
 - c. Each zone shall be configurable to control the following light sources:



- 1) Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
 - 2) Line-voltage incandescent lamps.
 - 3) Low-voltage incandescent lamps.
 - 4) Cold cathode lamps.
 - 5) Non-dimmed loads.
 - 6) LED lamps.
- d. Control of each zone shall interface with controls for the following accessory functions:
- 1) Curtains and drapes.
 - 2) Blackout curtains.
 - 3) Projector screens.
 - 4) Motorized partitions.
 - 5) Manually positioned partitions.
- e. Memory: Retain preset scenes and fade settings through power failures for at least 90 days by retaining physical settings of controls or by an on-board, automatically recharged battery.
- C. Control Network
1. Dimmers shall receive signals from control stations that are linked to dimmer cabinet with a common network data cable.
 2. Functions of network control stations shall be set up at master station that include the number and arrangement of scene presets, zones, and fade times at wall stations.
 - a. Control Voltage: 24- or 10-V dc.
 - b. Comply with USITT AMX 192 **OR** USITT DMX 512, **as directed**, for data transmission.
- D. Master-Control Stations
1. Functions and Features:
 - a. Control adjustment of the lighting level for each scene of each zone, and adjustment of fade-time setting for each scene change from one preset scene to another. Controls shall use analog manual sliders **OR** digital rocker switches with LCD graphic display of light level, **as directed**.
 - b. Master channel shall raise and lower lighting level of all zones.
 - c. Fade rate for each scene shall be adjustable from zero to 60 seconds.
 - d. Fade override control for each scene.
 - e. Recall each preset scene and allow adjustment of zone controls associated with that scene.
 - f. Lockout switch to prevent changes when set.
 - g. On and off scene controls for non-dim channel contactors.
 - h. Emergency-control pushbutton to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
 - i. Master on and off switch; off position enables housekeeping controls.
 - j. Housekeeping controls to turn on selected lighting fixtures for housekeeping functions.
 - k. Pushbuttons for accessory functions.
 - l. Enable and disable wall stations.
 - m. Communications link to other master stations.
 - n. Provide for connecting a portable computer to program the master station.
 - o. Rear-illuminate all scene-select buttons.
 - p. Show lighting-level setting and fade-rate setting graphically using LEDs or backlighted bar-graph indicator.
 2. Mounting: Single, flush wall box with manufacturer's standard faceplate with hinged transparent locking cover, **as directed**.
- E. Partitioned-Space Master-Control Station
1. Functions and Features:
 - a. Automatically combine and separate lighting and accessory function controls as spaces are configured with movable partitions; with controls for adjustment of the lighting level for



- each scene of each dimmer, and adjustment of fade-rate setting for each scene change from one preset scene to another.
- b. Master controls shall accommodate partitioning the space into six adjacent rooms.
 - c. Manual controls to set up six scenes for each room. Include wall stations in each room to control scenes.
 - d. Master channel to raise and lower the lighting level of all zones.
 - e. Adjustable fade rate for each scene from zero to 60 seconds.
 - f. Fade override control for each scene.
 - g. On and off scene controls for non-dim channel contactors.
 - h. Emergency-control pushbutton to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
 - i. Master on and off switch; off position enables housekeeping controls.
 - j. Housekeeping controls to turn on selected lighting fixtures for housekeeping functions.
 - k. Pushbuttons for accessory functions.
 - l. Provide for connecting a portable computer to program the master station.
 - m. Rear-illuminate all scene-select buttons.
 - n. Show lighting-level setting and fade-rate setting graphically using LEDs or backlighted bar-graph indicator.
2. Custom Graphics. Include a graphical display of room configurations and the names for each. Indicate the current spaces configuration with LCD graphic or LED-illuminated indicators, and show which wall stations are active. Inactive wall stations shall be automatically deactivated.
 3. Mounting: Single, flush wall box with manufacturer's standard faceplate with hinged transparent locking cover, **as directed**.

F. Wall Stations

1. Functions and Features:
 - a. Wall stations shall function as a submaster to a master station, containing limited control of selected scenes of the master station.
 - b. Controls to adjust the lighting level of each dimmer for each scene, and the fade time setting for each scene change from one preset scene to another.
 - c. Numbered pushbuttons to select scenes.
 - d. Off switch to turn master station off. Operating the off switch at any remote station shall automatically turn on selected housekeeping lighting, **as directed**.
 - e. On switch turns all scenes of master station to full bright.
 - f. Pushbutton controls for accessory functions.
2. Mounting: Flush, wall box with manufacturer's standard faceplate.
3. Hand-held Cordless Control: Scene-select and accessory function pushbuttons using infrared **OR** radio-frequency, **as directed**, transmission.

G. Dimmer Cabinets

1. Factory wired, convection cooled without fans, with barriers to accommodate 120- and 277-V feeders and suitable to control designated lighting equipment or accessory functions.
2. Ambient Conditions:
 - a. Temperature: 60 to 95 deg F (15 to 35 deg C).
 - b. Relative Humidity: 10 to 90 percent, noncondensing.
 - c. Filtered air supply.
3. Dimmer Cabinet Assembly: NRTL listed and labeled.
4. Cabinet Type: Plug in, modular, and accepting dimmers of each specified type in any plug-in position.
 - a. Integrated Fault-Current Rating: 10,000-A RMS symmetrical.
5. Lighting Dimmers: Solid-state SCR dimmers.
 - a. Primary Protection: Magnetic or thermal-magnetic circuit breaker, also serving as the disconnecting means.
 - b. Dimmer response to control signal shall follow the "Square Law Dimming Curve" specified in IESNA's "IESNA Lighting Handbook."



- c. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
 - d. Dimmed circuits shall be filtered to provide a minimum 350-mic.sec. current-rise time at a 90-degree conduction angle and 50 percent of rated dimmer capacity. Rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load-current waveform.
 - e. Protect controls of each dimmer with a fuse and transient voltage surge suppression, **as directed**.
6. Non-dim modules shall include relays with contacts rated to switch 20-A tungsten-filament load at 120-V ac and 20-A electronic ballast load at 277-V ac.
 7. Accessory function control modules shall be compatible with requirement of the accessory being controlled.
 8. Digital Control Network:
 - a. Dimmers shall receive digital signals from digital network control stations that are linked to the dimmer cabinet with a common network data cable.
 - b. Functions of digital network control stations shall be set up at the dimmer cabinet's electronic controls that include indicated number and arrangement of scene presets, channels, and fade times.
 9. Emergency Power Transfer Switch: Comply with UL 1008; factory prewired and pretested to automatically transfer load circuits from normal to emergency power supply when normal supply fails.
 - a. Transfer from normal to emergency supply when normal-supply voltage drops to 55 percent or less.
 - b. Retransfer immediately to normal on failure of emergency supply and after an adjustable time-delay of 10 to 90 seconds on restoration of normal supply while emergency supply is available.
 - c. Integrated Fault-Current Rating: Same value as listed for the panel.
 - d. Test Switch: Simulate failure of normal supply to test controls associated with transfer scheme.
 - e. Fabricate and test dimmer boards to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
- H. Portable Computer
1. Description: As recommended by master-control station manufacturer, to program master station and associated wall stations, and all interconnected master stations, **as directed**. Portable computer shall be laptop style with a battery runtime of at least two hours. Display shall be an 11-inch (280-mm) interactive-matrix LCD and shall have required hardware, firmware, and software to program specified control functions of master-control stations.
 2. Software shall be configured and customized by master-station manufacturer.
- I. Manual Switches And Plates
1. Switches: Modular, momentary pushbutton, low-voltage type.
 - a. Color: White unless otherwise indicated.
 - b. Integral Pilot Light: Indicate when circuit is on. Use where indicated.
 - c. Locator Light: Internal illumination.
 - d. Wall Plates: Comply with requirements in Division 26 Section "Wiring Devices" for materials, finish, and color. Use multigang plates if more than one switch is indicated at a location.
 - e. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.
- J. Conductors And Cables
1. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".



2. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
3. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 **OR** 16 **OR** 18, **as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
4. Unshielded, Twisted-Pair Data Cable: Category 5e **OR** 6, **as directed**. Comply with requirements in Division 27 Section "Communications Horizontal Cabling".

1.3 EXECUTION

A. Wiring Installation

1. Comply with NECA 1.
2. Wiring Method:
 - a. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables"
 - b. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Division 27 Section "Communications Horizontal Cabling".
 - c. Minimum conduit size shall be 1/2 inch (13 mm).
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
4. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
5. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
6. Install dimmer cabinets for each zone.

B. Identification

1. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for identifying components and power and control wiring.
2. Label each dimmer module with a unique designation.
3. Label each scene control button with approved scene description.

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Continuity tests of circuits.
 - b. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
 - 1) Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
 - c. Emergency Power Transfer: Test listed functions.
3. Remove and replace malfunctioning dimming control components and retest as specified above.
4. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
5. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

D. Demonstration



1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, the Owner's maintenance personnel to adjust, operate, and maintain central dimming controls. Laptop portable computer shall be used in training, **as directed**.
2. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls".

END OF SECTION 26 09 23 00d



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SECTION 26 09 23 00e - MODULAR DIMMING CONTROLS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for modular dimming controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Manual modular dimming controls.
 - b. Integrated, multipreset modular dimming controls.

C. Definitions

1. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
3. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
4. SCR: Silicon-controlled rectifier.
5. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

D. Submittals

1. Product Data: For each type of product indicated.
 - a. For modular dimming controls; include elevation, dimensions, features, characteristics, ratings, and labels.
 - b. Device plates and plate color and material.
 - c. Ballasts and lamp combinations compatible with dimmers.
 - d. Wiring Diagrams: Power, signal, and control wiring.
2. Samples: For master and remote-control stations, and faceplates with factory-applied color finishes and technical features.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. General Dimming Device Requirements

1. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.
2. Dimmers and Dimmer Modules: Comply with UL 508.
 - a. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
 - b. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.



B. Manual Modular Multiscene Dimming Controls

1. Description: Factory-fabricated equipment providing manual modular dimming control consisting of a wall-box-mounted, master-scene controller and indicated number of wall-box zone stations. Controls and dimmers shall be integrated for mounting in one-, two-, or three-gang wall box under a single wall plate. Each zone station shall be adjustable to indicated number of scenes, which shall be recorded on the zone controller.
2. Operation: Automatically change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
3. Each manual modular multiscene dimming controller shall include a master control and remote controls.
4. Each zone shall be configurable to control the following:
 - a. Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
 - b. Incandescent lamps.
 - c. Low-voltage incandescent lamps.
5. Memory: Retain preset scenes through power failures for at least seven days.
6. Device Plates: Style, material, and color shall comply with Division 26 Section "Wiring Devices".
7. Master-Scene Controller: Suitable for mounting in a single flush wall box.
 - a. Switches: Master off, group dim, group bright, and selectors for each scene.
 - b. LED indicator lights, one associated with each scene switch, and one for the master off switch.
8. Fluorescent Zone Dimmer: Suitable for operating lighting fixtures and ballasts specified in Division 26 Section "Interior Lighting", and arranged to dim number of scenes indicated for the master-scene controller. Scene selection is at the master-scene controller for setting light levels of each zone associated with scene.
 - a. Switch: Rocker **OR** Slider, **as directed**, style for setting the light level for each scene.
 - b. LED indicator lights, one associated with each scene.
 - c. Electrical Rating: 1000 **OR** 2000, **as directed**, VA, 120 V.
9. Incandescent Zone Dimmer: Suitable for operating incandescent lamps at line-voltage or low-voltage lamps connected to a transformer and arranged to dim number of scenes indicated for the master-scene controller. Scene selection shall be at the master-scene controller for setting light levels of each zone associated with scene.
 - a. Switch: Rocker **OR** Slider, **as directed**, style for setting the light level for each scene.
 - b. LED indicator lights, one associated with each scene.
 - c. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.

C. Integrated, Multipreset Modular Dimming Controls

1. Indicate number of wall-box, remote-control stations.
2. Description: Factory-fabricated, microprocessor-based, solid-state controls providing manual dimming control consisting of a master station and multiple wall-box, remote-control stations.
3. Operation: Automatically changes variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
4. Each zone shall be configurable to control the following:
 - a. Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
 - b. Incandescent lamps.
 - c. Low-voltage incandescent lamps.
5. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.
6. Master Station:
 - a. Contains control panel and multiple control and dimmer modules.
 - b. Controls and commands adjustment of each dimmer-zone setting for each scene change from one preset scene to another.
 - 1) Master zone raises and lowers lighting level.
 - 2) Adjustable fade rate for each scene from 1 to 60 seconds.
 - c. Rear-illuminated, scene-select buttons.



- d. Lighting-level setting and fade-rate setting shall be graphically shown using LEDs or backlighted bar-graph indicator.
- e. Mounting: Flush wall box with manufacturer's standard faceplate.
7. Remote-Control Stations:
 - a. Numbered push buttons to select scenes.
 - b. Off switch to turn master station off. Operating the off switch at any remote station shall automatically turn on selected housekeeping lighting, **as directed**.
 - c. On switch turns all scenes of master station to full bright.
 - d. Control Wiring: NFPA 70, Class 2.
 - e. Mounting: Single flush wall box with manufacturer's standard faceplate.
8. Infrared Remote-Control Station: Same functions as for standard remote-control station, except that functions are input by a hand-held infrared transmitter.
9. Dimmers: Modular, plug-in type, with circuit breaker to protect the dimmer and branch circuit.
 - a. Dimming Circuit: Two SCR dimmers, in inverse parallel configuration.
 - b. Dimming Curve: Modified "square law" as specified in IESNA's "IESNA Lighting Handbook"; control voltage is 0- to 10-V dc.
 - c. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
 - d. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.
 - e. Short-Circuit Rating: 10 kA for 120 V, 14 kA for 277 V.

D. Conductors And Cables

1. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
2. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

1.3 EXECUTION

A. Wiring Installation

1. Comply with NECA 1.
2. Wiring Method: Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables". Minimum conduit size shall be 1/2 inch (13 mm).
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
4. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
5. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

B. Identification

1. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for identifying components and power and control wiring.
2. Label each dimmer module with a unique designation.
3. Label each scene control button with approved scene description.

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.



2. Tests and Inspections:
 - a. Continuity tests of circuits.
 - b. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
 - 1) Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
3. Remove and replace malfunctioning modular dimming control components and retest as specified above.
4. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
5. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

D. Demonstration

1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls. Laptop portable computer shall be used in training, **as directed**.
2. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls".

END OF SECTION 26 09 23 00e



Task	Specification	Specification Description
26 09 23 00	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 09 23 00	02 84 16 00a	Interior Lighting
26 09 23 00	02 84 16 00b	Exterior Lighting



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SECTION 26 11 13 00 - SECONDARY UNIT SUBSTATIONS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for secondary unit substations. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes indoor and outdoor secondary unit substations, each consisting of the following:
 - a. Primary incoming section.
 - b. Transformer.
 - c. Secondary distribution section.

C. Definitions

1. NETA ATS: Acceptance Testing Specification.

D. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Time-Current Characteristic Curves: For overcurrent protective devices.
4. Primary Fuses: Submit recommendations and size calculations.
5. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
6. Field quality-control test reports.
7. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C2.
3. Comply with IEEE C37.121.
4. Comply with NFPA 70.

F. Delivery, Storage, And Handling

1. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
2. Coordinate delivery of secondary unit substations to allow movement into designated space.
3. Store secondary unit substation components protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.
4. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

G. Project Conditions

1. Service Conditions: IEEE C37.121, usual service conditions, except for the following:
 - a. Exposure to significant solar radiation.
 - b. Altitudes above 3300 feet (1000 m).



- c. Exposure to fumes, vapors, or dust.
- d. Exposure to explosive environments.
- e. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
- f. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
- g. Exposure to excessively high or low temperatures.
- h. Unusual transportation or storage conditions.
- i. Unusual grounding resistance conditions.
- j. Unusual space limitations.

1.2 PRODUCTS

A. Manufactured Units

1. Indoor Unit Arrangement: Single assembly **OR** Separate secondary distribution equipment connected with busway, **as directed**.
2. Outdoor Unit Arrangement: Single assembly **OR** Separate secondary distribution equipment connected with busway, **as directed**.
 - a. Weatherproof, listed for installation outdoors, complying with IEEE C37.20.1.
 - b. Aisleless Construction: Full-height doors in front of basic weatherproof equipment.
3. Enclosure Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating **OR** Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface, **as directed**.

B. Incoming Section

1. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters.
 - OR**
 - Transformer cover-mounted bushings.
 - OR**
 - Enclosed, air-interrupter, dual primary **OR** primary, **as directed**, switch.
 - a. Three pole, single throw, dead front, metal enclosed, with manual stored energy operator, with fuses mounted on a single frame **OR** without fuses, **as directed**, complying with IEEE C37.20.3.
 - b. Key interlocking system to prevent fuse access door from being opened unless switch is open. Additionally, interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.
 - c. Phase Barriers: Located between blades and fuses of each phase, designed for easy removal, allows visual inspection of switch components when barrier is in place.
 - d. Window: Permits viewing switch-blade positions when door is closed.
 - e. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.
 - f. Continuous-Current Rating: 600 A.
 - g. Short-Circuit Rating:
 - 1) Short-time momentary asymmetrical fault rating of 40 kA.
 - 2) 3-second symmetrical rating of 25-kA RMS.
 - 3) Fault close asymmetrical rating of 40 kA.
 - h. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading. Comply with the following:
 - 1) Current-limiting type, rated for not less than 50-kA RMS symmetrical current-interrupting capacity.
 - 2) Indicator integral with each fuse to show when it has blown.



- 3) Spares: Include three fuses in use and three spare fuses in storage clips in each switch.
 2. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.
- C. Liquid-Filled Transformer Section
1. Description: IEEE C57.12.00 and UL 1062, liquid-filled, 2-winding, secondary unit substation transformer.
 2. Insulating Liquid: Mineral oil complying with ASTM D 3487, Type II, and tested according to ASTM D 117.
OR
Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
OR
Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
OR
Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.
 3. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12-percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.
OR
Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.
 4. Basic Impulse Level: Comply with UL 1062.
OR
Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed**, kV.
 5. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
OR
Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
 6. Cooling System: Class OA, liquid cooled **OR** OA/FA, liquid cooled, and with forced-air rating **OR** OA/FFA, liquid cooled, and with provisions for future forced-air rating, **as directed**. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.
 7. Sound level may not exceed 58 dB, without fans.
 8. Impedance: Percentage as directed.
 9. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:
 - a. Liquid-level gage.
 - b. Pressure-vacuum gage.
 - c. Liquid temperature indicator.
 - d. Drain and filter valves.
 - e. Pressure relief device.
- D. Dry-Type Transformer Section



1. Description: IEEE C57.12.01, IEEE C57.12.50 for dry-type transformers rated up to 500 kVA, IEEE C57.12.51 for dry-type transformers rated 501 kVA and larger, or IEEE C57.12.52 for sealed dry-type transformers rated 501 kVA and larger, NEMA ST 20, and dry-type, 2-winding, secondary unit substation transformer.
 2. Enclosure: Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
OR
Enclosure: Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, vacuum-pressure, impregnated type and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
 3. Cooling System: Class AA, air cooled **OR** AA/FA, air cooled with forced-air rating **OR** AA/FFA, air cooled with provisions for future forced-air rating, **as directed**, complying with IEEE C57.12.01.
 - a. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
 - b. Include mounting provision for fans.
 4. Insulation Materials: IEEE C57.12.01, rated 220 deg C.
 5. Insulation Temperature Rise: 80 **OR** 115 **OR** 150, **as directed**, deg C, maximum rise above 40 deg C.
 6. Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed**, kV.
 7. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.
OR
Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps below rated primary voltage.
 8. Sound level may not exceed maximum dBA level **as directed**, without fans operating.
 9. Impedance: Percentage **as directed**.
 10. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.
- E. Secondary Distribution Section
1. Secondary Terminal Compartment: Bus bars mounted on standoff insulators **OR** duct flange for close coupling with busway, **as directed**.
OR
Secondary Distribution: Low-voltage switchgear as specified in Division 26 Section "Low-voltage Switchgear".
OR
Secondary Distribution: Low-voltage switchboard as specified in Division 26 Section "Switchboards".
OR
Secondary Distribution: Motor-control center as specified in Division 26 Section "Motor-control Centers".
OR
Distribution Panelboard: Panelboards as specified in Division 26 Section "Panelboards".
 2. Network Protectors:
 - a. Rated for continuous service in an ambient temperature of up to 40 deg C, applied to 3-phase, 4-wire, solidly grounded wye secondary networks. Comply with IEEE C57.12.44.
 - b. Dead-front, drawout design with externally mounted fuses, using hand-cranked rail system. Relay and control panel located on a separate drawout module.
 - c. Protector Operator: Spring-close and/or stored-energy mechanism, rated to close on a 25,000 **OR** 40,000, **as directed**, RMS symmetrical load.
 - d. Control Voltage: Not more than 125 V.



- e. Control microprocessor-based, three-phase, tripping relay with features and functions as follows:
 - 1) Close protector if positive sequence power flows into the network. Adjustable closing range shall be from 0.5 to 3.5 V in phase difference between network and transformer voltages.
 - 2) Trip protector if there is a net, three-phase, reverse power flow through protector. Trip protectors shall be adjustable from 0.05 to 5 percent of continuous-current rating of current transformers within protector.
 - 3) Trip protector if there is a flow of reverse magnetizing current of its associated transformer.
 - 4) Field-adjustable relay parameters and watt or watt-var trip values.
- f. Protector shall not open under any fault on network side of protector.
- g. Current-limiting fuses shall have interrupting capacity of 150,000 A on network side of protector for protection against switchboard bus faults.
- h. Mechanical interlocks shall prevent racking in and racking out when protector is closed.
- i. Auxiliary contacts shall be remotely tripped and locked out by four-wire remote pilot devices.
- j. Network protectors shall have not less than two spare auxiliary dry contacts.
- k. Network Switchgear-Mounted Disconnect Switch: Supply each network-protector circuit with a switchgear-mounted fuse truck, with Class L fuses rated for 200-kA interrupting capacity, and key interlocked with each associated protector.
OR
Network Switchgear-Mounted Disconnect Switch: Supply each network-protector circuit with a switchgear-mounted main circuit breaker rated for fault current that can be delivered by the network transformers, less one. Use drawout type to provide a means of isolating the load side of each protector from the network bus.

F. Identification Devices

- 1. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification For Electrical Systems".

G. Source Quality Control

- 1. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.
OR
Factory Tests: Perform the following factory-certified tests on each secondary unit substation:
 - a. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
 - b. Ratios on the rated voltage connection and on tap extreme connections.
 - c. Polarity and phase relation on the rated voltage connection.
 - d. No-load loss at rated voltage on the rated voltage connection.
 - e. Exciting current at rated voltage on the rated voltage connection.
 - f. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
 - g. Applied potential.
 - h. Induced potential.
 - i. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class FA rating.
 - 1) Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.
 - j. the Owner will witness all required factory tests. Notify the Owner at least 14 days before date of tests and indicate their approximate duration.



1.3 EXECUTION

A. Installation

1. Install secondary unit substations on concrete bases.
 - a. Anchor secondary unit substations to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Section "Hangers And Supports For Electrical Systems".
 - b. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
 - c. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
 - d. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 - e. Install epoxy-coated anchor bolts for anchoring equipment to the concrete base.
 - f. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - g. Bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.
2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

B. Identification

1. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification For Electrical Systems".
2. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

C. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

D. Cleaning

1. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

E. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
 - a. Perform each visual and mechanical inspection and electrical test according to NETA ATS. Certify compliance with test parameters.
 - b. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.
 - c. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
 - d. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 - 1) Remove and replace malfunctioning units and retest as specified above.



F. Follow-Up Service

1. Voltage Monitoring and Adjusting: After Final Completion, if requested by the Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 - a. During a period of normal load cycles as evaluated by the Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
 - b. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - 1) Adjust transformer taps.
 - 2) Rebalance loads.
 - 3) Prepare written request for voltage adjustment by electric utility.
 - c. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
 - d. Report: Prepare a written report covering monitoring performed and corrective action taken.
2. Infrared Scanning: Perform as specified in Division 26 Section "Medium-voltage Switchgear".

END OF SECTION 26 11 13 00



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SECTION 26 11 16 00 - SWITCHGEAR

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for switchgear. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes metal-enclosed, low-voltage power circuit-breaker switchgear rated 1000 V and less for use in ac systems.

C. Definitions

1. ATS: Acceptance Testing Service.
2. GFCI: Ground-fault circuit interrupter.

D. Submittals

1. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: For each type of switchgear and related equipment.
 - a. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
 - b. Wiring Diagrams: Power, signal, and control wiring.
3. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
4. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.
5. Manufacturer Seismic Qualification Certification: Submit certification that switchgear, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
6. Field quality-control test reports.
7. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.
8. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. Include the following:
 - a. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - b. Time-current curves, including selectable ranges for each type of overcurrent protective device.

E. Quality Assurance

1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - a. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.



2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with NFPA 70.

F. Delivery, Storage, And Handling

1. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.
2. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.
3. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

G. Project Conditions

1. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.
2. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service.
3. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
4. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 40 deg C.
 - b. Altitude: Not exceeding 6600 feet (2010 m).

1.2 PRODUCTS

A. Ratings

1. Nominal System Voltage: 480 V, 3 wire **OR** 480/277 V, 4 wire **OR** 240 V, 3 wire **OR** 208/120 V, 4 wire, **as directed**, 60 Hz.
2. Main-Bus Continuous: 4000 **OR** 3200 **OR** 2000 **OR** 1600, **as directed**, A.
3. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

B. Fabrication

1. Factory assembled and tested and complying with IEEE C37.20.1.
2. Indoor Enclosure Material: Steel.
3. Outdoor Enclosure Material: Galvanized steel.
4. Outdoor Enclosure Fabrication Requirements: Weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating; and each compartment equipped with the following features:
 - a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h), **as directed**, wind.
 - b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
 - c. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
 - d. Hinged front door with padlocking provisions.
 - e. Interior light with switch.
 - f. Weatherproof duplex receptacle.



- g. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
 - h. Aisle access doors with outside padlocking provisions and interior panic latches.
 - i. Aisle space heaters operating at one-half or less of rated voltage, thermostatically controlled.
 - j. Vaporproof fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at each entrance.
 - k. GFCI duplex receptacles, a minimum of two, located in aisle.
 - l. Aisle ventilation louvers equipped with insect and rodent screen and filter and arranged to permit air circulation while excluding insects, rodents, and exterior dust.
5. Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.
6. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.
7. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
8. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.
9. Fabricate enclosure with removable, hinged, rear cover panels to allow access to rear interior of switchgear.
10. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
- a. Utility metering compartment that complies with utility company requirements.
 - b. Bus transition sections.
 - c. Incoming-line pull sections.
 - d. Hinged front panels for access to metering, accessory, and blank compartments.
 - e. Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.
 - 1) Set pull box back from front to clear circuit-breaker lifting mechanism.
 - 2) Bottom: Insulating, fire-resistant material with separate holes for cable drops into switchgear.
 - 3) Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.
11. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.
- a. Main Phase Bus: Uniform capacity the entire length of assembly.
 - b. Neutral Bus: 50 **OR** 100, **as directed**, percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
 - c. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
 - d. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.

OR

Phase- and Neutral-Bus Material: Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections.

OR

Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
 - e. Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
 - f. Use copper for connecting circuit-breaker line to copper bus.
 - g. Contact Surfaces of Buses: Silver plated.
 - h. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.



- i. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches (6 by 50 mm).
- j. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
- k. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
- l. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.
- m. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
- n. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
 - 1) Sprayed Insulation Thickness: 3 mils (0.08 mm), minimum.
 - 2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

C. Components

1. Instrument Transformers: Comply with IEEE C57.13.
 - a. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 - b. Current Transformers: Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.
2. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - a. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
 - b. Switch-selectable digital display of the following:
 - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
 - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - 4) Three-Phase Real Power: Plus or minus 2 percent.
 - 5) Three-Phase Reactive Power: Plus or minus 2 percent.
 - 6) Power Factor: Plus or minus 2 percent.
 - 7) Frequency: Plus or minus 0.5 percent.
 - 8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - 9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 - c. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Analog Instruments: Rectangular, 4-1/2-inch (115-mm) square, accurate within 1 percent, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment, complying with ANSI C39.1.
 - a. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
 - b. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
 - c. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
 - d. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
 - e. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
 - f. Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, 3 phase, 3 wire; with 3 elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.



- g. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
 - 1) Operation: Meter counts and records a succession of pulses entering two channels.
 - 2) Housing: Drawout, back-connected case arranged for semiflush mounting.
 - 4. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.
 - 5. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with IEEE C62.11 and NEMA LA 1.
 - a. Install in cable termination compartments and connect in each phase of circuit.
 - b. Coordinate rating with circuit voltage.
 - 6. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
 - 7. Fungus Proofing: Permanent fungicidal treatment for switchgear interior, including instruments and instrument transformers.
 - 8. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices. Include the following features:
 - a. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
 - b. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
 - 1) Secondary windings connected through a relay or relays to control bus to effect an automatic transfer scheme.
 - 2) Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.
 - c. Control Power Fuses: Primary and secondary fuses with current-limiting and overload protection.
 - d. Fuses are specified in Division 26 Section "Fuses".
 - 9. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
 - a. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
 - b. Conductors sized according to NFPA 70 for duty required.
- D. Circuit Breakers
- 1. Description: Comply with IEEE C37.13.
 - 2. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
 - 3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
 - a. Normal Closing Speed: Independent of both control and operator.
 - b. Slow Closing Speed: Optional with operator for inspection and adjustment.
 - c. Stored-Energy Mechanism: Manually charged **OR** Electrically charged, with optional manual charging, **as directed**.
 - d. Operation counter.
 - 4. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
 - a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
 - b. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
 - c. Field-adjustable, time-current characteristics.
 - d. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
 - e. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
 - f. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I^2t operation.



- g. Pickup Points: Five minimum, for instantaneous-trip functions.
 - h. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
 - 1) Three-wire circuit or system.
 - 2) Four-wire circuit or system.
 - 3) Four-wire, double-ended substation.
 - i. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
5. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.
6. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
- a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
 - b. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
 - 1) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
 - 2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
7. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
8. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
9. Operating Handle: One for each circuit breaker capable of manual operation.
10. Electric Close Button: One for each electrically operated circuit breaker.
11. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
12. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
13. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage **OR** Adjustable time-delay and pickup voltage, **as directed**.
14. Shunt-Trip Devices: Where indicated.
15. Fused Circuit Breakers: Circuit breaker and fuse combinations complying with requirements for circuit breakers and trip devices and with the following:
- a. Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.
 - b. Circuit Breakers with Frame Size 1600 A and Smaller: Fuses on line side of associated circuit breaker, on a common drawout mounting, arranged so fuses are accessible only when circuit breaker is in disconnected position.
 - c. Circuit Breakers with Frame Sizes More Than 1600 A: Fuses and circuit breakers may be installed in separate compartments on separate drawout mountings. Fuse drawout element is interlocked with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in open position.
 - d. Open-Fuse Trip Device: Positive means of tripping and holding circuit breaker in open position when a fuse opens. Open-fuse status is indicated at front of circuit breaker or fuse drawout element.



16. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

E. Accessories

1. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
 - a. Racking handle to manually move circuit breaker between connected and disconnected positions.
 - b. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
 - c. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
2. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
3. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
4. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
5. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

F. Identification

1. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.
 - a. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
 - b. Medium: Painted graphics, as selected by Architect.
 - c. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.
2. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:
 - a. Frame size of each circuit breaker.
 - b. Trip rating for each circuit breaker.
 - c. Conduit and wire size for each feeder.

1.3 EXECUTION

A. Installation

1. Comply with applicable portions of NECA 400.
2. Anchor switchgear assembly to 4-inch (100-mm), channel-iron floor sill embedded in floor **OR** concrete base, **as directed**, and attach by bolting.
 - a. Sills: Select to suit switchgear; level and grout flush into floor **OR** concrete base, **as directed**.
 - b. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Hangers And Supports For Electrical Systems" for seismic-restraint requirements.
 - c. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Hangers And Supports For Electrical Systems".
3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.



- B. Identification
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification For Electrical Systems".
 2. Diagram and Instructions:
 - a. Frame and mount under clear acrylic plastic on the front of switchgear.
 - 1) Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
 - 2) System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
 - b. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.
- C. Connections
1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- D. Field Quality Control
1. Prepare for acceptance tests as follows:
 - a. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
 - b. Test continuity of each circuit.
 2. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - a. Inspect switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.
 - b. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 22.
 - c. Complete installation and startup checks according to manufacturer's written instructions.
 - d. Assist in field testing of equipment including pretesting and adjusting of equipment and components.
 - e. Report results in writing.
 3. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
 - 1) Switchgear.
 - 2) Circuit breakers.
 - 3) Protective relays.
 - 4) Instrument transformers.
 - 5) Metering and instrumentation.
 - 6) Ground-fault systems.
 - 7) Battery systems.
 - 8) Surge arresters.
 - 9) Capacitors.
 - b. Remove and replace malfunctioning units and retest as specified above.
 4. Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Final Completion.



- b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- E. Adjusting
- 1. Set field-adjustable, protective-relay trip characteristics according to results in Division 26 Section "Overcurrent Protective Device Coordination Study".
 - 2. Set field-adjustable, protective-relay trip characteristics.
- F. Cleaning
- 1. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
- G. Protection
- 1. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

END OF SECTION 26 11 16 00



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Task	Specification	Specification Description
26 11 16 00	26 11 13 00	Secondary Unit Substations



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SECTION 26 12 13 00 - MEDIUM-VOLTAGE TRANSFORMERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for medium-voltage transformers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following types of transformers with medium-voltage primaries:
 - a. Liquid-filled distribution and power transformers.
 - b. Dry-type distribution and power transformers.
 - c. Pad-mounted, liquid-filled transformers.

C. Definitions

1. NETA ATS: Acceptance Testing Specification.

D. Submittals

1. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.
2. Shop Drawings: Diagram power signal and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Field quality-control test reports.
5. Follow-up service reports.
6. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C2.
3. Comply with ANSI C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.
4. Comply with NFPA 70.

F. Delivery, Storage, And Handling

1. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

G. Project Conditions

1. Service Conditions: IEEE C37.121, usual service conditions except for the following:
 - a. Exposure to significant solar radiation.
 - b. Altitudes above 3300 feet (1000 m).
 - c. Exposure to fumes, vapors, or dust.
 - d. Exposure to explosive environments.
 - e. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
 - f. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
 - g. Exposure to excessively high or low temperatures.



- h. Unusual transportation or storage conditions.
- i. Unusual grounding-resistance conditions.
- j. Unusual space limitations.

1.2 PRODUCTS

A. Liquid-Filled Distribution And Power Transformers

1. Description: IEEE C57.12.00 and UL 1062, liquid-filled, 2-winding transformers.
2. Insulating Liquid: Mineral oil, complying with ASTM D 3487, Type II, and tested according to ASTM D 117.
OR
Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
OR
Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
OR
Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.
3. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12 percent kilovolt-ampere output, at 65 deg C temperature rise, without decreasing rated transformer life.
OR
Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.
4. Basic Impulse Level: Comply with UL 1062.
OR
Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed** kV.
5. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
OR
Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
6. Cooling System: Class OA, self-cooled **OR** OA/FA, self-cooled, and with forced-air-cooled rating **OR** OA/FFA, self-cooled, and with provisions for future forced-air-cooled rating, **as directed**. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.
7. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.
8. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:
 - a. Liquid-level gage.
 - b. Pressure-vacuum gage.
 - c. Liquid temperature indicator.
 - d. Drain and filter valves.
 - e. Pressure relief device.



B. Dry-Type Distribution And Power Transformers

1. Description: NEMA ST 20, IEEE C57.12.01, ANSI C57.12.50 for dry-type transformers rated up to 500 kVA, ANSI C57.12.51 for dry-type transformers rated 501 kVA and larger, or ANSI C57.12.52 for sealed dry-type transformers rated 501 kVA and larger, UL 1562 listed and labeled, dry-type, 2-winding transformers.
 - a. Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
 - b. Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, vacuum-pressure impregnated and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
2. Primary Connection: Air terminal compartment with removable **OR** hinged, **as directed**, door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.
OR
Primary Connection: Transition terminal compartment with connection pattern to match switchgear.
3. Secondary Connection: Air terminal compartment with removable **OR** hinged, **as directed**, door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.
OR
Secondary Connection: Transition terminal compartment with connection pattern to match switchgear **OR** bus duct, **as directed**.
4. Insulation Materials: IEEE C57.12.01, rated at 220 deg C.
5. Insulation Temperature Rise: 80 **OR** 115 **OR** 150, **as directed**, deg C, maximum rise above 40 deg C.
6. Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed**, kV.
7. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.
OR
Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage.
8. Cooling System: Class AA, self-cooled **OR** AA/FA, self-cooled, and with forced-air-cooled rating **OR** AA/FFA, self-cooled, and with provisions for future forced-air-cooled rating, **as directed**, complying with IEEE C57.12.01.
 - a. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
 - b. Include mounting provision for fans.
9. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.
10. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

C. Pad-Mounted, Liquid-Filled Transformers

1. Description: ANSI C57.12.13, ANSI C57.12.26 for pad-mounted transformers with dead-front, separable, insulated, high-voltage, load-break cable connectors, IEEE C57.12.00 IEEE C57.12.22 for pad-mounted transformers with live-front high-voltage bushings pad-mounted, 2-winding transformers. Stainless-steel tank base and cabinet, **OR** cabinet, and sills, **as directed**.
2. Insulating Liquid: Mineral oil, complying with ASTM D 3487, Type II, and tested according to ASTM D 117.
OR
Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

**OR**

Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

OR

Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.

3. Insulation Temperature Rise: 55 **OR** 65, **as directed**, deg C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.
4. Basic Impulse Level: 30 **OR** 60 **OR** 95, **as directed**, kV.
5. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
6. High-Voltage Switch: 200 **OR** 300 **OR** 400, **as directed**, A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for radial feed with 3-phase, 2-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.

OR

High-Voltage Switch: 200 **OR** 300 **OR** 400, **as directed**, A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for loop feed with 3-phase, 4-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.
7. Primary Fuses: 150-kV fuse assembly with fuses complying with IEEE C37.47. Rating of current-limiting fuses shall be 50-kA RMS at specified system voltage.
 - a. Current-limiting type in dry-fuse holder wells, mechanically interlocked with liquid-immersed switch in transformer tank to prevent disconnect under load.
 - b. Internal liquid-immersed cartridge fuses.
 - c. Bay-O-Net liquid-immersed fuses that are externally replaceable without opening transformer tank.
 - d. Bay-O-Net liquid-immersed fuses in series with liquid-immersed current-limiting fuses. Bay-O-Net fuses shall be externally replaceable without opening transformer tank.
 - e. Bay-O-Net liquid-immersed current-limiting fuses that are externally replaceable without opening transformer tank.
8. Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment. Transformers shall have three arresters for radial-feed **OR** three arresters for loop-feed **OR** six arresters for loop-feed, **as directed**, circuits.
9. High-Voltage Terminations and Equipment: Live front with externally clamped porcelain bushings and cable connectors suitable for terminating primary cable.

OR

High-Voltage Terminations and Equipment: Dead front with universal-type bushing wells for dead-front bushing-well inserts, complying with IEEE 386 and including the following:

 - a. Bushing-Well Inserts: One for each high-voltage bushing well.
 - b. Surge Arresters: Dead-front, elbow-type, metal-oxide-varistor units.
 - c. Parking Stands: One for each high-voltage bushing well.
 - d. Portable Insulated Bushings: Arranged for parking insulated, high-voltage, load-break cable terminators; one for each primary feeder conductor terminating at transformer.
10. Accessories:
 - a. Drain Valve: 1 inch (25 mm), with sampling device.
 - b. Dial-type thermometer.
 - c. Liquid-level gage.
 - d. Pressure-vacuum gage.
 - e. Pressure Relief Device: Self-sealing with an indicator.
 - f. Mounting provisions for low-voltage current transformers.



- g. Mounting provisions for low-voltage potential transformers.
- h. Busway terminal connection at low-voltage compartment.
- i. Alarm contacts for gages and thermometer listed above.

D. Identification Devices

- 1. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification For Electrical Systems".

E. Source Quality Control

- 1. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to ANSI C57.12.50 for ventilated dry-type distribution transformers 1 to 500 kVA, single phase, and 15 to 500 kVA, 3 phase, with high voltage 601 to 34,500 V and low voltage 208Y/120 to 4160 V; ANSI C57.12.51 for ventilated dry-type power transformers 501 kVA and larger, 3 phase, with high voltage 601 to 34,500 V and low voltage 208Y/120 to 4160 V; IEEE C57.12.90 for liquid-filled transformers; and IEEE C57.12.91 for dry-type distribution and power transformers.
- 2. Factory Tests: Perform the following factory-certified tests on each transformer:
 - a. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
 - b. Ratios on rated-voltage connection and on tap extreme connections.
 - c. Polarity and phase relation on rated-voltage connection.
 - d. No-load loss at rated voltage on rated-voltage connection.
 - e. Excitation current at rated voltage on rated-voltage connection.
 - f. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
 - g. Applied potential.
 - h. Induced potential.
 - i. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
 - 1) Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

1.3 EXECUTION

A. Installation

- 1. Install transformers on concrete bases.
 - a. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Section "Hangers And Supports For Electrical Systems".
 - b. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
 - c. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
 - d. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 - e. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
 - f. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - g. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.



2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- B. Identification
1. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification For Electrical Systems", **as directed**.
- C. Connections
1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- D. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
 - a. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
 - b. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
 - c. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 2. Remove and replace malfunctioning units and retest as specified above.
 3. Test Reports: Prepare written reports to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.
- E. Follow-Up Service
1. Voltage Monitoring and Adjusting: If requested by the Owner, perform the following voltage monitoring after Final Completion but not more than six months after Final Acceptance:
 - a. During a period of normal load cycles as evaluated by the Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
 - b. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:
 - 1) Adjust transformer taps.
 - 2) Prepare written request for voltage adjustment by electric utility.
 - c. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
 - d. Report: Prepare written report covering monitoring and corrective actions performed.
 2. Infrared Scanning: Perform as specified in Division 26 Section "Medium-voltage Switchgear".

END OF SECTION 26 12 13 00



SECTION 26 12 13 00a - LOW-VOLTAGE TRANSFORMERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for low-voltage transformers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
 - a. Distribution transformers.
 - b. Buck-boost transformers.

C. Submittals

1. Product Data: For each product indicated.
2. Shop Drawings: Indicate dimensions and weights.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Field quality-control test reports.
5. Operation and maintenance data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

E. Delivery, Storage, And Handling

1. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.2 PRODUCTS

A. General Transformer Requirements

1. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
2. Cores: Grain-oriented, non-aging silicon steel.
3. Coils: Continuous windings without splices except for taps.
 - a. Internal Coil Connections: Brazed or pressure type.
 - b. Coil Material: Aluminum **OR** Copper, **as directed**.

B. Distribution Transformers

1. Comply with NEMA ST 20, and list and label as complying with UL 1561.
2. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Cores: One leg per phase.
4. Enclosure: Ventiladed **OR** Totally enclosed, nonventilated, **as directed**, NEMA 250, Type 2.



- a. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
5. Enclosure: Ventilated **OR** Totally enclosed, nonventilated, **as directed**, NEMA 250, Type 3R **OR** Type 4X, stainless steel, **as directed**.
 - a. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
6. Transformer Enclosure Finish: Comply with NEMA 250.
 - a. Finish Color: Gray **OR** ANSI 49 gray **OR** ANSI 61 gray, **as directed**.
7. Taps for Transformers Smaller Than 3 kVA: None **OR** One 5 percent tap above normal full capacity, **as directed**.
8. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity **OR** Two 5 percent taps below rated voltage, **as directed**.
9. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity **OR** Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity, **as directed**.
10. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 **OR** 115 **OR** 80, **as directed**, deg C rise above 40 deg C ambient temperature.
11. Energy Efficiency for Transformers Rated 15 kVA and Larger:
 - a. Complying with NEMA TP 1, Class 1 efficiency levels.
 - b. Tested according to NEMA TP 2.
12. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
 - a. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
 - b. Indicate value of K-factor on transformer nameplate.
13. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
14. Wall Brackets: Manufacturer's standard brackets.
15. Fungus Proofing: Permanent fungicidal treatment for coil and core.
16. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

C. Buck-Boost Transformers

1. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.
2. Enclosure: Ventilated, NEMA 250, Type 2.
 - a. Finish Color: Gray **OR** ANSI 49 gray **OR** ANSI 61 gray, **as directed**.

D. Identification Devices

1. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 26 Section "Identification For Electrical Systems".

1.3 EXECUTION

A. Installation

1. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 - a. Brace wall-mounting transformers as specified in Division 26 Section "Hangers And Supports For Electrical Systems".
2. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, **as directed**, and requirements in Division 26 Section "Hangers And Supports For Electrical Systems".

B. Field Quality Control



1. Perform tests and inspections.
 2. Tests and Inspections:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - b. Infrared Scanning: Two months after Final Completion, perform an infrared scan of transformer connections.
 - 1) Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 - 2) Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Final Completion.
 - 3) Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
- C. Adjusting
1. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
 2. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
 3. Output Settings Report: Prepare a written report recording output voltages and tap settings.
- D. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 12 13 00a



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Task	Specification	Specification Description
26 12 13 00	02 84 33 00	Overhead Electrical Distribution
26 12 16 00	26 12 13 00	Medium-Voltage Transformers
26 12 16 00	26 12 13 00a	Low-Voltage Transformers
26 12 19 00	26 12 13 00	Medium-Voltage Transformers
26 12 19 00	26 12 13 00a	Low-Voltage Transformers
26 13 16 00	26 11 13 00	Secondary Unit Substations
26 13 19 00	26 11 13 00	Secondary Unit Substations
26 18 16 00	26 11 16 00	Switchgear
26 21 13 00	26 05 13 00	Conductors And Cables
26 21 13 00	26 05 13 00a	Undercarpet Cables
26 21 13 00	26 05 13 00b	Medium-Voltage Cables
26 21 13 00	02 84 33 00	Overhead Electrical Distribution
26 22 13 00	26 12 13 00	Medium-Voltage Transformers
26 22 13 00	02 84 33 00	Overhead Electrical Distribution
26 22 13 00	26 12 13 00a	Low-Voltage Transformers



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SECTION 26 24 13 00 - ELECTRICITY METERING**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for electricity metering. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes equipment for electricity metering by utility company and electricity metering by the Owner.

C. Definitions

1. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.
2. PC: Personal computer.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For electricity-metering equipment.
 - a. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.
3. Field quality-control reports.
4. Operation and Maintenance Data. Include the following:
 - a. Application and operating software documentation.
 - b. Software licenses.
 - c. Software service agreement.
 - d. Hard copies of manufacturer's operating specifications, design user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy Submittal.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Delivery, Storage, And Handling

1. Receive, store, and handle modular meter center according to NECA 400.

G. Project Conditions

1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical service.
 - b. Do not proceed with interruption of electrical service without the Owner's written permission.

H. Coordination

1. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:



- a. Comply with requirements of utilities providing electrical power services.
 - b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.
- I. Software Service Agreement (May Not Be Allowed For Publicly Funded Projects)
1. Technical Support: Beginning with Final Completion, provide software support for two years.
 2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade its computer equipment if necessary.

1.2 PRODUCTS

- A. Equipment For Electricity Metering By Utility Company
1. Meters will be furnished by utility company.
 2. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
 3. Meter Sockets: Comply with requirements of electrical-power utility company.
- OR**
- Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.
4. Modular Meter Center: Factory-coordinated assembly of a main service terminal box with lugs only **OR** disconnect device, **as directed**, wireways, tenant meter socket modules, and tenant feeder circuit breakers arranged in adjacent vertical sections. Assembly shall be complete with interconnecting buses and other features as specified below.
 - a. Comply with requirements of utility company for meter center.
 - b. Housing: NEMA 250, Type 1 **OR** Type 3R, **as directed**, enclosure.
 - c. Minimum Short-Circuit Rating: 22,000 **OR** 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A symmetrical at rated voltage.
 - d. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers.

OR

 Main Disconnect Device: Fusible switch, series-combination rated by circuit-breaker manufacturer to protect downstream feeder and branch circuit breakers.
 - e. Tenant Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect circuit breakers in downstream tenant and to house loadcenters and panelboards that have 10,000-A interrupting capacity.
 - 1) Identification: Complying with requirements in Division 26 Section "Identification For Electrical Systems" with legend identifying tenant's address.
 - 2) Physical Protection: Tamper resistant, with hasp for padlock.
 - f. Meter Socket: Rating coordinated with indicated tenant feeder circuit rating.
 - g. Surge Protection: For main disconnect device, comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
- B. Equipment For Electricity Metering By the Owner
1. General Requirements for the Owner's Meters:
 - a. Comply with UL 1244.
 - b. Meters used for billing shall have an accuracy of 0.2 **OR** 0.5 **OR** 1.0, **as directed**, percent of reading, complying with requirements in ANSI C12.20.
 - c. Meters shall be certified by California Type Evaluation Program, **as directed**, as complying with Title 4, California Code of Regulations, Article 2.2, **as directed**.
 - d. Enclosure: NEMA 250, Type 1 **OR** Type 3R, **as directed**, minimum, with hasp for padlocking or sealing.



- e. Identification: Comply with requirements in Division 26 Section "Identification For Electrical Systems".
 - f. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
 - g. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
 - 1) Type: Split **OR** Split and solid, **as directed**, core.
 - h. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
 - i. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BAS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.
2. Kilowatt-hour Meter: Electronic single **OR** three **OR** single- and three, **as directed**, -phase meters, measuring electricity used.
 - a. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 - b. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.
OR
Display: Digital electromechanical counter, indicating accumulative kilowatt-hours.
 3. Kilowatt-hour/Demand Meter: Electronic single **OR** three **OR** single- and three, **as directed**, -phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.
 - a. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 - b. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours, current time and date, current demand, and historic peak demand, and time and date of historic peak demand. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.
 4. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 26 Section "Control-voltage Electrical Power Cables".
 5. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation and billing, **as directed**.
 - a. Utility Cost Allocation: Automatically import energy-usage records to allocate energy costs for the following:
 - 1) At least 15 departments.
 - 2) At least 30 tenants.
 - 3) At least five processes.
 - 4) At least five buildings.
 - b. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare tenant bills **OR** activity demand and energy-use statements, **as directed**, based on metering of energy use and peak demand, **as directed**. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

1.3 EXECUTION

A. Installation

1. Comply with equipment installation requirements in NECA 1.
2. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
3. Install modular meter center according to NECA 400 switchboard installation requirements.



B. Identification

1. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
 - a. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.
 - b. Equipment Identification Labels: Adhesive film labels with clear protective overlay. For residential meters, provide an additional card holder suitable for printed, weather-resistant card **OR** typewritten card, **as directed**, with occupant's name.

C. Field Quality Control

1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
 - b. Turn off circuits supplied by metered feeder and secure them in off condition.
 - c. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
 - d. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
3. Electricity metering will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

END OF SECTION 26 24 13 00



SECTION 26 24 13 00a - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for enclosed switches and circuit breakers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Fusible switches.
 - b. Nonfusible switches.
 - c. Receptacle switches.
 - d. Shunt trip switches.
 - e. Molded-case circuit breakers (MCCBs).
 - f. Molded-case switches.
 - g. Enclosures.

C. Definitions

1. NC: Normally closed.
2. NO: Normally open.
3. SPDT: Single pole, double throw.

D. Performance Requirements

1. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed**.

E. Submittals

1. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
2. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - a. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
4. Field quality-control reports.
5. Operation and maintenance data.

F. Quality Assurance

1. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with NFPA 70.

G. Project Conditions

1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:



- a. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
- b. Altitude: Not exceeding 6600 feet (2010 m).
2. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - a. Notify the Owner no fewer than seven days in advance of proposed interruption of electric service.
 - b. Indicate method of providing temporary electric service.
 - c. Do not proceed with interruption of electric service without the Owner's written permission.
 - d. Comply with NFPA 70E.

1.2 PRODUCTS

A. Fusible Switches

1. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge **OR** plug, **as directed**, fuse interiors to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
2. Type HD, Heavy Duty, Single Throw, 240 **OR** 600, **as directed**, -V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
3. Type HD, Heavy Duty, Six Pole, Single Throw, 240 **OR** 600, **as directed**, -V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
4. Type HD, Heavy Duty, Double Throw, 240 **OR** 600, **as directed**, -V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
5. Accessories:
 - a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - c. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - d. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - e. Auxiliary Contact Kit: One **OR** Two, **as directed**, NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 - f. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - g. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, and conductor material.
 - h. Service-Rated Switches: Labeled for use as service equipment.
 - i. Accessory Control Power Voltage: Remote mounted and powered; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

B. Nonfusible Switches

1. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.



2. Type HD, Heavy Duty, Single Throw, 240 **OR** 600, **as directed**,-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
3. Type HD, Heavy Duty, Six Pole, Single Throw, 240 **OR** 600, **as directed**,-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
4. Type HD, Heavy Duty, Double Throw, 240 **OR** 600, **as directed**,-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
5. Accessories:
 - a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - c. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - d. Auxiliary Contact Kit: One **OR** Two, **as directed**, NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 - e. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - f. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, and conductor material.
 - g. Accessory Control Power Voltage: Remote mounted and powered; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

C. Receptacle Switches

1. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 240 **OR** 600, **as directed**,-V ac, 30 **OR** 60 **OR** 100, **as directed**, A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
2. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 240 **OR** 600, **as directed**,-V ac, 30 **OR** 60 **OR** 100, **as directed**, A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
3. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
4. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

D. Shunt Trip Switches

1. General Requirements: Comply with ASME A17.1, **as directed**, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.
2. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
3. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer **OR** source, **as directed**, of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.
4. Accessories:
 - a. Oiltight key switch for key-to-test function.
 - b. Oiltight red **OR** green **OR** white **OR** yellow, **as directed**, ON pilot light.
 - c. Isolated neutral lug; 100 **OR** 200, **as directed**, percent rating.
 - d. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
 - e. Form C alarm contacts that change state when switch is tripped.



- f. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac **OR** 24-V dc, **as directed**, coil voltage.
- g. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

E. Molded-Case Circuit Breakers

1. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
4. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
5. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
6. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
7. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
8. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
9. Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, trip ratings, and conductor material.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - d. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered **OR** remote-mounted and powered, **as directed**, type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - e. Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system, specified in Division 26 Section "Electrical Power Monitoring And Control".
 - f. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - h. Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - i. Alarm Switch: One NO **OR** NC, **as directed**, contact that operates only when circuit breaker has tripped.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - k. Zone-Selective Interlocking: Integral with electronic **OR** ground-fault, **as directed**, trip unit; for interlocking ground-fault protection function.
 - l. Electrical Operator: Provide remote control for on, off, and reset operations.



- m. Accessory Control Power Voltage: Integrally mounted, self-powered **OR** Remote mounted and powered, **as directed**; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

F. Molded-Case Switches

1. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
2. Features and Accessories:
 - a. Standard frame sizes and number of poles.
 - b. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, trip ratings, and conductor material.
 - c. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - d. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - f. Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
 - g. Alarm Switch: One NO **OR** NC, **as directed**, contact that operates only when switch has tripped.
 - h. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
 - i. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
 - j. Electrical Operator: Provide remote control for on, off, and reset operations.
 - k. Accessory Control Power Voltage: Integrally mounted, self-powered **OR** Remote mounted and powered, **as directed**; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

G. Enclosures

1. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 - a. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Kitchen **OR** Wash-Down, **as directed**, Areas: NEMA 250, Type 4X, stainless steel.
 - d. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 - f. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 **OR** Type 9, **as directed**.

1.3 EXECUTION

A. Installation

1. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
2. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
4. Install fuses in fusible devices.
5. Comply with NECA 1.



- B. Identification
1. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
 - a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
- C. Field Quality Control
1. Perform tests and inspections.
 2. Acceptance Testing Preparation:
 - a. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - b. Test continuity of each circuit.
 3. Tests and Inspections:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - c. Perform the following infrared scan tests and inspections and prepare reports:
 - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Final Completion.
 - 3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - d. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 4. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
 5. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Adjusting
1. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
 2. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".

END OF SECTION 26 24 13 00a



SECTION 26 24 13 00b - SWITCHBOARDS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for switchboards. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Service and distribution switchboards rated 600 V and less.
 - b. Transient voltage suppression devices.
 - c. Disconnecting and overcurrent protective devices.
 - d. Instrumentation.
 - e. Control power.
 - f. Accessory components and features.
 - g. Identification.
 - h. Mimic bus.

C. Performance Requirements

1. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For each switchboard and related equipment.
 - a. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 - b. Detail enclosure types for types other than NEMA 250, Type 1.
 - c. Detail bus configuration, current, and voltage ratings.
 - d. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 - e. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - f. Detail utility company's metering provisions with indication of approval by utility company.
 - g. Include evidence of NRTL listing for series rating of installed devices.
 - h. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - i. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
 - j. Include diagram and details of proposed mimic bus.
 - k. Include schematic and wiring diagrams for power, signal, and control wiring.
3. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
4. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
5. Field Quality-Control Reports.



6. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA PB 2.
3. Comply with NFPA 70.
4. Comply with UL 891.

F. Delivery, Storage, And Handling

1. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
2. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) **OR** connect factory-installed space heaters to temporary electrical service, **as directed**, to prevent condensation.
3. Handle and prepare switchboards for installation according to NECA 400 **OR** NEMA PB 2.1, **as directed**.

G. Project Conditions

1. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - a. Notify the Owner no fewer than seven days in advance of proposed interruption of electric service.
 - b. Indicate method of providing temporary electric service.
 - c. Do not proceed with interruption of electric service without the Owner's written permission.
 - d. Comply with NFPA 70E.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within five years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units

1. Front-Connected, Front-Accessible Switchboards:
 - a. Main Devices: Panel **OR** Fixed, individually, **as directed**, mounted.
 - b. Branch Devices: Panel mounted.
 - c. Sections front and rear aligned.
2. Front- and Side-Accessible Switchboards:
 - a. Main Devices: Fixed, individually mounted.
 - b. Branch Devices: Panel mounted.
 - c. Sections front and rear aligned.
3. Front- and Rear-Accessible Switchboards:
 - a. Main Devices: Fixed, individually **OR** Drawout, **as directed**, mounted.
 - b. Branch Devices: Panel **OR** Fixed, individually **OR** Panel and fixed, individually **OR** Fixed and individually compartmented **OR** Individually compartmented and drawout, **as directed**, mounted.
 - c. Sections front and rear **OR** rear, **as directed**, aligned.
4. Nominal System Voltage: 480Y/277 V **OR** 208Y/120 V, **as directed**.
5. Main-Bus Continuous: 5000 **OR** 4000 **OR** 3000 **OR** 2500 **OR** 2000 **OR** 1600 **OR** 1200, **as directed**, A.



6. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
7. Indoor Enclosures: Steel, NEMA 250, Type 1 **OR** Type 5, **as directed**.
8. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray **OR** custom color, **as directed**, finish over a rust-inhibiting primer on treated metal surface.
9. Outdoor Enclosures: Type 3R **OR** Type 3R, with interior-lighted walk-in aisle, **as directed**.
 - a. Finish: Factory-applied finish in manufacturer's standard **OR** custom, **as directed**, color; undersurfaces treated with corrosion-resistant undercoating.
 - b. Enclosure: Flat **OR** Downward, rearward sloping, **as directed**, roof; bolt-on rear covers **OR** rear hinged doors, **as directed**, for each section, with provisions for padlocking.
 - c. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking **OR** cylinder lock, **as directed**.
 - d. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; ground-fault circuit interrupter (GFCI) duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
 - e. Walk-in Aisle Heating and Ventilating:
 - 1) Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F (5 deg C) with outside design temperature of 104 deg F (40 deg C).
 - 2) Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 100 deg F (38 deg C) with outside design temperature of 23 deg F (minus 5 deg C).
 - 3) Ventilating openings complete with replaceable fiberglass air filters.
 - 4) Thermostat: Single stage; wired to control heat and exhaust fan.
 - f. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a control-power transformer within the switchboard. Supply voltage shall be 120 **OR** 120/240 **OR** 120/208, **as directed**, -V ac.
 - g. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.
10. Barriers: Between adjacent switchboard sections.
11. Insulation and isolation for main bus of main section, **as directed**, and main and vertical buses of feeder sections.
12. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
 - a. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point **OR** Manual switching of branch-circuit protective device, **as directed**.
 - b. Space-Heater Power Source: Transformer, factory installed in switchboard **OR** 120-V external branch circuit, **as directed**.
13. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.
14. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks, **as directed**.
15. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
16. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws **OR** standard bolts, **as directed**, for access to rear interior of switchboard.
17. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.



18. Pull Box on Top of Switchboard:
 - a. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 - b. Set back from front to clear circuit-breaker removal mechanism.
 - c. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
 - d. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 - e. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
19. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - a. Phase- and Neutral-Bus Material: One of the following:
 - 1) Hard-drawn copper of 98 percent conductivity, silver-plated, **as directed**, with tin-plated aluminum or copper feeder circuit-breaker line connections.
 - 2) Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
 - 3) Hard-drawn copper of 98 percent conductivity, silver-plated, **as directed**, or tin-plated, high-strength, electrical-grade aluminum alloy.
 - b. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 - c. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) **OR** 1/4-by-1-inch- (6-by-25-mm-) **OR** Minimum-size required by UL 891, **as directed**, hard-drawn copper of 98 percent conductivity, equipped with mechanical **OR** compression, **as directed**, connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 - d. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 - e. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 - f. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 - g. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
20. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
21. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
22. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

B. Transient Voltage Suppression Devices

1. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, wired-in **OR** plug-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:
 - a. Fuses, rated at 200-kA interrupting capacity.
 - b. Fabrication using bolted compression lugs for internal wiring.
 - c. Integral disconnect switch.
 - d. Redundant suppression circuits.
 - e. Redundant replaceable modules.
 - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.



- g. LED indicator lights for power and protection status.
 - h. Audible alarm, with silencing switch, to indicate when protection has failed.
 - i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - j. Four **OR** Six, **as directed**, -digit, transient-event counter set to totalize transient surges.
- 2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
 - 3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
 - 4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**, -V, three-phase, four-wire circuits shall be as follows:
 - a. Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - b. Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - c. Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
 - 5. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
 - a. Line to Neutral: 400 V, 800 V from high leg.
 - b. Line to Ground: 400 V.
 - c. Neutral to Ground: 400 V.
 - 6. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
 - a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
 - b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- C. Disconnecting And Overcurrent Protective Devices
- 1. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
 - a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long- and short-time time adjustments.
 - 4) Ground-fault pickup level, time delay, and I^2t response.
 - d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 - f. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - g. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - h. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - 1) Standard frame sizes, trip ratings, and number of poles.
 - 2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.



- 3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - 4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - 6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring And Control".
 - 7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
 - 8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - 20) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
2. Insulated-Case Circuit Breaker (ICCB): 80 **OR** 100, **as directed**, percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
- a. Fixed **OR** Drawout, **as directed**, circuit-breaker mounting.
 - b. Two-step, stored-energy closing.
 - c. Standard **OR** Full, **as directed**,-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time time adjustments.
 - 3) Ground-fault pickup level, time delay, and I^2t response.
 - d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - e. Remote trip indication and control.
 - f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring And Control".
 - g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - h. Control Voltage: 40-V dc **OR** 125-V dc **OR** 250-V dc **OR** 120-V ac, **as directed**.
3. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.
- a. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
 - b. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
 - 1) Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
 - 2) Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
 - c. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
 - d. Service-Rated Switches: Labeled for use as service equipment.



- e. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
 - 1) Configuration: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 2) Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
 - 3) No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
 - 4) Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
- f. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
- 4. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.
 - a. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
 - b. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
 - 1) Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
 - 2) Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
 - c. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
 - d. Service-Rated Switches: Labeled for use as service equipment.
 - e. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
 - 1) Configuration: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 2) Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
 - 3) No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
 - 4) Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
 - f. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
- 5. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- 6. Fuses are specified in Division 26 Section "Fuses".

D. Instrumentation

- 1. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
 - a. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single **OR** tapped **OR** double, **as directed**, secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 - b. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound **OR** bushing **OR** bar or window, **as directed**, type; single **OR** double, **as directed**, secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 - c. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 - d. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.



2. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - a. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
 - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - 4) Megawatts: Plus or minus 2 percent.
 - 5) Megavars: Plus or minus 2 percent.
 - 6) Power Factor: Plus or minus 2 percent.
 - 7) Frequency: Plus or minus 0.5 percent.
 - 8) Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - 9) Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
 - 10) Contact devices to operate remote impulse-totalizing demand meter.
 - b. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
 - a. Meters: 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment.
 - b. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
4. Instrument Switches: Rotary type with off position.
 - a. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
 - b. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
5. Feeder Ammeters: 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
6. Watt-Hour Meters and Wattmeters:
 - a. Comply with ANSI C12.1.
 - b. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
 - c. Suitable for connection to three- and four-wire circuits.
 - d. Potential indicating lamps.
 - e. Adjustments for light and full load, phase balance, and power factor.
 - f. Four-dial clock register.
 - g. Integral demand indicator.
 - h. Contact devices to operate remote impulse-totalizing demand meter.
 - i. Ratchets to prevent reverse rotation.
 - j. Removable meter with drawout test plug.
 - k. Semiflush mounted case with matching cover.
 - l. Appropriate multiplier tag.
7. Impulse-Totalizing Demand Meter:
 - a. Comply with ANSI C12.1.
 - b. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
 - c. Cyclometer.
 - d. Four-dial, totalizing kilowatt-hour register.
 - e. Positive chart drive mechanism.
 - f. Capillary pen holding a minimum of one month's ink supply.
 - g. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
 - h. Capable of indicating and recording five **OR** 15 **OR** 30, **as directed**, -minute integrated demand of totalized system.



- E. Control Power
1. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer **OR** 120-V ac, supplied from remote branch circuit, **as directed**.
 2. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
 3. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
 4. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
- F. Accessory Components And Features
1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
 2. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
 3. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
 4. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
 5. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.
- G. Identification
1. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
 - a. Nameplate: At least 0.032-inch- (0.813-mm-) thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.
 2. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
 - a. Nameplate: At least 0.0625-inch- (1.588 mm-) thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.
 3. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
 4. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
 5. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
 6. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

1.3 EXECUTION

- A. Installation
1. Install switchboards and accessories according to NECA 400 **OR** NEMA PB 2.1, **as directed**.
 2. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.



- b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to switchboards.
3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
 4. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers And Supports For Electrical Systems".
 5. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
 6. Install filler plates in unused spaces of panel-mounted sections.
 7. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
 - a. Set field-adjustable switches and circuit-breaker trip ranges.
 8. Install spare-fuse cabinet.
 9. Comply with NECA 1.
- B. Connections
1. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies". Drawings indicate general arrangement of bus, fittings, and specialties.
 2. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays For Electrical Systems". Drawings indicate general arrangement of cable trays, fittings, and specialties.
- C. Identification
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
 2. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
 3. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
- D. Field Quality Control
1. Acceptance Testing Preparation:
 - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - b. Test continuity of each circuit.
 2. Tests and Inspections:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - c. Perform the following infrared scan tests and inspections and prepare reports:
 - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front **OR** front and rear, **as directed**, panels so joints and connections are accessible to portable scanner.
 - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Final Completion.
 - 3) Instruments and Equipment:



-
- a) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - d. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Switchboard will be considered defective if it does not pass tests and inspections.
 - 4. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- E. Adjusting
- 1. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
 - 2. Set field-adjustable circuit-breaker trip ranges as indicated **OR** as specified in Division 26 Section "Overcurrent Protective Device Coordination Study", **as directed**.
- F. Protection
- 1. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

END OF SECTION 26 24 13 00b



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Task	Specification	Specification Description
26 24 16 00	01 51 13 00	Panelboards



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SECTION 26 24 19 00 - POWER DISTRIBUTION UNITS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for power distribution units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes freestanding, prepackaged, power distribution units for transforming, conditioning, and distributing electrical power.

C. Definitions

1. TVSS: Transient voltage surge suppression.
2. UPS: Uninterrupted power supply.

D. Submittals

1. Product Data: For power distribution units.
2. Shop Drawings: Include dimensioned plans, sections, and elevations. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that power distribution units, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems". Include the following:
4. Field quality-control test reports.
5. Operation and Maintenance Data: For power distribution units to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

F. Delivery, Storage, And Handling

1. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.
2. Store equipment in spaces with environments controlled within manufacturer's ambient temperature and humidity tolerances for non-operating equipment.

1.2 PRODUCTS

A. Manufactured Units

1. Description: Integrated and coordinated assembly of power-line-conditioning and distribution components packaged in a single cabinet or modular assembly of cabinets each with full-swivel casters mounted to bottom frame, **as directed**. Include the following components:
 - a. Input-power, circuit-breaker section.
 - b. Isolation transformer.
 - c. TVSS system.
 - d. Output panelboard(s).



- e. Alarm, monitoring, and control system.
 2. Provide units that are constructed to withstand seismic forces specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
 3. Unit Capacity Rating: Unit shall carry indicated rms kilovolt-ampere load continuously without exceeding rated insulation temperature for the following input voltage and load current:
 - a. Input Voltage: Within rated input-voltage tolerance band of unit.
 - b. Load Current: Minimum of 3.0 crest factor and 85 percent total harmonic distortion.
- B. Input-Power, Circuit-Breaker Section
1. Description: 3-pole, shunt-tripped, thermal-magnetic-type circuit breaker, rated for indicated interrupting capacity and 125 percent of input current of unit at 100 percent rated load.
 - a. Dual-Input Units:
 - 1) Two input circuit breakers arranged to provide transfer between two input-voltage sources.
 - 2) Controls and interfaces to allow both open- and closed-transition transfer between two input-voltage sources.
 - 3) Use a 120-V permissive signal from both upstream voltage sources to indicate acceptable conditions for closed-transition transfer.
 - 4) Open second circuit breaker automatically after closed-transition transfer is completed.
- C. Isolation Transformer Section
1. Description: Dry-type, electrostatically shielded, three-phase, common-core, convection-air-cooled isolation transformer.
 - a. Comply with UL 1561 including requirements for nonsinusoidal load-current-handling capability defined by designated K-factor, **as directed**.
 - b. Cores: Grain-oriented, non-aging silicon steel, one leg per phase.
 - c. Coil Material and Insulation: Copper windings with a 220 deg C insulation class.
 - d. Temperature Rise: Designed for 80 **OR** 115 **OR** 150, **as directed**, deg C rise above 40 deg C ambient.
 - e. Output Impedance: 3.5 plus or minus 0.5 percent.
 - f. Regulation: 2 to 4 percent maximum, at full-resistive load; 5 percent maximum, at rated nonlinear load.
 - g. Taps: 6 full-capacity compensation taps at 2.5 percent increments; 2 above and 4 below nominal voltage.
 - h. Full-Load Efficiency: Minimum 96 percent at rated nonlinear, **as directed**, load.
 - i. Magnetic-Field Strength External to Transformer Enclosure: Less than 0.1 gauss at 450 mm.
 - j. Audible Noise: Comply with NEMA ST 20.
 - k. Electrostatic Shielding: Independently shield each winding with a double-copper, electrostatic shield arranged to minimize interwinding capacitance.
 - 1) Coil leads and terminal trips shall be arranged to minimize capacitive coupling between input and output connections.
 - 2) Shield Terminal: Separate, and marked "Shield" for grounding connection.
 - 3) Capacitance: Limit capacitance between primary and secondary windings to a maximum of 33 picofarads over a frequency range of 20 Hz to 1 MHz.
 - 4) Common-Mode Noise Attenuation: 120 dB minimum, 0.5 to 1.5 kHz; minus 65 dB minimum, 1.5 to 100 kHz.
 - 5) Normal-Mode Noise Attenuation: Minus 52 dB minimum, 1.5 to 10 kHz.
 - l. Neutral Rating: 1.732 times the system full-load ampere rating.
- D. TVSS System
1. Description: Integrated TVSS system complying with Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits", to protect unit panelboard, and having the following features:



- a. Disconnect Device: Manual, three-pole, fused disconnect switch to de-energize TVSS system while permitting power distribution units to continue operation. Fuses are rated at 200-kA interrupting capacity.
 - b. Nonlinear Loading: System shall accommodate rated-load current with a minimum 3.0 crest factor and 85 percent total harmonic distortion.
- E. Output Panelboards
1. Description: Panelboards complying with Division 26 Section "Panelboards", except for mounting provisions. Mount in front of power distribution units behind flush doors. Include the following features:
 - a. Construction: 42 pole, 240 V, 3 phase; capable of accepting branch circuit breakers rated to 100 A.
 - b. Panelboard Rating: 225 A, with main circuit breaker.
 - c. Panelboard Phase, Neutral and Ground Buses: Copper, with neutral bus at least 1.732 times the nominal phase bus rating.
 - d. Isolated Ground Bus: Copper, adequate for branch-circuit equipment ground conductors; insulated from supports.
 - e. Branch Circuit Breakers: Bolt **OR** Plug, **as directed**, on.
 - f. Cable Racks: Removable and arranged for supporting and routing cables for panelboard entrance.
 - g. Access Panels: Arranged so additional branch-circuit wiring can be installed and connected in the future.
- F. Power Distribution Unit Controls
1. Include the following control features:
 - a. Emergency, power-off switch integral with power distribution unit.
 - b. Emergency, power-off input terminals for connection to remote power-off switch.
 - c. Over-under alarm shutdown with automatic unit disconnection for the following alarm conditions:
 - 1) High temperature.
 - 2) High and low input or output voltage.
 - 3) Phase loss.
 - 4) Ground fault.
 - 5) Reverse phase rotation.
 - d. Ground-fault protection with automatic system shutdown.
 - e. Alarm Contacts: Electrically isolated, Form C (one normally open and one normally closed), summary alarm; contact set shall change state if any monitored function goes into alarm mode.
 - f. Remote Power-Off Control: Control circuit with connection to shunt trip of power distribution unit main power circuit breaker and terminals for connection to one or more remote power-off, push-button stations.
- G. Monitoring, Status, And Alarm Annunciation
1. Description: Microprocessor-based monitoring, status, and alarm annunciation panel mounted flush in front of power distribution unit to provide status display and failure-indicating interface for the following:
 - a. Power Monitoring:
 - 1) Input Voltage: Line to line, rms.
 - 2) Output Voltage: Line to line, rms.
 - 3) Output Voltage: Line to neutral, rms.
 - 4) Output current.
 - b. Status Indication: Unit on.
 - c. Alarm Annunciation:
 - 1) High temperature.
 - 2) High and low input voltage.
 - 3) High and low output voltage.



- 4) Phase loss.
 - 5) Ground fault.
 - 6) Frequency.
 - 7) Phase rotation.
 - 8) TVSS module failure.
- d. Audible Alarm and Silencing Switch: Alarm sounds when alarm indication occurs. Silencing switch shall silence audible alarm but leave visual indication active until failure or other alarm conditions are corrected.

H. Sound Level

1. General: Fully assembled products comply with minimum sound-level requirements in NEMA ST 20 for transformers of corresponding ratings when factory tested according to IEEE C57.12.91.
2. General: Fully assembled products have a minimum of 3 dB less than the maximum sound levels prescribed for transformers of corresponding ratings when factory tested according to IEEE C57.12.91.

I. Finishes

1. Manufacturer's standard finish over corrosion-resistant pretreatment and primer.

J. Source Quality Control

1. Factory Tests: Design and routine tests shall comply with referenced standards.
2. Factory Sound-Level Tests: Conduct sound-level tests on equipment. Comply with IEEE C57.12.91 and NEMA ST 20.

1.3 EXECUTION

A. Installation

1. Arrange power distribution units to provide adequate access to equipment and circulation of cooling air.
2. Anchor or restrain floor-mounting power distribution units according to manufacturer's written instructions, seismic codes applicable to Project, **as directed**, and requirements in Division 26 Section "Hangers And Supports For Electrical Systems".
3. Identify equipment and install warning signs according to Division 26 Section "Identification For Electrical Systems".

B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 - a. Separately Derived Systems: Make grounding connections to grounding electrodes as indicated; comply with NFPA 70.
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification for circuit breakers, molded case; and for transformers, dry type, air cooled, low voltage, small. Certify compliance with test parameters.
 - b. Perform functional tests of power distribution units throughout their operating ranges. Test each monitoring, status, and alarm function.
 - c. Infrared Scanning: Two months after Final Completion, perform an infrared scan of conductor and bus connections.



- 1) Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 - 2) Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Final Completion.
 - 3) Prepare a certified report identifying connections checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
3. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.
- D. Adjusting
1. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 2. Adjust power distribution units to provide optimum voltage to equipment served throughout normal operating cycle of loads served. Record input and output voltages and adjustment settings, and incorporate into test results.
- E. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 24 19 00



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Task	Specification	Specification Description
26 24 19 00	01 22 16 00	No Specification Required
26 24 19 00	26 09 23 00b	Electrical Power Monitoring And Control
26 24 19 00	23 09 23 00	Enclosed Controllers
26 24 19 00	26 11 16 00	Switchgear
26 24 19 00	26 09 23 00c	Motor-Control Centers



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SECTION 26 25 00 00 - ENCLOSED BUS ASSEMBLIES**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for enclosed bus assemblies. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Feeder-bus assemblies.
 - b. Plug-in bus assemblies.
 - c. Bus plug-in devices.

C. Definitions

1. TVSS: Transient voltage surge suppressor.

D. Submittals

1. Shop Drawings: For each type of bus assembly **OR** bus assembly and plug-in device, **as directed**.
 - a. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
 - b. Show fittings, materials, fabrication, and installation methods for listed fire-stop barriers and weather barriers.
 - c. Indicate required clearances, method of field assembly, and location and size of each field connection.
 - d. Detail connections to switchgear, switchboards, transformers, and panelboards.
 - e. Wiring Diagrams: Power and signal **OR** and control, **OR** signal, and control, **as directed**, wiring.
 - f. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.
 - 1) Design Calculations: Calculate requirements for selecting seismic restraints.
 - 2) Detail fabrication, including anchorages and attachments to structure and to supported equipment.
2. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:
 - a. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
 - b. Clearances for access above and to the side of enclosed bus assemblies.
 - c. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
 - d. Support locations, type of support, and weight on each support.
3. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.
4. Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.
5. Manufacturer Seismic Qualification Certification: Submit certification that enclosed bus assemblies, plug-in devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems" Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 1) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."



- 2) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Qualification Data: For professional engineer and testing agency.
7. Field quality-control test reports.
8. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - a. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 1.3.
2. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
3. Source Limitations: Obtain enclosed bus assemblies and plug-in devices through one source from a single manufacturer.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. Comply with NEMA BU 1, "Busways."
6. Comply with NFPA 70.

F. Delivery, Storage, And Handling

1. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less."

G. Project Conditions

1. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 122 deg F (50 deg C) **OR** 140 deg F (60 deg C), **as directed**.

H. Coordination

1. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
2. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified in Division 31.

1.2 PRODUCTS

A. Enclosed Bus Assemblies

1. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.
 - a. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces



- defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems" when mounting provisions and attachments are anchored to building structure
- b. Voltage: 120/208 **OR** 240 **OR** 480 **OR** 277/480, **as directed**, V; 3 phase; 100 **OR** 200 **OR** percent neutral capacity, **as directed**.
 - c. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
 - d. Bus Materials: Current-carrying copper **OR** aluminum, **as directed**, conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
 - e. Ground:
 - 1) 50 percent capacity integral with housing.
 - 2) 50 percent capacity internal bus bars of material matching bus material.
 - 3) 50 percent capacity isolated, internal bus bar of material matching bus material.
 - f. Enclosure: Steel with manufacturer's standard finish **OR** Aluminum with manufacturer's standard finish **OR** Weatherproof, steel or aluminum with manufacturer's standard finish, sealed seams, drains, and removable closures, **as directed**.
 - g. Fittings and Accessories: Manufacturer's standard.
 - h. Mounting: Arranged flat, edgewise, or vertically without derating.
2. Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.
- a. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for switchboards with reinforcement strong enough to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems" when mounting provisions and attachments are anchored to building structure.
 - b. Voltage: 120/208 **OR** 240 **OR** 480 **OR** 277/480, **as directed**, V; 3 phase; 100 **OR** 200 **OR** percent neutral capacity, **as directed**.
 - c. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
 - d. Bus Materials: Current-carrying copper **OR** aluminum, **as directed**, conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.
 - e. Ground:
 - 1) 50 percent capacity integral with housing.
 - 2) 50 percent capacity internal bus bar of material matching bus material.
 - 3) 50 percent capacity isolated, internal bus bar of material matching bus material.
 - f. Enclosure: Steel, with manufacturer's standard finish, plug-in openings 24 inches (610 mm) o.c., and hinged covers over unused openings **OR** Aluminum, with manufacturer's standard finish, plug-in openings 24 inches (610 mm) o.c., and hinged covers over unused openings, **as directed**.
 - g. Fittings and Accessories: Manufacturer's standard.
 - h. Mounting: Arranged flat, edgewise, or vertically without derating.
- B. Plug-In Devices
1. Fusible Switches: NEMA KS 1, heavy duty; with R-type rejection **OR** J-type **OR** L-type, **as directed**, fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. See Division 16 Section "Fuses" for fuses and fuse installation requirements.
 2. Molded-Case Circuit Breakers: NEMA AB 1; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position.
 3. TVSS: NEMA 250, Type 1 enclosure with NEMA KS 1, fusible, disconnect switch and external handle to isolate TVSS from busway. TVSS product and installation requirements are specified in Division 16 Section "Transient Voltage Suppression."
 4. Motor Controllers: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
 - a. Control Circuit: 120 V; obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.



- b. Combination Controller: Factory-assembled combination controller and disconnect switch with or without overcurrent protection as indicated.
 - 1) Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with R-type rejection **OR** J-type, **as directed**, fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory (NRTL) acceptable to authorities having jurisdiction. See Division 26 Section "Fuses" for fuses and fuse installation requirements.
OR
Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
OR
Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- c. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic. Overload relays shall have heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
- d. Adjustable Overload Relay: Dipswitch selected for motor running overload protection with NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Adjustable overload relays shall have Class II ground-fault protection with start and run delays to prevent nuisance trip on starting.
- 5. Multispeed Motor Controllers: Match controller to motor type, application, and number of speeds; include the following accessories:
 - a. Compelling relay ensures motor starts only at low speed.
 - b. Accelerating relay ensures properly timed acceleration through speeds lower than that selected.
 - c. Decelerating relay ensures automatically timed deceleration through each speed.
- 6. Accessories: Hookstick operator, adjustable to maximum extension of 14 feet (4.3 m), **as directed**.

1.3 EXECUTION

A. Installation

- 1. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.
 - a. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
 - b. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
 - c. Support bus assembly to prevent twisting from eccentric loading.
 - d. Support bus assembly with not less than 3/8-inch (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
 - e. Fasten supports securely to building structure according to Division 26 Section "Hangers And Supports For Electrical Systems".
- 2. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
- 3. Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Division 07 Section "Penetration Firestopping".



4. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Division 07 Section "Joint Sealants" for materials and application.
 5. Install a concrete curb at least 4 inches (100 mm) high around bus-assembly floor penetrations.
 6. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.
 7. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.
 8. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.
- B. Connections
1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
 2. Tests and Inspections:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 3. Remove and replace units that do not pass tests and inspections and retest as specified above.
 4. Infrared Scanning: Two months after Final Completion, perform an infrared scan of bus assembly including joints and plug-in units.
 - a. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 - b. Perform 2 follow-up infrared scans of bus assembly, one at 4 months and the other at 11 months after Final Completion.
 - c. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
 5. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.
- D. Adjusting
1. Set field-adjustable, circuit-breaker trip ranges and overload relay trip settings, **as directed**, as indicated.
- E. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
- F. Protection
1. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 26 25 00 00



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Task	Specification	Specification Description
26 26 00 00	26 24 19 00	Power Distribution Units
26 27 13 00	02 84 33 00	Overhead Electrical Distribution
26 27 16 00	01 22 16 00	No Specification Required
26 27 16 00	26 05 33 16	Raceways And Boxes
26 27 16 00	26 09 23 00b	Electrical Power Monitoring And Control
26 27 16 00	26 09 23 00c	Motor-Control Centers
26 27 23 00	26 05 33 16a	Wiring Devices
26 27 26 00	01 22 16 00	No Specification Required
26 27 26 00	26 05 33 16	Raceways And Boxes
26 27 26 00	26 05 33 16a	Wiring Devices
26 27 26 00	26 09 23 00b	Electrical Power Monitoring And Control
26 27 26 00	23 09 23 00	Enclosed Controllers
26 27 73 00	26 05 33 16a	Wiring Devices



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SECTION 26 28 13 00 - FUSES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for fuses. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, panelboards, switchboards, enclosed controllers, and motor-control centers.
 - b. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches, fuseholders, and panelboards.
 - c. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.
 - d. Spare-fuse cabinets.

C. Submittals

1. Product Data: For each type of product indicated.
2. Operation and maintenance data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA FU 1 for cartridge fuses.
3. Comply with NFPA 70.
4. Comply with UL 248-11 for plug fuses.

E. Project Conditions

1. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.2 PRODUCTS

A. Cartridge Fuses

1. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

B. Plug Fuses

1. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

C. Plug-Fuse Adapters

1. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

D. Spare-Fuse Cabinet

1. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 - a. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.



- b. Finish: Gray, baked enamel.
- c. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
- d. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

1.3 EXECUTION

A. Fuse Applications

1. Cartridge Fuses:
 - a. Service Entrance: Class L, fast acting **OR** Class L, time delay **OR** Class RK1, fast acting **OR** Class RK1, time delay **OR** Class J, fast acting **OR** Class J, time delay **OR** Class T, fast acting, **as directed**.
 - b. Feeders: Class L, fast acting **OR** Class L, time delay **OR** Class RK1, fast acting **OR** Class RK1, time delay **OR** Class RK5, fast acting **OR** Class RK5, time delay **OR** Class J, fast acting **OR** Class J, time delay, **as directed**.
 - c. Motor Branch Circuits: Class RK1 **OR** Class RK5, **as directed**, time delay.
 - d. Other Branch Circuits: Class RK1, time delay **OR** Class RK5, time delay **OR** Class J, fast acting **OR** Class J, time delay, **as directed**.
 - e. Control Circuits: Class CC, fast acting **OR** time delay, **as directed**.
2. Plug Fuses:
 - a. Motor Branch Circuits: Edison-base type, dual **OR** Edison-base type, single **OR** Type S, dual **OR** Type S, single, **as directed**, -element time delay.
 - b. Other Branch Circuits: Edison-base type, single-element fast acting **OR** Edison-base type, dual-element time delay **OR** Edison-base type, single-element time delay **OR** Type S, dual-element time delay **OR** Type S, single-element time delay, **as directed**.

B. Installation

1. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
2. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.
3. Install spare-fuse cabinet(s).

C. Identification

1. Install labels complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 28 13 00



Task	Specification	Specification Description
26 28 13 00	26 11 16 00	Switchgear
26 29 13 13	01 22 16 00	No Specification Required
26 29 13 13	23 09 23 00	Enclosed Controllers



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**SECTION 26 31 00 00 - PHOTOVOLTAIC ENERGY EQUIPMENT**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for Photovoltaic Energy Equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. PV laminates (cells laminated into rigid sheets, with connecting cables).
 - b. PV modules (laminates in mounting frames).
 - c. Charge controllers.
 - d. Inverters.
 - e. Mounting structures.

C. Definitions

1. CEC: California Energy Commission.
2. ETFE: Ethylene tetrafluoroethylene.
3. FEP: Fluorinated ethylene propylene.
4. IP Code: Required ingress protection to comply with IEC 60529.
5. MPPT: Maximum power point tracking.
6. PTC: USA standard conditions for PV.
7. PV: Photovoltaic.
8. STC: Standard Test Conditions defined in IEC 61215.

D. Action Submittals

1. Product Data: For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.
 - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For PV modules.
 - a. Include plans, elevations, sections, and mounting details.
 - b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Detail fabrication and assembly.
 - d. Include diagrams for power, signal, and control wiring.

E. Informational Submittals

1. Field quality-control reports.
2. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

F. Closeout Submittals

1. Operation and Maintenance Data: For PV modules to include in operation and maintenance manuals.

G. Warranty



1. Manufacturer's Special Materials and Workmanship Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.
 - a. Manufacturer's materials and workmanship warranties include, but are not limited to, the following:
 - 1) Faulty operation of PV modules.
 - b. Warranty Period: Two **OR** Five years from date of Final Completion.
2. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.
 - a. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Final Completion:
 - 1) Specified minimum power output to 80 percent or more, for a period of 25 years.

1.2 PRODUCTS

A. Performance Requirements

1. NRTL (Nationally Recognized Testing Laboratory) Listing: Entire assembly shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for electrical and fire safety, Class A **OR** Class C, according to UL 1703.
2. FM approved for NFPA 70, Class 1, Division 2, Group C and Group D hazardous locations.

B. System Description

1. Grid-Tied PV System:
 - a. Connected via a utility meter to the electrical utility.
 - b. An array of six modules to generate a total nominal 1000 rated W.
 - c. System Components:
 - 1) Cell materials.
 - 2) PV modules.
 - 3) Array frame.
 - 4) Charge controller.
 - 5) Inverter.
 - 6) Overcurrent protection/combiner box.
 - 7) Mounting structure.
 - 8) Utility meter.
2. Battery-Storage PV System:
 - a. Connected to a battery bank to provide electricity to Project.
 - b. An array of six modules to generate a total nominal 1000 rated W.
 - c. System Components:
 - 1) Cell materials.
 - 2) PV modules.
 - 3) Array frame.
 - 4) Charge controller.
 - 5) Inverter.
 - 6) Overcurrent protection/combiner box.
 - 7) Mounting structure.
 - 8) Battery charge controller(s).
 - 9) Batteries.
 - 10) Battery-storage structure.

C. Manufactured Units

1. Cell Materials: Amorphous silicon (a-Si) **OR** Cell Materials: Copper indium (di)selenide (CIS) **OR** Cell Materials: Copper indium gallium (di)selenide (CIGS) **OR** Cadmium telluride (CdTe) **OR**



- Cadmium sulfide **OR** Polycrystalline (c-Si) **OR** Polycrystalline (Gallium arsenide (GaAs) **OR** Monocrystalline (c-Si) **OR** Monocrystalline (Gallium arsenide (GaAs)), **as directed**.
2. Module Construction:
 - a. Nominal Size: 32 inches (800 mm) wide by 64 inches (1600 mm) long.
 - b. Weight: 42.8 lb (19.4 kg).
 3. Insulating Substrate Film: Flexible **OR** Rigid, polyester **OR** polyimide, **as directed**.
 4. Conducting Substrate Film: Flexible **OR** Rigid **OR** luoropolymer, ETFE **OR** FEP, **as directed**.
 5. Encapsulant: Ethyl vinyl acetate.
 6. Front Panel: Fully tempered glass.
 7. Front Panel: 0.125-inch- (3.2-mm-) thick glass.
 8. Front Panel: Low iron glass.
 9. Front Panel: Antireflective coating glass.
 10. Front Panel: Laminating film.
 11. Front Panel: Laminating material.
 12. Backing Material: Tempered glass.
 13. Backing Material: 0.125-inch- (3.2-mm-) thick glass; color **as directed**.
 14. Backing Material: Polyester film.
 - a. Layers: **as directed**.
 - b. Color: White **OR as directed**.
 15. Backing Material: PVC film.
 - a. Layers: **as directed**.
 - b. Color: White **OR as directed**.
 16. Bypass Diode Protection: Internal.
 17. Junction Box:
 - a. Size: 1.56 by 3.96 by 0.52 inch (39.6 by 100.6 by 13.2 mm).
 - b. Fully potted, vandal resistant.
 - c. IP Code: IP65 **OR** IP66 **OR** IP67, **as directed**.
 - d. Flammability Test: UL 1703.
 18. Output Cabling:
 - a. **0.158 inch (4 mm)**.
 - b. Quick, multiconnect, polarized connectors.
 - c. Two-Conductor Harness: No traditional return wire is needed from the end of a row back to the source combiner.
 19. Series Fuse Rating: **as directed**.
- D. Capacities And Characteristics
1. Minimum Electrical Characteristics:
 - a. Rated Open Circuit Voltage (V_{oc}): **as directed**.
 - b. Maximum System Voltage: **as directed**.
 - c. Maximum Power at Voltage (V_{pm}): **as directed**.
 - d. Short-Circuit Temperature Coefficient: **as directed**.
 - e. Rated Short-Circuit Current (I_{sc}): **as directed**.
 - f. Maximum System: **as directed**.
 - g. Rated Operation Current (I_{mp}): **as directed**.
 - h. Maximum Power at STC (P_{max}): **as directed**.
 2. Additional Electrical Characteristics:
 - a. PTC Rating: **as directed**.
 - b. Peak Power per Unit Area: **as directed**.
 - c. Tolerance of Pmax: **as directed**.
 - d. Minimum Peak Power: **as directed**.
 - e. Series Fuse Rating: **as directed**.
 - f. Module Efficiency: **as directed**.
 - g. Temperature Cycling Range: **as directed**.
 - h. Humidity, Freeze, Damp Heat Condition: **as directed**.
 - i. Wind Loading or Surface Pressure: **as directed**.
 - j. Maximum Distortion Angle: **as directed**.



- k. Hailstone Impact Withstand: **as directed.**
- l. Series Fuse Rating: **as directed.**
- 3. Normal Operating Temperature Characteristics (NOTC):
 - a. Temperature at Nominal Operating Cell Temperature: **as directed.**
 - b. Temperature Coefficient (NOTC P_{max}): **as directed.**
 - c. Temperature Coefficient (NOTC V_{oc}): **as directed..**
 - d. Temperature Coefficient (NOTC I_{sc}): **as directed.**
 - e. Temperature Coefficient (NOTC V_{mp}): **as directed.**
 - f. Temperature Coefficient (NOTC I_{mp}): **as directed.**
- E. Module Framing
 - 1. PV laminates mounted in anodized extruded-aluminum frames.
 - a. Entire assembly UL listed for electrical and fire safety, Class A **OR** Class C, according to UL 1703, complying with IEC 61215.
 - b. Frame strength exceeding requirements of certifying agencies in subparagraph above.
 - c. Finish: Anodized aluminum.
 - 1) Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
 - 2) Color: As indicated by manufacturer's designations.
 - d. Finish: High-performance organic finish.
 - 1) Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent PVC resin by weight.
 - 2) Color: As indicated by manufacturer's designations.
 - e. Finish: Baked-enamel finish.
 - 1) Color: As indicated by manufacturer's designations.
- F. Array Construction
 - 1. Framing:
 - a. Material: Extruded aluminum **OR** Galvanized steel **OR** Coated steel, **as directed.**
 - b. Maximum System Weight: Less than 4 lb/sq. ft. (19.53 kg/sq. m).
 - c. Minimum Distance to Connectors: **as directed.**
 - d. Raceway Cover Plates: Plastic **OR** Aluminum **OR** Galvanized steel, **as directed.**
 - 2. Flat-Roof Mounting:
 - a. No roof penetrations.
 - b. Self-ballasting.
 - c. Wind-tunnel tested to 110-mph (160-km/h) wind.
 - d. Service Life: **25** years.
 - e. Freestanding system.
- G. Charge Controller
 - 1. Charge Controller Electrical Characteristics:
 - a. Output Current Rating: **as directed.**
 - b. Nominal Battery Voltage: **as directed.**
 - c. PV Maximum Open Circuit Voltage: **as directed.**
 - d. Equalization Voltage: **as directed.**
 - e. Voltage Step-Down Capability: **as directed.**
 - f. Power Conversion Efficiency: **as directed.**
 - 2. Charge controllers shall have the following:
 - a. Digital display.
 - b. Data logging.
 - c. Remote interface.
 - d. External sensors.
 - e. Temperature compensation.



H. Inverter

1. Control Type: Pulse width modulation control.
2. Control Type: Maximum power point tracker control.
3. Inverter Electrical Characteristics:
 - a. Maximum Recommended PV Input Power: **as directed**.
 - b. Maximum Voc: **as directed**.
 - c. PV Start Voltage: **as directed**.
 - d. MPPT Voltage Range: **as directed**.
 - e. Maximum Input Current: **as directed**.
 - f. Number of String Inputs: **as directed**.
 - g. Number of Independent MPPT Circuits: **as directed**.
 - h. Nominal Output Voltage: **as directed**.
 - i. CEC Rated Power: **as directed**.
 - j. Nominal Output Voltage: **as directed**.
 - k. Maximum Output Current: **as directed**.
 - l. Peak Efficiency: **as directed**.
 - m. CEC Weighted Efficiency: **as directed**.
 - n. CEC Night Tare Loss: **as directed**.
 - o. DC/AC Terminal Range (AWG): **as directed**.
 - p. NEMA 250 Enclosure Rating: **as directed**.
4. Operating Conditions:
 - a. Operating Ambient Temperatures: Minus 4 to plus 122 deg F (20 to plus 50 deg C).
 - b. Storage Temperature: Minus 40 to plus 122 deg F (minus 40 to plus 50 deg C).
 - c. Relative Humidity: 0 to 95 percent, noncondensing.
5. Charge controllers shall have the following:
 - a. Overcurrent protection.
 - b. Generator input breaker box.
 - c. Automatic transfer relay.
 - d. Digital display.
 - e. Transformer.
 - f. Disconnect switch.
 - g. Shunt controller.
 - h. Shunt regulator.
 - i. Surge overload protection.
6. Enclosure:
 - a. NEMA 250, Type 3R.
 - b. Enclosure Material: Galvanized steel **OR** Steel, **as directed**.
 - c. Cooling Methods:
 - 1) Fan convection cooling.
 - 2) Passive cooling.
 - d. Protective Functions:
 - 1) AC over/under voltage.
 - 2) AC over/under frequency.
 - 3) Ground over current.
 - 4) Overtemperature.
 - 5) AC and dc overcurrent.
 - 6) DC over voltage.
 - e. Standard liquid crystal display, four lines, 20 characters, with user display and on/off toggle switch.
 - f. Weight: 260 lb (118 kg).
 - g. Dimensions: 54 by 36 by 19 inches (137 by 91 by 48 cm).
7. Disconnects:
 - a. Low-voltage disconnect.
 - b. Low-voltage reconnect.
 - c. High-temperature disconnect.
 - d. High-temperature reconnect.



8. Regulatory Approvals:
 - a. IEEE 1547.1.
 - b. IEEE 1547.3.
 - c. UL 1741.
9. Characteristics:
 - a. Inverter Dimensions: **as directed**.
 - b. Inverter Weight: **as directed**.

I. System Overcurrent Protection

1. Combiner Box:
 - a. Fuses: **as directed**.
 - b. Circuit Breakers: **as directed**.

J. Mounting Structures

1. Roof Mount: Extruded aluminum, two **OR** four rails, **as directed**, tilt legs, and roof standoffs.
2. Pole Mount: Top **OR** Panel tops **OR** Side, **as directed**.
3. Tracking Mounts: One **OR** Two axis, **as directed**.

1.3 EXECUTION

A. Examination

1. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
2. Do not begin installation until mounting surfaces have been properly prepared.
3. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
4. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.
5. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.
6. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Field Quality Control

1. Perform tests and inspections **with the assistance of a factory-authorized service representative**.
2. PV module will be considered defective if it does not pass tests and inspections.
3. Prepare test and inspection reports.

END OF SECTION 26 31 00 00



Task	Specification	Specification Description
26 31 00 00	01 22 16 00	No Specification Required



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SECTION 26 32 13 13 - PACKAGED ENGINE GENERATORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for packaged engine generators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes packaged engine-generator sets for emergency **OR** standby, **as directed**, power supply with the following features:
 - a. Gas and Diesel engine.
 - b. Unit-mounted and Remote-mounting cooling system.
 - c. Unit-mounted and Remote-mounting control and monitoring.
 - d. Performance requirements for sensitive loads.
 - e. Load banks.
 - f. Outdoor enclosure.

C. Definitions

1. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
2. LP: Liquid petroleum.

D. Submittals

1. Product Data: For each type of packaged engine generator and accessory indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

E. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. Comply with ASME B15.1.
5. Comply with NFPA 37.
6. Comply with NFPA 70.
7. Comply with NFPA 99 for healthcare facilities.
8. Comply with NFPA 110 requirements for Level 1 **OR** 2, **as directed**, emergency power supply system.



9. Comply with UL 2200.
10. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
11. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

F. Project Conditions

1. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - a. Ambient Temperature: 5 to 40 deg C **OR** Minus 15 to plus 40 deg C, **as directed**.
 - b. Relative Humidity: 0 to 95 percent for outdoor units.
 - c. Altitude: Sea level to 1000 feet (300 m).
2. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:
 - a. High salt-dust content in the air due to sea-spray evaporation.

1.2 PRODUCTS

A. Engine-Generator Set

1. Factory-assembled and -tested, engine-generator set.
2. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 - a. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
3. Capacities and Characteristics:
 - a. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
 - b. Output Connections: Three-phase, three **OR** four, **as directed**, wire.
 - c. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
4. Generator-Set Performance:
 - a. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 - b. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
 - c. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
 - d. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 - e. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
 - f. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
 - g. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
 - h. Start Time: Comply with NFPA 110, Type 10, system requirements.



5. Generator-Set Performance for Sensitive Loads:
 - a. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - 1) Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
 - b. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
 - c. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
 - d. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
 - e. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 - f. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
 - g. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
 - h. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
 - i. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - 1) Provide permanent magnet excitation for power source to voltage regulator.
 - j. Start Time: Comply with NFPA 110, Type 10, system requirements.

B. Engine

1. Fuel: Fuel oil, Grade DF-2 **OR** Natural gas with automatic LP-gas standby **OR** Natural gas, **as directed**.
2. Rated Engine Speed: 1800 rpm.
3. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
4. Lubrication System: The following items are mounted on engine or skid:
 - a. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 - b. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 - c. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
5. Engine Fuel System:
 - a. Main Fuel Pump For Diesel-Fueled Engine: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 - b. Relief-Bypass Valve For Diesel-Fueled Engine: Automatically regulates pressure in fuel line and returns excess fuel to source.
 - c. Dual Natural Gas with LP-Gas Backup (Vapor-Withdrawal) System:
 - 1) Carburetor.
 - 2) Secondary Gas Regulators: One for each fuel type.
 - 3) Fuel-Shutoff Solenoid Valves: One for each fuel source.
 - 4) Flexible Fuel Connectors: One for each fuel source.
6. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
7. Governor: Adjustable isochronous, with speed sensing.



8. Cooling System:
 - a. Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 - 1) Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - 2) Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 3) Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - 4) Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 - 5) Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a) Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b) End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
 - b. Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.
 - 1) Configuration: Vertical **OR** Horizontal, **as directed**, air discharge.
 - 2) Radiator Core Tubes: Aluminum **OR** Nonferrous-metal construction other than aluminum, **as directed**.
 - 3) Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 4) Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - 5) Fan: Driven by multiple belts from engine shaft **OR** totally enclosed electric motor with sealed bearings, **as directed**.
 - 6) Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - 7) Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
9. Muffler/Silencer:
 - a. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - 1) Minimum sound attenuation of 25 dB at 500 Hz.
 - 2) Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
 - b. Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - 1) Minimum sound attenuation of 18 dB at 500 Hz.
 - 2) Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 95 dBA or less.
 - c. Industrial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - 1) Minimum sound attenuation of 12 dB at 500 Hz.
 - 2) Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 87 dBA or less.
10. Air-Intake Filter: Standard **OR** Heavy, **as directed**, -duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
11. Starting System: 12 **OR** 24, **as directed**, -V electric, with negative ground.



- a. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
- b. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
- c. Cranking Cycle: As required by NFPA 110 for system level specified **OR** 60 seconds, **as directed**.
- d. Battery: Adequate capacity within ambient temperature range specified in Part 1.1 "Project Conditions" Article to provide specified cranking cycle at least twice **OR** three times, **as directed**, without recharging.
- e. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
- f. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1.1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
- g. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
- h. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236.
 - 1) Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - 2) Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - 3) Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - 4) Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - 5) Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - 6) Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

C. Fuel Oil Storage

1. Comply with NFPA 30.
2. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 - a. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
 - 1) Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
 - b. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine-generator system without being refilled.
 - c. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
 - d. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
 - e. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.



- f. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
 - g. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.
3. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
 - a. Tank level indicator.
 - b. Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.
 - c. Vandal-resistant fill cap.
 - d. Containment Provisions: Comply with requirements of authorities having jurisdiction.
- D. Control And Monitoring
1. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.
 2. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.
 3. Configuration:
 - a. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
 - b. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.
 - c. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:
 - 1) Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
 - 2) Switchboard Construction: Freestanding unit complying with Division 26 Section "Switchboards".
 - 3) Switchgear Construction: Freestanding unit complying with Division 26 Section "Low-voltage Switchgear".
 - 4) Current and Potential Transformers: Instrument accuracy class.
 4. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 **OR 2, as directed**, system, and the following:
 - a. AC voltmeter.
 - b. AC ammeter.
 - c. AC frequency meter.
 - d. DC voltmeter (alternator battery charging).
 - e. Engine-coolant temperature gage.
 - f. Engine lubricating-oil pressure gage.
 - g. Running-time meter.
 - h. Ammeter-voltmeter, phase-selector switch(es).



- i. Generator-voltage adjusting rheostat.
- j. Fuel tank derangement alarm.
- k. Fuel tank high-level shutdown of fuel supply alarm.
- l. Generator overload.
5. Indicating and Protective Devices and Controls:
 - a. AC voltmeter.
 - b. AC ammeter.
 - c. AC frequency meter.
 - d. DC voltmeter (alternator battery charging).
 - e. Engine-coolant temperature gage.
 - f. Engine lubricating-oil pressure gage.
 - g. Running-time meter.
 - h. Ammeter-voltmeter, phase-selector switch(es).
 - i. Generator-voltage adjusting rheostat.
 - j. Start-stop switch.
 - k. Overspeed shutdown device.
 - l. Coolant high-temperature shutdown device.
 - m. Coolant low-level shutdown device.
 - n. Oil low-pressure shutdown device.
 - o. Fuel tank derangement alarm.
 - p. Fuel tank high-level shutdown of fuel supply alarm.
 - q. Generator overload.
6. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
7. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 26 Section "Electrical Power Monitoring And Control".
8. Common Remote Audible Alarm:
 - a. Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
 - 1) Overcrank shutdown.
 - 2) Coolant low-temperature alarm.
 - 3) Control switch not in auto position.
 - 4) Battery-charger malfunction alarm.
 - 5) Battery low-voltage alarm.
 - b. Common Remote Audible Alarm for manually starting systems or for automatically starting systems not specified to comply with NFPA 110, Level 1, but where some remote alarm functions are needed. Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
 - 1) Engine high-temperature shutdown.
 - 2) Lube-oil, low-pressure shutdown.
 - 3) Overspeed shutdown.
 - 4) Remote emergency-stop shutdown.
 - 5) Engine high-temperature prealarm.
 - 6) Lube-oil, low-pressure prealarm.
 - 7) Fuel tank, low-fuel level.
 - 8) Low coolant level.
9. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.



10. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

E. Generator Overcurrent And Fault Protection

1. Generator Circuit Breaker:
 - a. Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.
 - 1) Tripping Characteristic: Designed specifically for generator protection.
 - 2) Trip Rating: Matched to generator rating.
 - 3) Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 - 4) Mounting: Adjacent to or integrated with control and monitoring panel.
 - b. Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
 - 1) Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - 2) Trip Settings: Selected to coordinate with generator thermal damage curve.
 - 3) Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 - 4) Mounting: Adjacent to or integrated with control and monitoring panel.
 - c. Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.
 - d. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - e. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - f. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 - g. Mounting: Adjacent to or integrated with control and monitoring panel.
2. Generator Disconnect Switch: Molded-case type, 100 percent rated.
 - a. Rating: Matched to generator output rating.
 - b. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.
3. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
 - a. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 - b. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 - c. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
 - d. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
 - e. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

F. Generator, Exciter, And Voltage Regulator

1. Comply with NEMA MG 1.
2. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
3. Electrical Insulation: Class H or Class F.
4. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.



5. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
6. Enclosure: Dripproof.
7. Instrument Transformers: Mounted within generator enclosure.
8. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - a. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
9. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
10. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
11. Subtransient Reactance: 12 percent, maximum.

G. Load Bank

1. Description: Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, resistive **OR** resistive and reactive, **as directed**, unit capable of providing a balanced 3-phase, delta-connected load to generator set at 100 percent rated-system capacity, at 80 percent power factor, lagging. Unit may be composed of separate resistive and reactive load banks controlled by a common control panel. Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.
2. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases.
3. Reactive Load Elements: Epoxy-encapsulated reactor coils.
4. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.
5. Load Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.
6. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.
7. Load-Bank Enclosures: NEMA 250, Type 3R, complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch- (13-mm-) square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge.
8. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.
9. Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.
10. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

H. Outdoor Generator-Set Enclosure

1. Description:
 - a. Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.



- b. Prefabricated or preengineered walk-in enclosure with the following features:
 - 1) Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
 - 2) Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
 - 3) Space Heater: Thermostatically controlled and sized to prevent condensation.
 - 4) Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
 - 5) Hinged Doors: With padlocking provisions.
 - 6) Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
 - 7) Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
 - 8) Muffler Location: Within **OR** External to, **as directed**, enclosure.
 2. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
 - a. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
 - b. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
 3. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
 - a. AC lighting system and connection point for operation when remote source is available.
 - b. DC lighting system for operation when remote source and generator are both unavailable.
 4. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.
- I. Motors
1. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
- J. Vibration Isolation Devices
1. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 - a. Material: Standard neoprene **OR** Natural rubber **OR** Bridge-bearing neoprene, complying with AASHTO M 251, **as directed**.
 - b. Durometer Rating: 30 **OR** 40 **OR** 45 **OR** 50 **OR** 60 **OR** 65 **OR** 70, **as directed**.
 - c. Number of Layers: One **OR** Two **OR** Three **OR** Four, **as directed**.
 2. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
 - a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - b. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.



- K. Finishes
 - 1. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.
- L. Source Quality Control
 - 1. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - a. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
 - b. Report factory test results within 10 days of completion of test.

1.3 EXECUTION

- A. Installation
 - 1. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
 - 2. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
 - 3. Install packaged engine generator with elastomeric isolator pads **OR** restrained spring isolators, **as directed**, having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
 - 4. Install remote radiator with elastomeric isolator pads **OR** restrained spring isolators, **as directed**, having a minimum deflection of 1 inch (25 mm) on concrete base on grade **OR** roof equipment supports on roof, **as directed**.
 - 5. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger **OR** remote radiator, **as directed**. Piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping".
 - 6. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping".
 - a. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping".
 - 7. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
 - 8. Piping installation requirements are specified in Division 21. Drawings indicate general arrangement of piping and specialties.
 - 9. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
 - 10. Connect cooling-system water piping to engine-generator set and remote radiator **OR** heat exchanger, **as directed** with flexible connectors.
 - 11. Connect engine exhaust pipe to engine with flexible connector.
 - 12. Connect fuel piping to engines with a gate valve and union and flexible connector.
 - a. Natural-gas piping, valves, and specialties for gas distribution are specified in Division 23 Section "Facility Natural-gas Piping".
 - b. LP-gas piping, valves, and specialties for gas piping are specified in Division 23 Section "Facility Liquefied-petroleum Gas Piping".
 - 13. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 - 14. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
 - 15. Identify system components according to Division 23 Section "Identification For Hvac Piping And Equipment" and Division 26 Section "Identification For Electrical Systems".



B. Field Quality Control

1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - b. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 - c. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - 1) Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - 2) Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - 3) Verify acceptance of charge for each element of the battery after discharge.
 - 4) Verify that measurements are within manufacturer's specifications.
 - d. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 - e. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 - f. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 - g. Exhaust Emissions Test: Comply with applicable government test criteria.
 - h. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 - i. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 - j. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
3. Coordinate tests with tests for transfer switches and run them concurrently.
4. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
5. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
7. Remove and replace malfunctioning units and retest **OR** reinspect, **as directed**, as specified above.
8. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
9. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

C. Demonstration



1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 26 32 13 13



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Task	Specification	Specification Description
26 32 13 19	26 32 13 13	Packaged Engine Generators
26 32 13 26	26 32 13 13	Packaged Engine Generators
26 32 29 00	26 32 13 13	Packaged Engine Generators



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**SECTION 26 33 43 00 - CENTRAL BATTERY INVERTERS**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for central battery inverters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes slow-transfer, fast-transfer, and UPS central battery inverters with the following features:
 - a. Output distribution section.
 - b. Internal maintenance bypass/isolation switch.
 - c. External maintenance bypass/isolation switch.
 - d. Multiple output voltages.
 - e. Emergency-only circuits.
 - f. Remote monitoring provisions.

C. Definitions

1. LCD: Liquid-crystal display.
2. LED: Light-emitting diode.
3. THD: Total harmonic distortion.
4. UPS: Uninterruptible power supply.

D. Submittals

1. Product Data: For the following:
 - a. Electrical ratings, including the following:
 - 1) Capacity to provide power during failure of normal ac.
 - 2) Inverter voltage regulation and THD of output current.
 - 3) Rectifier data.
 - 4) Transfer time of transfer switch.
 - 5) Data for specified optional features.
 - b. Transfer switch.
 - c. Inverter.
 - d. Battery charger.
 - e. Batteries.
 - f. Battery monitoring.
 - g. Battery-cycle warranty monitor.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
 - a. Wiring Diagrams: Detail internal and interconnecting wiring; and power, signal, and control wiring.
 - b. Elevation and details of control and indication displays.
 - c. Output distribution section.
3. Manufacturer Seismic Qualification Certification: Submit certification that central battery inverter equipment will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Operation and Maintenance Data.

E. Quality Assurance



1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Central Battery Inverter System: UL 924 and UL 1778, **as directed**, listed.
3. Comply with NFPA 70 and NFPA 101.

F. Delivery, Storage, And Handling

1. Deliver equipment in fully enclosed vehicles.
2. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.
 - a. Warranty Period: Include the following warranty periods, from date of Final Completion:
 - 1) Premium, Valve-Regulated, Recombinant, Lead-Calcium Batteries:
 - a) Full Warranty: One year.
 - b) Pro Rata: 19 years.
 - 2) Standard, Valve-Regulated, Recombinant, Lead-Calcium Batteries:
 - a) Full Warranty: One year.
 - b) Pro Rata: Nine years.
 - 3) Nickel-Cadmium, Wet-Cell Batteries:
 - a) Full Warranty: Five years.
 - b) Pro Rata: 15 years.
 - 4) Lead-Calcium, Wet-Cell Batteries:
 - a) Full Warranty: One year.
 - b) Pro Rata: Nine years.
 - 5) Lead-Antimony, Wet-Cell Batteries:
 - a) Full Warranty: One year.
 - b) Pro Rata: Nine years.

1.2 PRODUCTS

A. Inverter Performance Requirements

1. Slow-Transfer Central Battery Inverters: Automatically sense loss of normal ac supply and use an electromechanical switch to transfer loads. Transfer in one second or less from normal supply to battery-inverter supply.
 - a. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.
2. Fast-Transfer Central Battery Inverters: Automatically sense loss of normal ac supply and use a solid-state switch to transfer loads. Transfer in 0.004 second or less from normal supply to battery-inverter supply.
 - a. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.
3. UPS-Type Central Battery Inverters: Continuously provide ac power to connected electrical system.
 - a. Automatic Operation:
 - 1) Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier-charger and inverter, with battery connected in parallel with rectifier-charger output.



- 2) Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
 - 3) If normal power fails, battery continues supply-regulated ac power through the inverter to the load without switching or disturbance.
 - 4) When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier-charger then supplies power to the load through the inverter and simultaneously recharges battery.
 - 5) If battery becomes discharged and normal supply is available, rectifier-charger charges battery. When battery is fully charged, rectifier-charger automatically shifts to float-charge mode.
 - 6) If any element of central battery inverter system fails and power is available at normal supply terminals of system, static bypass transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.
 - 7) If a fault occurs in system supplied by central battery inverter and current flows in excess of the overload rating of central battery inverter system, static bypass transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
 - 8) When fault has cleared, static bypass transfer switch returns the load to central battery inverter system.
 - 9) If battery is disconnected, central battery inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.
- b. Manual Operation:
- 1) Turning inverter off causes static bypass transfer switch to transfer the load directly to normal ac supply circuit without disturbance or interruption.
 - 2) Turning inverter on causes static bypass transfer switch to transfer the load to inverter.
4. Maximum Acoustical Noise: **<Insert value>** dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 39 inches (990 mm) from nearest surface of component enclosure.
- B. Service Conditions
1. Environmental Conditions: Inverter system shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - a. Ambient Temperature for Electronic Components: 32 to 98 deg F (0 to 37 deg C).
 - b. Relative Humidity: 0 to 95 percent, noncondensing.
 - c. Altitude: Sea level to 4000 feet (1220 m).
- C. Inverters
1. Description: Solid-state type, with the following operational features:
 - a. Automatically regulate output voltage to within plus or minus 5 percent.
 - b. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load at unit power factor over the operating range of battery voltage.
 - c. Output Voltage Waveform of Unit: Sine wave with maximum 10 percent THD throughout battery operating-voltage range, from no load to full load.
 - 1) THD may not exceed 5 percent when serving a resistive load of 100 percent of unit rating.
 - d. Output Protection: Current-limiting and short-circuit protection.
OR
Output Protection: Ferroresonant transformer to provide inherent overload and short-circuit protection.
 - e. Surge Protection: Panelboard **OR** Auxiliary panel, **as directed**, suppressors specified in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".



- f. Overload Capability: 125 percent for 10 minutes; 150 percent surge.
- g. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.

D. Battery Charger

- 1. Description: Solid-state, automatically maintaining batteries in fully charged condition when normal power is available. With LED indicators for "float" and "high-charge" modes.

E. Batteries

- 1. Description: Premium, valve-regulated, recombinant, lead-calcium **OR** Standard, valve-regulated, recombinant, lead-calcium **OR** Nickel-cadmium, wet-cell **OR** Lead-calcium, wet-cell **OR** Lead-antimony, wet-cell, **as directed**, batteries.
 - a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

F. Enclosures

- 1. NEMA 250, Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
- 2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

G. Seismic Requirements

- 1. Central battery inverter assemblies, subassemblies, components, fastenings, supports, and mounting and anchorage devices shall be designed and fabricated to withstand seismic forces, **as directed**. The term "withstand" is defined in the "Manufacturer Seismic Qualification Certification" Paragraph in Part 1.1 "Submittals" Article.

H. Control And Indication

- 1. Description: Group displays, indications, and basic system controls on common control panel on front of central battery inverter enclosure.
- 2. Minimum displays, indicating devices, and controls shall include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms shall include an audible signal and a visual display.
- 3. Indications: Labeled LED **OR** Plain-language messages on a digital LCD or LED, **as directed**.
 - a. Quantitative Indications:
 - 1) Input voltage, each phase, line to line.
 - 2) Input current, each phase, line to line.
 - 3) System output voltage, each phase, line to line.
 - 4) System output current, each phase.
 - 5) System output frequency.
 - 6) DC bus voltage.
 - 7) Battery current and direction (charge/discharge).
 - 8) Elapsed time-discharging battery.
 - b. Basic Status Condition Indications:
 - 1) Normal operation.
 - 2) Load-on bypass.
 - 3) Load-on battery.
 - 4) Inverter off.
 - 5) Alarm condition exists.
 - c. Alarm Indications:
 - 1) Battery system alarm.
 - 2) Control power failure.
 - 3) Fan failure.
 - 4) Overload.
 - 5) Battery-charging control faulty.
 - 6) Input overvoltage or undervoltage.
 - 7) Approaching end of battery operation.



- 8) Battery undervoltage shutdown.
 - 9) Inverter fuse blown.
 - 10) Inverter transformer overtemperature.
 - 11) Inverter overtemperature.
 - 12) Static bypass transfer switch overtemperature.
 - 13) Inverter power supply fault.
 - 14) Inverter output overvoltage or undervoltage.
 - 15) System overload shutdown.
 - 16) Inverter output contactor open.
 - 17) Inverter current limit.
- d. Controls:
- 1) Inverter on-off.
 - 2) Start.
 - 3) Battery test.
 - 4) Alarm silence/reset.
 - 5) Output-voltage adjustment.
4. Dry-form "C" contacts shall be available for remote indication of the following conditions:
- a. Inverter on battery.
 - b. Inverter on-line.
 - c. Inverter load-on bypass.
 - d. Inverter in alarm condition.
 - e. Inverter off (maintenance bypass closed).
5. Include the following minimum array:
- a. Ready, normal-power on light.
 - b. Charge light.
 - c. Inverter supply load light.
 - d. Battery voltmeter.
 - e. AC output voltmeter with minimum accuracy of 2 percent of full scale.
 - f. Load ammeter.
 - g. Test switch to simulate ac failure.
6. Enclosure: Steel, with hinged lockable doors, suitable for wall **OR** floor, **as directed**, mounting. Manufacturer's standard corrosion-resistant finish.
- I. Optional Features
1. Multiple Output Voltages: Supply unit branch circuits at different voltage levels if required. Transform voltages internally as required to produce indicated output voltages.
 2. Emergency-Only Circuits: Automatically energize only when normal supply has failed. Disconnect emergency-only circuits when normal power is restored.
 3. Maintenance Bypass/Isolation Switch: Load is supplied, bypassing central battery inverter system. Normal supply, electromechanical transfer switch, and system load terminals are completely disconnected from external circuits.
 4. Maintenance Bypass/Isolation Switch: Switch is interlocked so it cannot be operated unless static bypass transfer switch is in bypass mode. Switch provides manual selection among the following three conditions without interrupting supply to the load during switching:
 - a. Full Isolation: Load is supplied, bypassing central battery inverter system. Normal ac input circuit, static bypass transfer switch, and central battery inverter load terminals are completely disconnected from external circuits.
 - b. Maintenance Bypass: Load is supplied, bypassing central battery inverter system. Central battery inverter ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
 - c. Normal: Normal central battery inverter ac supply terminals are energized and the load is supplied either through static bypass transfer switch and central battery inverter rectifier-charger and inverter or through battery and inverter.
- J. Output Distribution Section



1. Panelboard: Comply with Division 26 Section "Panelboards" except provide assembly integral to equipment cabinet.

K. System Monitoring And Alarms

1. Remote Status and Alarm Panel: Labeled LEDs on panel faceplate shall indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
 - a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
2. Provisions for Remote Computer Monitoring: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in Part 1.2 "Control and Indication" Article. Remote computer and connecting signal wiring will be provided by the Owner. Include the following features:
 - a. Connectors and network interface units or modems for data transmission via RS-232 link.
 - b. Software shall be designed to control and monitor inverter system functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of reports. Include capability for storage and analysis of power-line transient records. Software shall be compatible with requirements in Division 26 Section "Electrical Power Monitoring And Control" and the operating system and configuration of the Owner-furnished computers.
3. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
 - a. Annunciation of Alarms: At inverter system control panel.
4. Battery-Cycle Warranty Monitoring: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring charge-discharge cycle history of batteries covered by cycle-life warranty.
 - a. Basic Functional Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on integral LCD.
 - b. Additional monitoring functions and features shall include the following:
 - 1) Measuring and recording of total voltage at battery terminals; providing alarm for excursions outside proper float voltage level.
 - 2) Monitoring of ambient temperature at battery and initiating an alarm if temperature deviates from normally acceptable range.
 - 3) Keypad on device front panel provides access to monitored data using front panel display.
 - 4) Alarm contacts arranged to provide local **OR** remote, **as directed**, alarm for battery discharge events **OR** abnormal temperature **OR** abnormal battery voltage or temperature, **as directed**.
 - 5) Memory device to store recorded data in nonvolatile electronic memory.
 - 6) RS-232 port to permit downloading of data to a portable personal computer.
 - 7) Modem to make measurements and recorded data accessible to remote personal computer via telephone line. Computer will be provided by the Owner.

L. Source Quality Control

1. Factory test complete inverter system, including battery, before shipment. Include the following:
 - a. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
 - b. Full-load test.
 - c. Transient-load response test.
 - d. Overload test.
 - e. Power failure test.
2. Observation of Test: Give 14 days' advance notice of tests and provide access for the Owner's representative to observe tests at the Owner's option.
3. Report test results. Include the following data:



- a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
- b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
- c. List of instruments and equipment used in factory tests.

1.3 EXECUTION

A. Installation

1. Install system components on floor **OR** concrete base, **as directed**, and attach by bolting.
 - a. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration And Seismic Controls For Electrical Systems" for seismic-restraint requirements.
 - b. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Hangers And Supports For Electrical Systems".
 - c. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - e. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

B. Connections

1. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.
2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 - a. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.
3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Identification

1. Identify equipment and components according to Division 26 Section "Identification For Electrical Systems".

D. Field Quality Control

1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
 - a. Inspect interiors of enclosures for integrity of mechanical and electrical connections, component type and labeling verification, and ratings of installed components.
 - b. Test manual and automatic operational features and system protective and alarm functions.
 - c. Test communication of status and alarms to remote monitoring equipment.
 - d. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications. Certify compliance with test parameters.



- e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning units and retest as specified above.

E. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
2. Verify that central battery inverter is installed and connected according to the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 22.
4. Complete installation and startup checks according to manufacturer's written instructions.

F. Adjusting And Cleaning

1. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
2. Install new filters in each equipment cabinet within 14 days from date of Final Completion.

END OF SECTION 26 33 43 00

**SECTION 26 33 43 00a - NURSE CALL****1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for nurse call. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes visual/tone and audiovisual/voice nurse-call system.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment cabinets and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Cabling Diagrams: Single-line block diagrams showing cabling interconnection of all components for this specific equipment. Include cable type for each interconnection.
 - c. Station Installation Details: For built-in equipment, dimensioned and to scale.
3. Qualification Data: For qualified Installer.
4. Field quality-control reports.
5. Operation and Maintenance Data: For nurse-call equipment to include in emergency, operation, and maintenance manuals.
6. Warranty: Sample of special warranty.

D. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Compatibility: System shall be capable of integration with any brand of phone system (wired or wireless), staff locating system, CCTV, and fire-alarm system.
3. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty for batteries applies to materials only, on a prorated basis for specified period.
 - a. Warranty Period: Include the following warranty periods, from date of Final Completion:
 - 1) Nickel-Cadmium Batteries, Lithium Batteries, and Wet-Cell Batteries:
 - a) Full Warranty: Five years.
 - b) Pro Rata: 15 years.

1.2 PRODUCTS**A. Nurse-Call System General Requirements**

1. Station Zones: Able to program 256 station zones for each master station in the network with eight priority levels and addressable visual and audible annunciation of audible devices such as smoke detectors and door contacts.
2. System shall provide integrated and centralized "Code Blue" and "Staff Emergency" calls.



3. Expansion Capability: Equipment ratings, housing volume, spare keys, switches, relays, annunciator modules, terminals, and cable conductor quantities adequate to increase the number of stations in the future by 25 percent above those indicated without adding internal or external components or main trunk cable conductors.
4. Existing System Compatibility: Functionally and electrically compatible with existing system so components and wiring operate as an extension or upgrade of the existing system and existing or upgraded functional performance of the existing system applies to the entire final system. Colors, tones, types, and durations of signal manifestation shall be common among new and existing systems.
5. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.
6. Equipment: Microprocessor, electronic, modular.
7. Master Nurse-Call Station: Programmed via a PC.
8. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.
9. Telephone Interface: Permit use of wired and wireless telephones to execute nurse-call master station functions.
10. Third-Party Pager Interface: Programmable to send tone, numeric, and alphanumeric message to pocket pagers or personal digital assistants and to use industry standard-protocol, RS-485 interface.

B. Visual/Tone Nurse-Call System

1. Operational Requirements:
 - a. Patient Station Call: Lights a steady call-placed lamp on the station, steady lamps in the zone light and corridor dome light associated with the patient's room, and steady lamps at the central annunciator and other system display devices and displays message on master and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the respective annunciator and master and staff/duty stations. Legends at the central annunciator and master station identify the calling station.
 - b. Pull-Cord-Call Station Call: Flashes a call-placed lamp on the station and distinctive-color lamps in the zone light and corridor dome light and at the central annunciator and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the central annunciator and master and staff/duty stations. A legend at the master station identifies the calling station, priority as programmed, and bed identification.
 - c. Emergency-Call Station Call: Produces the same responses as pull-cord-call station calls except rapidly flashing red emergency digital display and tone repetition rates are more frequent, tone frequency is higher, and lamps in the zone light and corridor dome light are a different color. Indicator lamps may be extinguished and the system reset only at the calling station. Displays message on pocket pagers, sounds programmed tone on phones, and displays message on display equipped phones.
 - d. System Reset: Operating reset button at the originating station cancels signals associated with the call. Illuminates a green digital display on the patient station and log presence on the master station.
 - e. Cord-Set Removal: Initiates a patient station call when the cord set is removed from the jack in the patient station faceplate. Displays location and "cord removed" message on master station, pocket pagers, and display equipped phones. Inserting a cord-set plug or a dummy plug into the jack and operating the station reset button resets the call.
 - f. Patient Control Unit: Controls entertainment volume and channel selection. Nurse button on the unit initiates a patient station call. Integral speaker reproduces entertainment sound.
 - g. Emergency Bath Station Call: Illuminates the digital display on the emergency bath station; rapidly flashes white dome lamp; displays location, priority, and bath on master



- station; and sounds programmed tone on master station display equipped phones and pocket pagers.
- h. Staff/Duty Station Operation: Operation shall be identified to patient station except the message staff shall display on all devices when the staff call button is activated.
 - i. Privacy Key Activation: When privacy key is activated on patient station, the system shall disconnect the patient station microphone and slowly flash yellow privacy digital display on the patient station. Displays "privacy" on master station when selecting this room/bed.
2. Central Annunciator:
 - a. Lamp type.
 - b. Lamp Legends: Machine lettered and legible from a distance of at least 48 inches (1200 mm) when a call is present. Legend shall identify initiating station and priority of call.
 - c. Power-on Indicator: Digital, or push-to-test switch.
 - d. Audible Signal: Electronic tone.
 3. Central Equipment Cabinet:
 - a. Lockable metal.
 - b. Houses power supplies, controls, terminal strips, and other components.
 - c. Power-on indicator lamp.
 - d. Battery Backup Unit: Sealed nickel-cadmium, wet-cell battery supplies power through an automatic switch when normal power fails, for a period of not less than six minutes at rated output. System shall lose no unanswered calls or calls in progress during the transfer operation.
 - 1) Automatic retransfer to normal power, after a 15-minute time delay.
 - 2) Two-rate battery charger with an automatic trickle rate and a recharge rate.
 4. Single-Patient Station: Call-placed lamp, reset push button, and polarized receptacle matching cord-set plug; mounted in a single faceplate.
 5. Dual-Patient Station: Single call-placed lamp, single reset push button, and two polarized receptacles matching cord-set plug; mounted in a single faceplate.
 6. Ambulatory-Patient Station: Call push-button switch, call-placed lamp, and reset push button; mounted in a single faceplate.
 7. Staff/Duty Stations: A minimum of two call lamps, one for routine calls and one for emergency calls; and an audible tone signal device.
- C. Audiovisual/Voice Nurse-Call System
1. Operational Requirements:
 - a. Station Selection from Master Station: Capable of selectively communicating with other stations or groups of stations on its system by touch screen, mouse click, or manual switch; and capable of programming up to 256 stations for each master station in the network.
 - b. Master Station Privacy: Capable of conversing with individual stations in complete privacy.
 - c. Called Station:
 - 1) Capable of hands-free and two-way conversation.
 - 2) Pressing "talk/listen" key shall cause the annunciation tone to cease.
 - 3) Pressing "cancel" key terminates normal calls and conversations.
 - 4) Terminating of high-priority level 1 **OR** 2 **OR** 3 **OR** 4, **as directed**, shall not be allowed except at calling station location and shall send "remind" message if the call is not acknowledged at point of origin in programmed time frame.
 - d. Annunciation:
 - 1) At the master station, a programmable tone announces an incoming call; an annunciator light or digital display identifies the calling station and indicates the priority of the call.
 - 2) Call type indications include alarm assist, bath, bed, code, communication fault, cord out, door, emergency, and fire.
 - 3) Memory lamps or lighted displays identify stations selected for outgoing calls.
 - e. System Reset at Master Station: A normal, incoming call can be canceled, associated lights and audible tones extinguished, and the system reset when the station switch is returned to the normal position.



- f. Patient Station Calls:
 - 1) Lights the call-placed lamp at patient station, zone, and corridor dome lights.
 - 2) Sounds a tone and lights the call lights at staff/duty stations and actuates annunciation at the master station.
 - 3) When the calling station is selected at the master station, the patient can converse with the master station without moving and without raising or directing the voice.
 - 4) During voice communications, entertainment audio at the calling station is automatically muted.
- g. Pull-Cord-Call Station Calls and Emergency-Call Station Calls:
 - 1) Lights call-placed lamp and corridor dome light and flashes zone light.
 - 2) Master station tone pulses and annunciator light for that room flashes.
 - 3) When master station acknowledges the call by touch screen or switch, the tone stops but lights continue to flash until the call is canceled at the initiating point.
- h. Code Blue and Staff/Duty Station Calls:
 - 1) Lights the call-placed lamp at the station and actuates annunciation at the master station.
 - 2) When the called station is selected at the master station, the caller and the master station operator can converse.
 - 3) Code Blue: Unique sound and light pattern indicating the highest priority emergency.
 - 4) Staff Station: Unique sound and light pattern indicating an emergency.
 - 5) Duty Station: Sound and light pattern indicating a call to the nurse station.
- i. Handset Operation: Lifting the handset on master station disconnects speaker/microphone and transfers conversation to the handset.
- j. Station Privacy: No patient or staff/duty station can be remotely monitored without lighting a warning lamp at the monitored station.
- k. Patient Station Cord-Set Removal:
 - 1) A patient station call is initiated as described above when a patient station cord-set plug is removed from the jack in the station faceplate.
 - 2) Tone stops but lights continue to flash until the call is canceled at the initiating point or the plug is reinserted or replaced with a dummy plug when the master station call button for the station is pressed.
- l. Patient Control Unit:
 - 1) Controls entertainment volume and channel selection.
 - 2) Speaker is used for both nurse communication and entertainment sound.
 - 3) Entertainment sound is automatically muted when station is communicating with master station.
 - 4) Nurse button on the unit initiates a patient station call.
- m. Selective Paging: Master station is capable of initiating a message to selected groups of stations or speakers simultaneously by using station group switches.
- n. Staff Reminder:
 - 1) Master station can initiate a staff reminder that a patient requires direct staff response by operating a reminder control while in contact with the patient station.
 - 2) This reminder will light a distinctive-color lamp in the corridor dome light at the patient's room and in the appropriate zone lights.
 - 3) Reminder calls are canceled by operating a staff reminder cancel switch in the patient's room.
- o. Call Priority Indication:
 - 1) Capable of eight call priority levels in addition to normal.
 - 2) Call priority switch near each patient station, or integral with the master station, shall control priority status of the call transmitted by individual stations.
 - 3) Switch selects one of the following status levels:
 - a) Normal: No change to the normal call initiation and canceling sequence.



- b) Emergency: Call initiation produces signals and indications identical to those of emergency-call stations. Indicator lamps are extinguished and the system is reset only at the originating station.
 - c) Priority: System response is the same for emergency status except voice communication between the master station and the calling station is locked in from the time of call initiation until the system is reset at the originating station.
- p. Additional Call:
- 1) Waiting display window on the master station similar to current call window displays incoming calls.
 - 2) Master station shall have a call-overflow indicator when incoming calls exceed **<Insert number>** calls.
 - 3) System shall store unlimited number of incoming calls.
 - 4) System shall be capable of automatically answering incoming calls in order of priority.
- q. Calling Intercom Stations:
- 1) Master station shall be capable of calling any intercom station using the handset or the hands-free speaker/microphone.
 - 2) Receipt of a call at the intercom station shall be preceded by an optional pre-announce tone.
 - 3) If there is a call in process, system shall place the active call on automatic hold while the new call is placed, then reestablish the previous call when the new call has ended.
- r. Privacy Override:
- 1) Temporarily deactivates the "Privacy" mode of a called station by calling the station and instructing the called party to press the call-cord button.
 - 2) On completion of the conversation, the called station shall automatically return to the "Privacy" mode.
 - 3) When in "Privacy" mode, a called station shall be capable of hearing the master station; however, the master station shall not be capable of hearing the called station; a privacy message shall be indicated on the master station display.
- s. Master-Station-to-Master-Station Calls:
- 1) Master stations shall be capable of calling other master stations using the handset.
 - 2) Calls from master stations shall be answered using the handset only.
 - 3) Busy master stations shall be indicated by a master station intercom busy tone.
- t. Voice Paging:
- 1) Capable of voice paging to all stations using a single "All Call" key. The page shall be preceded by an optional pre-announce tone, **as directed**.
 - 2) Capable of voice paging to eight user-defined groups of stations by selecting the group and then the "All Call" key. The page shall be preceded by a pre-announce tone, **as directed**.
 - 3) Capable of voice paging to all staff/duty stations and all patient stations where staff has registered presence using a single "Public Address (PA)/Staff" key. The page shall be preceded by a pre-announce tone, **as directed**.
 - 4) Capable of voice paging through a third-party PA system.
 - 5) Capable of including or excluding any station from the voice paging function(s).
 - 6) Automatically places an active station call on hold during any page and reestablishes the connection at the end of the page.
 - 7) Automatically cancels a page if the talk mode is inactive for more than 15 seconds.
- u. Station Monitor:
- 1) An audio monitor feature shall allow a user to sequentially or simultaneously listen to one or all stations that are included in the user-created list.
 - 2) Master station display shall indicate which station is being monitored when in sequential mode.
 - 3) The dwell time each station is monitored shall be user programmable.
 - 4) The user shall be able to stop the monitoring sequence by activating a "pause" key.



- 5) The user shall be able to manually sequence through stations using a "next" key.
- v. Night Service:
- 1) Functions shall be adaptable for nighttime staffing levels, patient traffic, and day/night operations.
 - 2) Staff Follow:
 - a) Capable of locating roving staff; forwarding visual and audible annunciation of incoming calls to station(s) where personnel have registered presence.
 - b) Master station shall display locations where staff have registered presence.
 - c) Incorporates a programmable timer that automatically cancels a forgotten staff presence registration.
 - 3) Tones:
 - a) Deactivates audio signals from a duty station and mini-master display telephones.
 - b) Capable of changing the tone volume at the master and duty stations.
 - c) Satellite function shall permit the user to deactivate audio signals from duty stations and other remote annunciator devices.
 - 4) Transfer:
 - a) Permits one nurse station to take control of all or individually selected bed call cords from another nurse station. It shall be possible to view transfer status of a nurse station.
 - b) Includes a minimum of three transfer modes to allow one nurse station to take control or share calls and operations from another nurse station.
 - i. Parallel Transfer Mode: Permits both nurse stations to share all calls and operations.
 - ii. Supervised Transfer Mode: Permits the transferred nurse station to share all calls and operations with the controlling nurse station; however, the controlling nurse station calls are not shared with the transferring station.
 - iii. Capture Transfer Mode: Transfers all calls and operations from the transferred nurse station to the controlling nurse station.
 - iv. Transferred station shall have no control over calls, and its display shall indicate calls have been transferred to another station.
 - c) Includes two "patient swing" modes to allow one nurse station to take control or share calls from one or many calls from another nurse station.
 - i. Supervised Transfer Mode: Permits the transferred calls to be shared with the controlling nurse station.
 - ii. Capture Transfer Mode: Transfers all calls from the call cord from the transferred nurse station to the controlling nurse station.
 - iii. Transferred station has no control over those transferred calls.
- w. Service Request:
- 1) Permits users to assign a service request to a substation, at programmable priority level.
 - 2) Displays service request on the nurse station display and light the green flashing corridor lamp at the respective substation and automatically generate a service reminder request.
 - 3) Cancels service requests only at the initiating point.
 - 4) Recall calls shall sound and be displayed at the master station if the service request has not been cancelled at the initiating point within the programmed period of time.
- x. Call Reminder Function:
- 1) Automatically generates a reminder call for a patient- or staff-initiated, high-priority 2 **OR 3 OR 4, as directed**, request that has had the call tones silenced, allowing time to physically attend to the request and cancel the call at the initiating point.
 - 2) Regenerated calls shall display the same tones and visual indications and priority as the original call and shall also display a "regenerated call" message.
 - 3) Capable of manually adding low-priority calls to the reminder list.



- 4) "Call Reminder" function and reminder timer shall be programmable by call priority.
- y. Hide Function: Prevents a selected station from displaying calls or generating tones on the nurse station.
- z. Door Control Function: Capable of being programmed to enable the user to remotely activate electric door locks.
- aa. Test and Diagnostics Feature:
 - 1) Able to automatically diagnose system faults and categorize them as warnings, communication errors, or fatal errors.
 - 2) Warnings shall indicate possible system problems.
 - 3) Communication errors shall indicate the inability of the master station to communicate with a substation or another nurse-call station.
 - 4) Fatal errors shall indicate a major hardware or software failure.
- bb. User-Configured System Programming - Access Code Not Required:
 - 1) Patient call-cord priority levels.
 - 2) Monitor list.
 - 3) "All Call" list.
 - 4) Master station communication parameters (volume, filtering, talk/listen, sensitivity).
 - 5) Master and duty station call annunciation tone volume.
 - 6) Date/time.
 - 7) Staff-follow operating mode.
 - 8) Transfer type.
 - 9) Pocket pager list assignment.
 - 10) Presence mode.
- cc. User-Configured System Programming - Access Code Required:
 - 1) Master station number.
 - 2) Room device type.
 - 3) Room number.
 - 4) Bed number.
 - 5) Bed alpha or numeric.
 - 6) Reminder duration.
 - 7) Staff presence registration cancel duration.
 - 8) Display language.
 - 9) Paging group assignment(s).
 - 10) Zone group assignments.
 - 11) Monitoring duration.
 - 12) Pocket pager number.
 - 13) Call tone assignment by priority.
 - 14) Pretone activation.
 - 15) Call tones minimum volume.
 - 16) Clock mode (12 h/24 h).
- 2. Master Station:
 - a. Speaker/microphone unit with operating controls.
 - b. Indicator lamps with legends or by digital display designate identification and priority of calling stations and called stations.
 - c. Pulse rate of incoming-call lights denotes priority of calls awaiting response.
 - d. Station Selection Controls: Touchpad select stations for two-way voice communications.
 - e. Signal Tones: Programmable to announce incoming calls.
 - f. Pulse rate and frequency of tone identify the highest priority call awaiting response at one time.
 - g. Volume Control: Regulates incoming-call volume.
 - h. Privacy Handset with Hook Switch: Of the type that does not require push-to-talk switch attached to each station unless otherwise indicated.
 - i. Staff Reminder Control: Initiates flashing of corresponding corridor dome lights for patients requiring service. Permits scanning equipment to indicate which patients are currently in reminder status.



- j. Call Priority Selection: Controls associated with patient-station selection switches determine the priority displayed when a call is initiated at a patient station.
- 3. Central Equipment Cabinet:
 - a. Lockable metal.
 - b. Houses amplifiers, tone generators, power supplies, controls, terminal strips, and other components.
 - c. Amplifier: With fidelity and overall gain necessary to achieve the sound-transmission and reproduction characteristics specified, considering interoperability with the installed speakers/microphones and wiring.
 - 1) Power Output: Not less than 3 W at a total harmonic distortion not exceeding 5 percent.
 - 2) Hum and Noise: 60 dB below full output with normal input open.
 - 3) Volume Control: Concealed within the amplifier unit to control the volume of sound reproduced at all stations.
 - 4) Protection: Circuit to prevent damage to the amplifier in case of shorted or open circuit.
 - d. Selective Paging Amplifiers: Plug-in card mounted in central equipment cabinet, rated 15 W.
 - e. System Power Supply:
 - 1) 24-V dc for operation of the call system.
 - 2) Equipment Rating: Suitable for continuous operation between 32 and 120 deg F (0 and 49 deg C), from a primary line voltage between 105- to 125-V ac, 60 Hz.
 - 3) Output: Regulated 24-V dc with protection against overloads. Line-to-load regulation shall not exceed 2-1/2 percent with ripple and noise remaining below the 10-mV, rms level.
 - 4) Overload Protection: Electronic fold-back circuit set to limit the volt-ampere output to less than 100 VA during overloaded or shorted output. Restore power output automatically on removal of overload without resetting circuit breakers or replacing fuses.
 - f. Power-on indicator lamp.
 - g. Surge Protector Device: Comply with Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" for auxiliary panel suppressors, with digital indicator lights for power and protection status.
 - h. Battery Backup Unit: Sealed nickel-cadmium, wet-cell battery supplies power through an automatic switch when normal power fails, for a period of not less than six minutes at rated output.
 - 1) Automatic retransfer to normal power, after a 15-minute time delay.
 - 2) Two-rate battery charger with an automatic trickle rate and a recharge rate.
- 4. Speaker/Microphones:
 - a. Type: Permanent-magnet, dynamic or ceramic, protected against dust and humidity.
 - b. Sound Reproduction: Sound level of 90 dB plus or minus 3 dB at a distance of 48 inches (1220 mm) on the axis without overdriving or distorting any frequencies between 300 and 3000 Hz when installed in an enclosure or in the pillow speaker.
 - c. Power Handling Capacity: Not susceptible to damage from overdriving within the range of power available from the amplifier.
 - d. Impedance Matching: Coordinated and matched to the input and output circuits of the amplifier, both for single connection and for group monitoring, to provide the sound reproduction specified. Subsystems or components shall not be combined, which could cause unacceptable distortion such as feedback between pillow speakers and unmuted room speaker/microphone combinations. This protection shall extend throughout the entire range of operation (volume control) of all components.
- 5. Single-Patient Station: Speaker/microphone with 2-inch (50-mm) dynamic cone, a polarized receptacle to match the cord-set plug, monitor lamp, reset switch, and call-placed lamp; assembled under a single faceplate.
- 6. Dual-Patient Station:



- a. Speaker/microphone with 2-inch (50-mm) dynamic cone, two polarized receptacles to match cord-set plugs, monitor lamp, and reset switch; assembled under a single faceplate.
 - b. Single call-placed lamp serves both beds.
OR
Dual call-placed lamps, one for each bed.
7. Staff/Duty Stations: Audible call-tone signal device, speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, routine-call lamp, emergency-call lamp, and call push button; assembled under a single faceplate.
 8. Code Blue Station: Audible call-tone signal device, speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, Code Blue emergency-call lamp, and call push button; assembled under a single faceplate.
 9. Ambulatory-Patient Station: Speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, call-placed lamp, and call push button; assembled under a single faceplate.
 10. Selective Paging Speakers: 8-inch (200-mm) cone type with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet, multitap matching transformer, flush-mounted steel back-box, and white enamel-finished metal ceiling grille.
 11. Call Priority Switch Station: Three-position, tamper-resistant priority selection switch. Positions designated by labeling "Normal," "Emergency," and "Priority."
 12. Staff Reminder Cancel Switch Station: Momentary contact.
- D. System Components
1. Emergency-Call Station: Locking-type push button, labeled "Push to Call Help"; reset trigger to release push button and cancel call; and call-placed lamp, mounted in a single faceplate.
 2. Emergency-Bath Station:
 - a. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "URGENT" in bold letters.
 - b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
 - c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
 - d. Water resistant and able to withstand routine cleaning and chemical disinfectants.
 - e. Uses magnetic reed switch technology for reliability and corrosion resistance.
 - f. Mounts on a single-gang electrical box wire to the respective patient station or input controller.
 3. Code Blue Station:
 - a. Consists of a sliding, chemical-resistant, ABS blue fascia marked with the word "CODE" in bold letters.
 - b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
 - c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
 - d. Water resistant and able to withstand routine cleaning and chemical disinfectants.
 - e. Uses magnetic reed switch technology for reliability and corrosion resistance.
 - f. Mounts on a single-gang electrical box wire to the respective patient station or input controller.
 4. Staff, Emergency Station:
 - a. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "EMERGENCY" in bold letters.
 - b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
 - c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
 - d. Mounts on a single-gang electrical box wire to the input controller.
 5. Pull-Cord-Call Station:
 - a. Pull-Down Switch: Lever-locking type, labeled "Pull Down to Call Help."
 - b. Reset trigger.



- c. Call-placed lamp.
- d. Water-resistant construction.
6. Patient Control Unit:
 - a. Equipped with plug and 96-inch- (2400-mm-) long white cord.
 - b. Ethylene oxide, sterilizable.
 - c. Light-Control Switch: Arranged for independent on-off control of patient's up and down light.
 - d. Integral Speaker: 2 inches (50 mm), with 0.35-oz. (9.9-g) magnet, rated 0.2 W.
 - e. Controls: Speaker volume, TV control, and nurse call.
 - f. Housing: High-impact white plastic.
 - g. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
 - h. Quantity: 12 units for every 10 patient beds.
7. Call-Button Cord Set:
 - a. Plug and 72-inch (1800-mm) white cord; cord set shall be resistant to medical gas environment equipped with momentary-action, call-button switch.
 - b. Ethylene oxide, sterilizable.
 - c. Washable cord.
 - d. Palladium switch contacts in high-impact white housing with cord-set strain relief.
 - e. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
 - f. Quantity: Three cord sets for every 10 patient beds.
8. Geriatric Call-Button Cord Set:
 - a. Plug and 72-inch (1800-mm) white cord.
 - b. Resistant to medical gas environment equipped with momentary-action, light-pressure switch in soft outer jacket.
 - c. Ethylene oxide, sterilizable.
 - d. Washable cord.
 - e. Palladium switch contacts in high-impact white housing with cord-set strain relief.
 - f. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
 - g. Quantity: Two cord sets for every 10 patient beds.
9. Squeeze-Bulb Switch Cord Set:
 - a. Plug and 72-inch (1800-mm) washable tube with white cord set.
 - b. Resistant to medical gas environment; washable; equipped with neoprene squeeze-bulb activator, and plug-mounted, momentary contact switch.
 - c. Ethylene oxide, sterilizable.
 - d. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
 - e. Quantity: Two cord sets for every 10 patient beds.
10. Breath Call Cord:
 - a. Flexible PVC jacketed cable and a momentary contact air-pressure sensitive switch.
 - b. Cord: 108 inches (2700 mm) long.
 - c. Include an adjustable arm for clamping and suitable for use in oxygen atmospheres.
 - d. Include 12 replacement straws.
11. Pillow Speakers:
 - a. Eight-conductor, DIN, flexible PVC jacketed cable.
 - b. Contain nurse-call button, volume control, speaker, and channel control in molded flame-retardant ABS housing.
 - c. Cord: 96 inches (2400 mm) long with sheet clip.
12. Call-Button Plug:
 - a. Designed to plug into patient station cord-set receptacle.
 - b. Button switches call circuit.
 - c. Two plugs for every 10 patient beds.
13. Dummy Plugs:
 - a. Designed to plug into patient station cord-set receptacle when call-button plug or patient cord set is not used.
 - b. Three plugs for every 10 patient beds.
14. Indicator Lamps: Digital type with rated life of 20 years unless otherwise indicated.



15. Station Faceplates:
 - a. Stainless steel, a minimum of 0.0375 inch (0.95 mm) thick.
 - b. Finish: Brushed.
 - c. Machine-engraved labeling identifies indicator lamps and controls.

OR

Station Faceplates:

 - a. High-impact plastic.
 - b. Color: Beige.
 - c. Molded or machine-engraved labeling identifies indicator lamps and controls.
16. Corridor Dome Lights and Zone Lights:
 - a. Three-lamp signal lights.
 - b. Lamps: Front replaceable without tools, low voltage with rated life of 7500 hours. Barriers are such that only one color is displayed at a time.
 - c. Lenses: Heat-resistant, shatterproof, translucent polymer that will not deform, discolor, or craze when exposed to hospital cleaning agents.
 - d. Filters: Two per unit, amber and red.
17. Cable:
 - a. Conductors: Jacketed single and multiple, twisted-pair copper cables.
 - b. Sizes and Types: As recommended by equipment manufacturer.
 - c. Cable for Use in Plenums: Listed and labeled for plenum installation.
18. Grounding Components: Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

E. Software Requirements

1. Telephone System Interface:
 - a. Permits use of wired and/or wireless telephones to execute nurse-call master station.
 - b. Two-way communication with patient and staff stations.
 - c. Two-way communication with the master nurse station.
 - d. "All Call," group call, and staff call paging.
 - e. Capable of being programmed to forward calls destined for a master nurse station to any connected telephone.
 - f. Telephones connected to the telephone interface shall have the same call tone ring patterns as those generated at the master nurse station.
 - g. Telephones having a display shall indicate the call type, priority code, and the calling station number of incoming calls.
 - h. Telephones shall be capable of initiating a service request for a particular patient station, logging calls on the master station's reminder list, and activating door lock mechanisms associated with a call station.
 - i. Capable of routine setup and configuration changes using the keypads on display telephone and/or the master station.
2. Display Telephones:
 - a. Digital telephones for use as mini-master nurse-call stations.
 - b. Digital display shall indicate the call type, priority code, and calling station number of incoming calls.
 - c. Ring patterns shall be identical to those generated at the master station.
 - d. Capable of two-way communication with patient and staff stations and the master station, and other telephones interfaced with the system.
 - e. Capable of placing or answering outside calls when interfaced with the facility telephone system.
 - f. Capable of "All Call," group call, and staff call paging and of initiating service requests, logging calls to the reminder list, and activating optional door controls.
3. Third-Party Pocket Pager Interface:
 - a. Equipped with a standalone pocket pager interface.
 - b. Connects with the facility paging system and transmit alphanumeric messages to the pocket pagers as preprogrammed in the system.
4. Statistical Software:



- a. Includes a data statistical software package that stores, sorts, and analyzes activities occurring on the nurse-call system network.
 - b. Windows based and operated on a PC that is connected to the nurse-call system network.
 - c. Stores events on the PC's hard disk. Accumulation of these stored events shall make up the database that is used to generate reports and statistics.
 - d. Events stored by the software shall include date, day of week, time, ward, priority, and room number.
 - e. Capable of assigning a patient name to bed number.
 - f. Stored events shall include, but not be limited to, calls placed, call priority, calls cancelled at the nurse station, calls cancelled at the point of origin, regenerated calls, calls answered, calls sent to pager interface, staff presence registration, staff presence cancellation, service request, service cancellation, and system and network error messages.
5. Data Analysis Software:
- a. Capable of analyzing the stored information and generating computed analysis.
 - b. Analysis of the database can be conducted by specifying one, many, or all of the following parameters of the database: date, day of week, time, wards, priority, and room number.
 - c. Analysis shall include, but not be limited to, total number of calls placed, average call response time (from call placed to call cancellation), total number of presence registrations, average presence time in a room, total number of service requests, average response time (from audio answer to call cancellation), and average ring time (from call placed to audio answer).
6. Statistical Software Package:
- a. Capable of displaying multiple calls/events on a PC monitor or on a RS-485 data-bus-driven digital display panel.
 - b. Calls from patient or staff stations and associated devices shall be displayed by priority. Display shall be customizable as follows:
 - 1) Choice of color by type of call.
 - 2) Choice of display size (character size).
 - 3) Choice of priority levels, type of events, points of origin.
 - 4) Identification of facility.
 - 5) Identification of ward.
 - 6) Identification of patient with specific patient information.

F. Conductors And Cables

1. Audio Cables:
 - a. Conductors: Jacketed, twisted-pair and twisted-multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
 - b. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
 - c. Shielding: For speaker/microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
 - d. Minimum Shielding Coverage on Conductors: 60 percent.
 - e. Plenum Cable: Listed and labeled for plenum installation.
2. Data Cable and Hardware: Category 5e **OR** Category 6, **as directed**, UTP and UTP hardware. Comply with requirements in Division 27 Section "Communications Horizontal Cabling".
3. Power Conductors and Cables: Copper, solid, No. 20 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
4. Grounding Conductors and Cables: Copper, stranded, No. 16 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

1.3 EXECUTION

A. Installation

1. Wiring Method:



- a. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**.
 - 1) Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2) Conceal raceway and cables except in unfinished spaces.
 - b. Cable Trays: Comply with requirements in Division 27 Section "Communications Horizontal Cabling".
 - c. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used, **as directed**.
 - 1) Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
2. Install cables without damaging conductors, shield, or jacket.
 3. Do not bend cables, while handling or installing, to radii smaller than as recommended by manufacturer.
 4. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
 - a. Pull cables simultaneously if more than one is being installed in same raceway.
 - b. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
 - c. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
 5. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, or fittings.
 6. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
 7. Separation of Wires: Separate speaker/microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, provide 12-inch (300-mm) minimum separation between conductors to speaker/microphones and adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.
 8. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.
 9. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.
 10. Identification of Conductors and Cables: Comply with requirements in Division 27 Section "Communications Horizontal Cabling" for cable administration, cable schedule, and cable and wire identification.
 11. Equipment Identification:
 - a. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for equipment labels and signs and labeling installation requirements.
 - b. Label stations, controls, and indications using approved consistent nomenclature.
- B. Existing Systems
1. Examine existing systems for proper operation, compatibility with new equipment, and deficiencies. If discrepancies or impairments to successful connection and operation of interconnected equipment are found, report them and do not proceed with installation until directed. Schedule existing systems' examination so there is reasonable time to resolve problems without delaying construction.
- C. Grounding
1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.



2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.
3. Grounding Provisions: Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

D. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Schedule tests a minimum of seven days in advance.
 - b. Report: Submit a written record of test results.
 - c. Operational Test: Perform an operational system test and demonstrate proper operations, adjustment, and sensitivity of each station. Perform tests that include originating station-to-station and "All Call" messages and pages at each nurse-call station. Verify proper routing, volume levels, and freedom from noise and distortion. Test each available message path from each station on the system. Meet the following criteria:
 - 1) Speaker Output: 90 dB plus or minus 3 dB, 300 to 3000 Hz, reference level threshold of audibility 0 dB at 0.02 mPa of sound pressure.
 - 2) Gain from patient's bedside station to nurse station, with distortion less than 65 dB (plus or minus 3 dB, 300 to 3000 Hz).
 - 3) Signal-to-Noise Ratio: Hum and noise level at least 45 dB below full output.
 - d. Test Procedure:
 - 1) Frequency Response: Determine frequency response of two transmission paths by transmitting and recording audio tones.
 - 2) Signal-to-Noise Ratio: Measure the ratio of signal to noise of the complete system at normal gain settings using the following procedure: Disconnect a speaker/microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise and repeat the test for four speaker microphones.
 - 3) Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 300, 400, 1000, and 3000 Hz into each nurse-call equipment amplifier, and measure the distortion in the amplifier output.
3. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify, by the system test, that the total system meets these Specifications and complies with applicable standards. Report results in writing.
4. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
5. Prepare test and inspection reports.

E. Adjusting

1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting sound levels and controls to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal operating hours for this purpose.

F. Demonstration

1. Train Owner's maintenance personnel and caregiver staff to adjust, operate, and maintain nurse-call equipment.

END OF SECTION 26 33 43 00a



SECTION 26 33 43 00b - PUBLIC ADDRESS AND MASS NOTIFICATION SYSTEMS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of public address and mass notification systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Preamplifiers.
 - b. Power amplifiers.
 - c. Transfer to standby amplifier.
 - d. Microphones.
 - e. Volume limiter/compressors.
 - f. Control console.
 - g. Equipment cabinet.
 - h. Equipment rack.
 - i. Telephone paging adapters.
 - j. Tone generator.
 - k. Monitor panel.
 - l. Loudspeakers.
 - m. Noise-operated gain controllers.
 - n. Microphone and headphone outlets.
 - o. Battery backup power unit.
 - p. Conductors and cables.
 - q. Raceways.

C. Definitions

1. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
2. VU: Volume unit.
3. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

D. Performance Requirements

1. Delegated Design: Design supports and seismic restraints for control consoles, equipment cabinets and racks, and components, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Supports and seismic restraints for control consoles, equipment cabinets and racks, and components shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components. Include plans, elevations, sections, details, and attachments to other work.



- a. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Console layouts.
 - c. Control panels.
 - d. Rack arrangements.
 - e. Calculations: For sizing backup battery.
 - f. Wiring Diagrams: For power, signal, and control wiring.
 - 1) Identify terminals to facilitate installation, operation, and maintenance.
 - 2) Single-line diagram showing interconnection of components.
 - 3) Cabling diagram showing cable routing.
3. Delegated-Design Submittal: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- a. Detail fabrication and assembly of supports and seismic restraints for control consoles, equipment cabinets and racks, and components.
4. Seismic Qualification Certificates: For control consoles, equipment cabinets and racks, accessories, and components, from manufacturer.
- a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Field quality-control reports.
6. Operation and maintenance data.
- F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with NFPA 70.

1.2 PRODUCTS

A. Functional Description Of System

1. System Functions:
 - a. Selectively connect any zone to any available signal channel.
 - b. Selectively control sound from microphone outlets and other inputs.
 - c. "All-call" feature shall connect the all-call sound signal simultaneously to all zones regardless of zone or channel switch settings.
 - d. Telephone paging adapter shall allow paging by dialing an extension from any local telephone instrument and speaking into the telephone.
 - e. Produce a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
 - f. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off; output free of non-uniform coverage of amplified sound.

B. General Equipment And Material Requirements

1. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
2. Equipment: Comply with UL 813. Equipment shall be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.



3. Equipment Mounting: Where rack, cabinet, or console mounting is indicated, equipment shall be designed to mount in a 19-inch (483-mm) housing complying with TIA/EIA-310-D.
 4. Weather-Resistant Equipment: Listed and labeled by a qualified testing agency for duty outdoors or in damp locations.
- C. Preamplifiers
1. Preamplifier: Separately mounted.
 2. Preamplifier: Integral to power amplifier.
 3. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.
 4. Total Harmonic Distortion: Less than 1 percent.
 5. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.
 6. Input Jacks: Minimum of two. One matched for low-impedance microphone; the other matchable to cassette deck, CD player, or radio tuner signals without external adapters.
 7. Minimum Noise Level: Minus 55 dB below rated output.
 8. Controls: On-off, input levels, and master gain.
- D. Power Amplifiers
1. Mounting: Console **OR** Rack, **as directed**.
 2. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.
 3. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.
 4. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
 5. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
 6. Output Regulation: Less than 2 dB from full to no load.
 7. Controls: On-off, input levels, and low-cut filter.
 8. Input Sensitivity: Matched to preamplifier and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.
- E. Transfer To Standby Amplifier
1. Monitoring Circuit and Sensing Relay: Detect reduction in output of power amplifier of 40 percent or more and, in such event, transfer load and signal automatically to standby amplifier.
- F. Microphones
1. Paging Microphone:
 - a. Type: Dynamic, with cardioid **OR** omni, **as directed**, polar characteristic.
 - b. Impedance: 150 ohms.
 - c. Frequency Response: Uniform, 50 to 14,000 Hz.
 - d. Output Level: Minus 58 dB, minimum.
 - e. Finish: Satin chrome.
 - f. Cable: C25J.
 - g. Mounting: Desk stand with integral-locking, press-to-talk switch.
- G. Volume Limiter/Compressor
1. Minimum Performance Requirements:
 - a. Frequency Response: 45 to 15,000 Hz, plus or minus 1 dB minimum.
 - b. Signal Reduction Ratio: At least a 10:1 and 5:1 selectable capability.
 - c. Distortion: 1 percent, maximum.
 - d. Rated Output: Minimum of plus 14 dB.
 - e. Inputs: Minimum of two inputs with variable front-panel gain controls and VU or decibel meter for input adjustment.
 - f. Rack mounting.
- H. Control Console
1. Cabinet: Modular, desktop **OR** desk style, **as directed**; complying with TIA/EIA-310-D.



2. Housing: Steel, 0.0478 inch (1.2 mm) minimum, with removable front and rear panels. Side panels are removable for interconnecting side-by-side mounting.
 3. Panel for Equipment and Controls: Rack mounted.
 4. Controls:
 - a. Switching devices to select signal sources for distribution channels.
 - b. Program selector switch to select source for each program channel.
 - c. Switching devices to select zones for paging.
 - d. All-call selector switch.
 5. Indicators: A visual annunciation for each distribution channel to indicate source being used.
 6. Self-Contained Power and Control Unit: A single assembly of basic control, electronics, and power supply necessary to accomplish specified functions.
 7. Spare Positions: 20 percent spare zone control and annunciation positions on console.
 8. Microphone jack.
- I. Equipment Cabinet
1. Comply with TIA/EIA-310-D.
 2. House amplifiers and auxiliary equipment at each location.
 3. Cabinet Housing:
 - a. Constructed of 0.0478-inch (1.2-mm) steel, minimum, with front- and rear-locking doors and standard TIA/EIA-310-D-compliant, 19-inch (483-mm) racks.
 - b. Arranged for floor or wall mounting as indicated.
 - c. Sized to house all equipment indicated, plus spare capacity.
 - d. Include 20 percent minimum spare capacity for future equipment in addition to space required for future cassette deck and CD player.
 4. Power Provisions: A single switch in cabinet shall disconnect cabinet power distribution system and electrical outlets, which shall be uniformly spaced to accommodate ac-power cords for each item of equipment.
 5. Ventilation: A low-noise fan for forced-air cabinet ventilation. Fan shall be equipped with a filtered input vent and shall be connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switched; arranged to be powered when main cabinet power switch is on.
- J. Equipment Rack
1. Racks: 19 inches (483 mm) standard, complying with TIA/EIA-310-D.
 2. Power-Supply Connections: Compatible plugs and receptacles.
 3. Enclosure Panels: Ventilated rear and sides and solid top. Use louvers in panels to ensure adequate ventilation.
 4. Finish: Uniform, baked-enamel factory finish over rust-inhibiting primer.
 5. Power-Control Panel: On front of equipment housing, with master power on-off switch and pilot light; and with socket for 5-A cartridge fuse for rack equipment power.
 6. Service Light: At top rear of rack with an adjacent control switch.
 7. Vertical Plug Strip: Grounded receptacles, 12 inches (300 mm) o.c.; the full height of rack.
 8. Maintenance Receptacles: Duplex convenience outlets supplied independent of vertical plug strip and located in front and bottom rear of rack.
 9. Spare Capacity: 20 percent in rack for future equipment.
- K. Telephone Paging Adapter
1. Adapters shall accept voice signals from telephone extension dialing access and automatically provide amplifier input and program override for preselected zones.
 - a. Minimum Frequency Response: Flat, 200 to 2500 Hz.
 - b. Impedance Matching: Adapter matches telephone line to public address equipment input.
 - c. Rack mounting.
- L. Tone Generator
1. Generator shall provide clock and program interface with public address and mass notification system.



2. Signals: Minimum of seven distinct, audible signal types including wail, warble, high/low, alarm, repeating and single-stroke chimes, and tone.
 3. Pitch Control: Chimes and tone.
 4. Volume Control: All outputs.
 5. Activation-Switch Network: Establishes priority and hierarchy of output signals produced by different activation setups.
 6. Mounting: Rack.
- M. Monitor Panel
1. Monitor power amplifiers.
 2. Components: VU or dB meter, speaker with volume control, and multiple-position rotary selector switch.
 3. Selector Switch and Volume Control: Selective monitoring of output of each separate power amplifier via VU or dB meter and speaker.
 4. Mounting: Rack.
- N. Loudspeakers
1. Cone-Type Loudspeakers:
 - a. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
 - b. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
 - c. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.
 - d. Minimum Dispersion Angle: 100 degrees.
 - e. Rated Output Level: 10 W.
 - f. Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.
 - g. Surface-Mounting Units: Ceiling, wall, or pendant mounting, as indicated, in steel back boxes, acoustically dampened. Front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and shop primed for field painting.
 - h. Flush-Ceiling-Mounting Units: In steel back boxes, acoustically dampened. Metal ceiling grille with white baked enamel.
 2. Horn-Type Loudspeakers:
 - a. Type: Single-horn units, double-reentrant design, with minimum full-range power rating of 15 W.
 - b. Matching Transformer: Full-power rated with four standard taps. Maximum insertion loss of 0.5 dB.
 - c. Frequency Response: Within plus or minus 3 dB from 250 to 12,000 Hz.
 - d. Dispersion Angle: 130 by 110 degrees.
 - e. Mounting: Integral bracket.
 - f. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located.
- O. Noise-Operated Gain Controller
1. Gain controller shall be designed to continuously sense space noise level and automatically adjust signal level to local speakers.
 2. Frequency Response: 20 to 20,000 Hz, plus or minus 1 dB.
 3. Level Adjustment Range: 20 dB minimum.
 4. Maximum Distortion: 1 percent.
 5. Control: Permits adjustment of sensing level of device.
- P. Outlets
1. Volume Attenuator Station: Wall-plate-mounted autotransformer type with paging priority feature.
 - a. Wattage Rating: 10 W unless otherwise indicated.
 - b. Attenuation per Step: 3 dB, with positive off position.
 - c. Insertion Loss: 0.4 dB maximum.



- d. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.
- e. Label: "PA Volume."
- 2. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.
- 3. Headphone Outlet (for the Hearing Impaired): Microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed-outlet covers.

Q. Battery Backup Power Unit

- 1. Unit shall be rack mounted, consisting of time-delay relay, sealed lead-calcium battery, battery charger, on-off switch, "normal" and "emergency" indicating lights, and adequate capacity to supply maximum equipment power requirements for one hour of continuous full operation.
- 2. Unit shall supply public address equipment with 12- to 15-V dc power automatically during an outage of normal 120-V ac power.
- 3. Battery shall be on float charge when not supplying system and to transfer automatically to supply system after three to five seconds of continuous outage of normal power, as sensed by time-delay relay.
- 4. Unit shall automatically retransfer system to normal supply when normal power has been reestablished for three to five seconds continuously.

R. Conductors And Cables

- 1. Jacketed, twisted pair and twisted multipair, untinned solid copper.
 - a. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
 - b. Microphone Cables: Neoprene jacketed, not less than 2/64 inch (0.8 mm) thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
 - c. Plenum Cable: Listed and labeled for plenum installation.

S. Raceways

- 1. Conduit and Boxes: Comply with Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used, unless directed otherwise.
 - a. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

1.3 EXECUTION

A. Wiring Methods

- 1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**. Conceal raceway and cables except in unfinished spaces.
 - a. Install plenum cable in environmental air spaces, including plenum ceilings.
 - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
- 2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- 3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.



- B. Installation Of Raceways
1. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
 2. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- C. Installation Of Cables
1. Comply with NECA 1.
 2. General Cable Installation Requirements:
 - a. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
 - b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
 - c. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
 - e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - f. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.
 3. Open-Cable Installation:
 - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - b. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
 - c. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
 4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.
- D. Installation
1. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
 2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
 3. Equipment Cabinets and Racks:
 - a. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
 - b. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
 - c. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.
 4. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.
 5. Wall-Mounted Outlets: Flush mounted.
 6. Floor-Mounted Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.



7. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.
 8. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
 9. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.
 10. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- E. Grounding
1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
 2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
 3. Install grounding electrodes as specified in Division 26 Section "Grounding And Bonding For Electrical Systems".
- F. Field Quality Control
1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. Schedule tests with at least seven days' advance notice of test performance.
 - b. After installing public address and mass notification systems and after electrical circuitry has been energized, test for compliance with requirements.
 - c. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
 - d. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - 1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
 - 2) Repeat test for each separately controlled zone of loudspeakers.
 - 3) Minimum acceptance ratio is 50 dB.
 - e. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
 - f. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
 - g. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
 - h. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Division 26 Section "Grounding And Bonding For Electrical Systems".



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3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
 4. Public address and mass notification systems will be considered defective if they do not pass tests and inspections.
 5. Prepare test and inspection reports.
 - a. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

END OF SECTION 26 33 43 00b



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SECTION 26 33 53 00 - STATIC UNINTERRUPTIBLE POWER SUPPLY

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for static uninterruptible power supply. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:
 - 1) Surge suppression.
 - 2) Input harmonics reduction.
 - 3) Rectifier-charger.
 - 4) Inverter.
 - 5) Static bypass transfer switch.
 - 6) Battery and battery disconnect device.
 - 7) Internal and External maintenance bypass/isolation switch.
 - 8) Output isolation transformer.
 - 9) Remote UPS monitoring provisions.
 - 10) Battery monitoring.
 - 11) Remote monitoring.

C. Definitions

1. EMI: Electromagnetic interference.
2. LCD: Liquid-crystal display.
3. LED: Light-emitting diode.
4. PC: Personal computer.
5. THD: Total harmonic distortion.
6. UPS: Uninterruptible power supply.

D. Performance Requirements

1. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to ASCE/SEI 7, **as directed**.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.
2. Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For UPS equipment, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.



- c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 4. Factory Test Reports: Comply with specified requirements.
- 5. Field quality-control reports.
- 6. Operation and maintenance data.
- 7. Warranties: Sample of special warranties.

F. Quality Assurance

- 1. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- 2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 3. UL Compliance: Listed and labeled under UL 1778 by an NRTL.
- 4. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

G. Warranty

- 1. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.
 - a. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	45 seconds	1.67	120 cycles

OR

Warranted Cycle Life for Premium Valve-Regulated, Lead-calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	40 cycles
30 minutes	30 minutes	1.67	125 cycles
15 minutes	1.5 minutes	1.67	750 cycles

OR

Warranted Cycle Life for Flooded Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.75	40 cycles
1 hour	1 hour	1.75	80 cycles
15 minutes	45 seconds	1.67	2700 cycles



2. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within Two **OR** Three, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Operational Requirements

1. Automatic operation includes the following:
 - a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
 - b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
 - c. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
 - d. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
 - e. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
 - f. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
 - g. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
 - h. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
 - i. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.
2. Manual operation includes the following:
 - a. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
 - b. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.
3. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:
 - a. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
 - b. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
 - c. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.
4. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.
 - a. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).



- b. Ambient Temperature for Battery: 41 to 95 deg F (5 to 35 deg C).
- c. Relative Humidity: 0 to 95 percent, noncondensing.
- d. Altitude: Sea level to 4000 feet (1220 m).

B. Performance Requirements

1. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:
 - a. Inverter is switched to battery source.
 - b. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
 - c. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
 - d. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
 - e. Load is 30 **OR** 50 **OR** 100, **as directed**, percent unbalanced continuously.
2. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is five **OR** 10 **OR** 15, **as directed**, minutes.
3. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 15 **OR** 20 **OR** 30, **as directed**, percent from nominal voltage.
4. Overall UPS Efficiency:

NOMINAL OVERALL UPS EFFICIENCY RATINGS

SIZE RANGE OF UPS UNITS	EFFICIENCY AT 100% RATED LOAD	EFFICIENCY AT 75% RATED LOAD	EFFICIENCY AT 50% RATED LOAD
30 kVA and Smaller	86	85	84
37.5 to 74 kVA	89	88	87
75 to 124 kVA	90	88	87
125 to 224 kVA	90	89	88
225 kVA and Larger	90	89	88

5. Maximum Acoustical Noise:

NOMINAL OVERALL UPS AUDIBLE NOISE RATINGS

SIZE RANGE OF UPS UNITS	MAXIMUM NOISE VALUE	DISTANCE AT WHICH MEASURED
10 kVA and Smaller	58 dB	36 inches (900 mm)
20 to 125 kVA	60 dB	48 inches (1200 mm)
150 to 300 kVA	78 dB	48 inches (1200 mm)
300 kVA and Larger	83 dB	48 inches (1200 mm)

6. Maximum Energizing Inrush Current: Six **OR** Eight, **as directed**, times the full-load current.
7. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.
8. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.
9. Limitation of harmonic distortion of input current to the UPS shall be as follows:



- a. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to 5 **OR** 10, **as directed**, percent, maximum, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.
OR
Description: THD is limited to a maximum of 32 percent, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.
 10. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.
OR
Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.
 11. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 30 seconds in all operating modes.
 12. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 100 ms:
 - a. 50 Percent: Plus or minus 5 percent.
 - b. 100 Percent: Plus or minus 5 percent.
 - c. Loss of AC Input Power: Plus or minus 1 percent.
 - d. Restoration of AC Input Power: Plus or minus 1 percent.
 13. Input Power Factor: A minimum of 0.70 **OR** 0.85, **as directed**, lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current.
 14. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.
- C. UPS Systems
1. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
 2. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.
 3. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
 4. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch, **as directed**. Protect rectifier-charger, inverter, controls, and output components.
 - a. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B **OR** Category C, **as directed**.
 - b. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.
 5. Maintainability Features (for units rated more than approximately 100 kVA): Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.
 6. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.
 7. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.
 8. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.



9. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity (for a UPS with heavy nonlinear loading): Rated phase current times a multiple of 1.73, minimum.

D. Rectifier-Charger

1. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
2. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.
3. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
 - a. Response Time: Field adjustable for maximum compatibility with local generator-set power source.
4. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

E. Inverter

1. Description: Pulse-width modulated, with sinusoidal output.
OR
 Description (if the UPS may be supplied power from a standby engine-generator set): Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

F. Static Bypass Transfer Switch

1. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.
2. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

G. Battery

ALTERNATIVE BATTERY TYPES FOR UPS SYSTEMS

TYPE	NOMINAL LIFE EXPECTANCY (YEARS)*	TYPICAL WARRANTY (YEARS)*		MINIMUM NOMINAL MAINTENANCE INTERVAL	APPROX. INITIAL COST FACTOR**	SPECIAL FEATURES
		FULL	PRO RATA			
Premium quality, valve regulated, recombinant, lead calcium	20	1	19	1 year	2.5	Spill proof.
Standard quality, valve regulated, recombinant, lead calcium	10	1	9	1 year	1.0	Spill proof.
Nickel cadmium, flooded	25	5	15	3 years	4.0	Can operate in high ambient temperatures. Can be completely discharged without damage.
Lead calcium, flooded	20	1	9	6 months	2.5	-

*Life expectancy and warranty data apply to installations where batteries are considered to be in a "float-service"



application. Use the data only as a general guide because UPS batteries are typically considered to be in a separate service application category that accounts for the numerous discharges of varying duration they experience.

**Cost includes an allowance for space requirements and environmental control.

1. Description: Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
 - a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

OR

Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units; factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.

 - a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

OR

Description: Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers mounted on three-tier, **as directed**, acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.
2. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

H. Controls And Indications

1. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.
2. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.
3. Indications: Labeled LED **OR** Plain-language messages on a digital LCD or LED, **as directed**.
 - a. Quantitative indications shall include the following:
 - 1) Input voltage, each phase, line to line.
 - 2) Input current, each phase, line to line.
 - 3) Bypass input voltage, each phase, line to line.
 - 4) Bypass input frequency.
 - 5) System output voltage, each phase, line to line.
 - 6) System output current, each phase.
 - 7) System output frequency.
 - 8) DC bus voltage.
 - 9) Battery current and direction (charge/discharge).
 - 10) Elapsed time discharging battery.
 - b. Basic status condition indications shall include the following:
 - 1) Normal operation.
 - 2) Load-on bypass.
 - 3) Load-on battery.
 - 4) Inverter off.
 - 5) Alarm condition.
 - c. Alarm indications shall include the following:
 - 1) Bypass ac input overvoltage or undervoltage.
 - 2) Bypass ac input overfrequency or underfrequency.
 - 3) Bypass ac input and inverter out of synchronization.
 - 4) Bypass ac input wrong-phase rotation.
 - 5) Bypass ac input single-phase condition.
 - 6) Bypass ac input filter fuse blown.
 - 7) Internal frequency standard in use.
 - 8) Battery system alarm.
 - 9) Control power failure.
 - 10) Fan failure.



- 11) UPS overload.
 - 12) Battery-charging control faulty.
 - 13) Input overvoltage or undervoltage.
 - 14) Input transformer overtemperature.
 - 15) Input circuit breaker tripped.
 - 16) Input wrong-phase rotation.
 - 17) Input single-phase condition.
 - 18) Approaching end of battery operation.
 - 19) Battery undervoltage shutdown.
 - 20) Maximum battery voltage.
 - 21) Inverter fuse blown.
 - 22) Inverter transformer overtemperature.
 - 23) Inverter overtemperature.
 - 24) Static bypass transfer switch overtemperature.
 - 25) Inverter power supply fault.
 - 26) Inverter transistors out of saturation.
 - 27) Identification of faulty inverter section/leg.
 - 28) Inverter output overvoltage or undervoltage.
 - 29) UPS overload shutdown.
 - 30) Inverter current sensor fault.
 - 31) Inverter output contactor open.
 - 32) Inverter current limit.
- d. Controls shall include the following:
- 1) Inverter on-off.
 - 2) UPS start.
 - 3) Battery test.
 - 4) Alarm silence/reset.
 - 5) Output-voltage adjustment.
4. Dry-form "C" contacts shall be available for remote indication of the following conditions:
- a. UPS on battery.
 - b. UPS on-line.
 - c. UPS load-on bypass.
 - d. UPS in alarm condition.
 - e. UPS off (maintenance bypass closed).
5. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.

I. Maintenance Bypass/Isolation Switch

1. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
 - a. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
 - b. Switch shall electrically isolate other UPS components to permit safe servicing.
2. Comply with NEMA PB 2 and UL 891.
3. Switch Rating: Continuous duty at rated full UPS load current.
4. Mounting Provisions: Internal to system cabinet **OR** Separate wall- or floor-mounted unit, **as directed**.
5. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

J. Output Isolation Transformer



1. Description: Shielded unit **OR** Unit, **as directed**, with low forward transfer impedance up to 3 kHz, minimum. Include the following features:
 - a. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately 4 **OR** 9 **OR** 13 **OR** 20, **as directed**.
 - b. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
 - c. Regulation: 5 percent, maximum, at rated nonlinear load current.
 - d. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
 - e. Electrostatic Shielding of Windings: Independent for each winding.
 - f. Coil Leads: Physically arranged for minimum interlead capacitance.
 - g. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
 - h. Capacitive Coupling between Primary and Secondary: 33 picofarads, maximum, over a frequency range of 20 Hz to 1 MHz.

- K. Output Distribution Section
 1. Panelboards: Comply with Division 26 Section "Panelboards" except provide assembly integral to UPS cabinet.

- L. Monitoring By Remote Status And Alarm Panel
 1. Description: Labeled LEDs on panel faceplate indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
 - a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

- M. Monitoring By Remote Computer
 1. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
 - a. Connectors and network interface units or modems for data transmission via RS-232 link.
 - b. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
 - c. Software and Hardware: Compatible with that specified in Division 26 Section "Electrical Power Monitoring And Control".

- N. Basic Battery Monitoring
 1. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
 2. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.
 3. Annunciation of Alarms: At UPS control panel.

- O. Additional Battery Monitoring
 1. Monitoring features and components shall include the following:
 - a. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
 - b. Connections for data transmission via RS-232 link, network interface and, **as directed**, modem and, **as directed**, external signal wiring to computer **OR** electrical power monitoring and control equipment, **as directed**. External signal wiring and computer are not specified in this Section.
 - c. PC-based software designed to store and analyze battery data. Software compiles reports on individual-cell parameters and total battery performance trends, and provides data for scheduling and prioritizing battery maintenance.



2. Performance: Automatically measures and electronically records the following parameters on a routine schedule and during battery discharge events. During discharge events, records measurements timed to nearest second; includes measurements of the following parameters:
 - a. Total battery voltage and ambient temperature.
 - b. Individual-cell voltage, impedance, and temperature. During battery-discharging events such as utility outages, measures battery and cell voltages timed to nearest second.
 - c. Individual-cell electrolyte levels.

P. Battery-Cycle Warranty Monitoring

1. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.
2. Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on front panel display.
3. Additional monitoring functions and features shall include the following:
 - a. Measuring and Recording: Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
 - b. Monitors: Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
 - c. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
 - d. Alarm Contacts: Arranged to initiate local **OR** remote, **as directed**, alarm for battery discharge events **OR** abnormal temperature **OR** abnormal battery voltage or temperature, **as directed**.
 - e. Memory: Stores recorded data in nonvolatile electronic memory.
 - f. RS-232 Port: Permits downloading of data to a portable PC.
 - g. Modem: Makes measurements and recorded data accessible to a remote PC via telephone line. Computer is not specified in this Section.

Q. Source Quality Control

1. Factory test complete UPS system before shipment. Use actual batteries that are part of final installation **OR** simulated battery testing, **as directed**. Include the following:
 - a. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
 - b. Full-load test.
 - c. Transient-load response test.
 - d. Overload test.
 - e. Power failure test.
2. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.
3. Report test results. Include the following data:
 - a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
 - b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
 - c. List of instruments and equipment used in factory tests.

1.3 EXECUTION

A. Installation

1. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.



- b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
 3. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.
- B. Grounding
1. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.
- C. Identification
1. Identify components and wiring according to Division 26 Section "Identification For Electrical Systems".
 - a. Identify each battery cell individually.
- D. Battery Equalization
1. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.
- E. Field Quality Control
1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 2. Tests and Inspections:
 - a. Comply with manufacturer's written instructions.
 - b. Inspect interiors of enclosures, including the following:
 - 1) Integrity of mechanical and electrical connections.
 - 2) Component type and labeling verification.
 - 3) Ratings of installed components.
 - c. Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
 - d. Test manual and automatic operational features and system protective and alarm functions.
 - e. Test communication of status and alarms to remote monitoring equipment.
 - f. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months according to NIST standards.
 - 1) Simulate malfunctions to verify protective device operation.
 - 2) Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
 - 3) Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
 - 4) Test output voltage under specified transient-load conditions.
 - 5) Test efficiency at 50, 75, and 100 percent of rated loads.
 - 6) Test remote status and alarm panel functions.
 - 7) Test battery-monitoring system functions.
 3. Seismic-restraint tests and inspections shall include the following:
 - a. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.



-
- b. Test mounting and anchorage devices according to requirements in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
 - 4. The UPS system will be considered defective if it does not pass tests and inspections.
 - 5. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.
 - 6. Prepare test and inspection reports.
- F. Demonstration
- 1. Train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 26 33 53 00



Task	Specification	Specification Description
26 33 53 00	26 33 43 00	Central Battery Inverters



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SECTION 26 35 33 00 - POWER FACTOR CORRECTION CAPACITORS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for power factor correction capacitors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes power and automatic power factor correction equipment rated 600 V and less.

C. Performance Requirements

1. Seismic Performance: Power factor correction equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals

1. Product Data: For each type of product indicated. Include dimensions, operating characteristics of multiple capacitor cells or elements, and data on features, ratings, and performance.
2. Shop Drawings: For automatic power factor correction units.
 - a. Detail equipment assemblies and indicate dimensions, weights, method of field assembly, components, and location and size of each field connection. Show access and workspace requirements and required clearances.
 - b. Wiring Diagrams: For power, signal, and control wiring.
3. Qualification Data: For qualified testing agency.
4. Seismic Qualification Certificates: For capacitors, accessories, and components, from manufacturer.
 - a. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Field quality-control reports.
6. Operation and Maintenance Data: For equipment to include in emergency, operation, and maintenance manuals. Include the following:
 - a. Lists of spare parts and replacement components recommended for storage at Project site.
 - b. Detailed instructions covering operation under both normal and abnormal conditions.
7. Warranty: Sample of special warranty.

E. Quality Assurance

1. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with IEEE 18 and NEMA CP 1.
4. Comply with NFPA 70.

F. Coordination



1. Coordinate sensor-communication module package with data network and with monitoring equipment specified in Division 26 Section "Electrical Power Monitoring And Control" for successful transmission and remote readout of remote monitoring data specified in this Section.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace capacitor-bank components that fail in materials or workmanship within five years from date of Final Completion.

1.2 PRODUCTS

A. Capacitors, General

1. Comply with UL 810.
2. Service Conditions: Capacitor equipment suitable for the following conditions:
 - a. Operating Temperature: Minus 40 to plus 115 deg F (Minus 40 to plus 46 deg C).
 - b. Maximum Altitude: 6000 feet (1800 m).
 - c. Humidity: 0 to 95 percent, noncondensing.
3. Construction: Multiple capacitor cells or elements, factory wired in three-phase groups and mounted in metal enclosures.
4. Cells: Dry metallized-dielectric, self-healing type. Each cell shall be encapsulated in thermosetting resin inside plastic container.
5. Rupture Protection: Pressure-sensitive circuit interrupter for each cell.

B. Fixed Capacitors

1. Description: Factory wired, ready for field connection to external circuits at a single set of pressure terminals. Comply with UL 810.
2. Fuses: Current-limiting, noninterchangeable type; factory installed in each phase and located within the equipment enclosure. Features include the following:
 - a. Interrupting Capacity: 100,000 **OR** 200,000, **as directed**, A
 - b. Fuse Ratings and Characteristics: As recommended by capacitor manufacturer.
 - c. Neon Indicator Lamp for Each Fuse: Connect to illuminate when fuse has opened, but is still in place, and locate so it is visible from outside the enclosure.
3. Discharge Resistors: Factory installed and wired.
4. Enclosure: NEMA 250, steel **OR** aluminum, **as directed**, arranged to contain the fluid leakage from capacitor cells; factory equipped with mounting brackets suitable for type of mounting indicated.
 - a. Indoor Enclosures: NEMA 250, Type 12 or as indicated.
OR
Outdoor Enclosures: NEMA 250, Type 3R or as indicated.
OR
Outdoor Enclosures: NEMA 250, Type 4, equipped with watertight conduit connections.

C. Automatic Power Factor Correction Units

1. Description: Capacitors, contactors, controls, and accessories factory installed in independent enclosures **OR** motor-control center, with a connection to motor-control center bus, **as directed**, complying with NEMA ICS 2. Comply with UL 810.
2. Performance Requirements: Controls permit selection of a target power factor, adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on circuits being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contractor to switch a capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Provide number of switching steps indicated on the Three-Phase Capacitor-Bank Schedule.
3. Current Transformer: Type, configuration, and ratio to suit sensing and mounting conditions.



4. Main Circuit Breaker: Thermal-magnetic, inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. Operable from outside the enclosure to disconnect the unit.
5. Controls: Solid-state, microprocessor-based controls, including the following:
 - a. Undervoltage relay that interrupts capacitor switching and disconnects capacitors for power-supply interruptions longer than 15 minutes.
 - b. "Advance" and "Retard" push buttons on the control panel to permit manually controlled capacitor-bank switching.
6. Contactors: Three pole; rated for the repetitive high-inrush-switching duty in the capacitor application.
7. Fuses for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring, and capacitors.
 - a. Spare-Fuse Cabinet: Identified and compartmented steel box **OR** cabinet with hinged lockable door, **as directed**.
8. Discharge Resistors: Factory installed and wired.
OR
Inductors: Air-core type, connected in capacitor circuits; rated to limit switching surges to within contactor ratings.
9. Precharge Capacitor Circuit: Resistive, precharge circuit to charge capacitors prior to switching and to limit switching surges to within contactor ratings.
10. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 12, **as directed**, steel or aluminum, with hinged door and hand-operated catch. Door shall be interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.
 - a. Factory Finish: Manufacturer's standard enamel over corrosion-resistant treatment or primer coat.
11. Local Display: LED or liquid-crystal digital type, mounted in door of enclosure, indicating the following:
 - a. Target and actual power factors accurate to plus or minus 1 percent of reading.
 - b. Steps energized.
 - c. Step reconnection delay.
 - d. Real and reactive currents.
 - e. Voltage total harmonic distortion.
 - f. Alarm codes.
12. System Alarms: Alarm relay and local display indication of the following conditions:
 - a. Low power factor.
 - b. Leading power factor.
 - c. Frequency not detected.
 - d. Overcurrent.
 - e. Overvoltage.
 - f. Overtemperature.
 - g. Excessive voltage total harmonic distortion.
 - h. Capacitor overload.
 - i. Loss of capacitance.
13. Remote Monitoring Components: Sensors, associated communication modules, and network interface units, matched to and compatible with electrical power monitoring and control network. Communication module shall have capability to transmit the following data to remote monitoring devices:
 - a. System in alarm.
 - b. Power factor set point.
 - c. Corrected power factor.
 - d. Number of capacitor steps activated.

D. Source Quality Control

1. Factory test power factor correction equipment before shipment. Comply with NEMA CP 1. Include the following:



- a. Routine capacitor production tests, including short-time overvoltage, capacitance, leak, and dissipation-factor tests.
- b. Functional test of all operations, controls, indicators, sensors, and protective devices.

1.3 EXECUTION

A. Installation

1. Install freestanding equipment on concrete bases. Cast-in-place concrete is specified in Division 3.
2. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Maintain minimum workspace according to manufacturer's written instructions.
4. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.
5. Identify components according to Division 26 Section "Identification For Electrical Systems".

B. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Perform tests and inspections.
3. Tests and Inspections: Perform each visual and mechanical inspection and electrical test stated in the following Sections, except optional tests, in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - a. Current Transformers.
 - b. Capacitors and Reactors, Capacitors.

C. Startup Service

1. Perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions.
 - b. Connect and run installed motors and equipment to verify the automatic switching of the capacitors. Verification shall include automatic switching of the total capacity of installed capacitors.
 - 1) Provide sufficient inductive/reactive load banks, in combination with resistive load banks, for the test.

D. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain automatic power factor correction units.

END OF SECTION 26 35 33 00



Task	Specification	Specification Description
26 35 33 00	26 09 23 00b	Electrical Power Monitoring And Control
26 35 53 00	26 32 13 13	Packaged Engine Generators



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SECTION 26 36 13 00 - TRANSFER SWITCHES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for transfer switches. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes transfer switches rated 600 V and less, including the following:
 - a. Automatic transfer switches.
 - b. Bypass/isolation switches.
 - c. Nonautomatic transfer switches.
 - d. Remote annunciation systems.
 - e. Remote annunciation and control systems.

C. Submittals

1. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
3. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems". Include the following:
4. Field quality-control test reports.
5. Operation and maintenance data.

D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NEMA ICS 1.
3. Comply with NFPA 70.
4. Comply with NFPA 99.
5. Comply with NFPA 110.
6. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.2 PRODUCTS

A. General Transfer-Switch Product Requirements

1. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
2. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - a. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
3. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.



4. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
 5. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
 6. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - a. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
 - b. Switch Action: Double throw; mechanically held in both directions.
 - c. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
 7. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles **OR** overlapping neutral contacts, **as directed**.
 8. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
 9. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
 10. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
 11. Battery Charger: For generator starting batteries.
 - a. Float type rated 2 **OR** 10, **as directed**, A.
 - b. Ammeter to display charging current.
 - c. Fused ac inputs and dc outputs.
 12. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
 13. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification For Electrical Systems".
 - a. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - b. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - c. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
 14. Enclosures: General-purpose NEMA 250, Type 1 **OR** 3R **OR** 12, **as directed**, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.
- B. Automatic Transfer Switches
1. Comply with Level 1 equipment according to NFPA 110.
 2. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
 3. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
 4. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
 5. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
 6. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
 7. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
 8. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:



- a. Fully automatic make-before-break operation.
 - b. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
 - c. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
 - 1) Initiation occurs without active control of generator.
 - 2) Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
 - d. Failure of power source serving load initiates automatic break-before-make transfer.
9. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
10. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
11. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.
12. Automatic Transfer-Switch Features:
- a. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 - b. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
 - c. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 - d. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 - e. Test Switch: Simulate normal-source failure.
 - f. Switch-Position Pilot Lights: Indicate source to which load is connected.
 - g. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - 1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - 2) Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
 - h. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
 - i. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.



- j. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
- k. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
- l. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
- m. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - 1) Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - 2) Push-button programming control with digital display of settings.
 - 3) Integral battery operation of time switch when normal control power is not available.

C. Bypass/Isolation Switches

1. Comply with requirements for Level 1 equipment according to NFPA 110.
2. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
 - a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
 - b. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
 - c. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
 - d. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
 - e. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
 - f. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
 - g. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
3. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

D. Nonautomatic Transfer Switches

1. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
2. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." In addition, removable manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.
3. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.



4. Nonautomatic Transfer-Switch Accessories:
 - a. Pilot Lights: Indicate source to which load is connected.
 - b. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternate-source sensing circuits.
 - 1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - 2) Emergency Power Supervision: Red light with nameplate engraved "Alternate Source Available."
 - c. Unassigned Auxiliary Contacts: One set of normally closed contacts for each switch position, rated 10 A at 240-V ac.
- E. Remote Annunciator System
 1. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
 - a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - b. Switch position.
 - c. Switch in test mode.
 - d. Failure of communication link.
 2. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
 - a. Indicating Lights: Grouped for each transfer switch monitored.
 - b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
 - c. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
 - d. Lamp Test: Push-to-test or lamp-test switch on front panel.
- F. Remote Annunciator And Control System
 1. Functional Description: Include the following functions for indicated transfer switches:
 - a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - b. Indication of switch position.
 - c. Indication of switch in test mode.
 - d. Indication of failure of digital communication link.
 - e. Key-switch or user-code access to control functions of panel.
 - f. Control of switch-test initiation.
 - g. Control of switch operation in either direction.
 - h. Control of time-delay bypass for transfer to normal source.
 2. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.
 3. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
 - a. Controls and indicating lights grouped together for each transfer switch.
 - b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
 - c. Digital Communication Capability: Matched to that of transfer switches supervised.
 - d. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
- G. Source Quality Control
 1. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.



1.3 EXECUTION

A. Installation

1. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Hangers And Supports For Electrical Systems".
2. Floor-Mounting Switch: Anchor to floor by bolting.
 - a. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers And Supports For Electrical Systems".
3. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
4. Identify components according to Division 26 Section "Identification For Electrical Systems".
5. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

B. Connections

1. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to the Owner if necessary to accommodate required wiring.
2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - b. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - c. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - d. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - 1) Check for electrical continuity of circuits and for short circuits.
 - 2) Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - 3) Verify that manual transfer warnings are properly placed.
 - 4) Perform manual transfer operation.
 - e. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - 1) Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - 2) Simulate loss of phase-to-ground voltage for each phase of normal source.
 - 3) Verify time-delay settings.
 - 4) Verify pickup and dropout voltages by data readout or inspection of control settings.
 - 5) Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.



- 6) Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
 - f. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - 1) Verify grounding connections and locations and ratings of sensors.
 3. Coordinate tests with tests of generator and run them concurrently.
 4. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
 5. Remove and replace malfunctioning units and retest as specified above.
 6. Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Final Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Demonstration
1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
 2. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 13 00



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Task	Specification	Specification Description
26 36 13 00	26 24 13 00a	Enclosed Switches And Circuit Breakers
26 36 23 00	26 24 13 00a	Enclosed Switches And Circuit Breakers
26 36 23 00	26 36 13 00	Transfer Switches
26 41 13 00	26 05 26 00	Lightning Protection



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SECTION 26 43 13 00 - TRANSIENT VOLTAGE SUPPRESSION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for transient voltage suppression. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.

C. Definitions

1. ATS: Acceptance Testing Specifications.
2. SVR: Suppressed voltage rating.
3. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.
2. Field quality-control reports.
3. Operation and maintenance data.
4. Warranties: Sample of special warranties.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.
2. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.
3. Comply with NEMA LS 1.
4. Comply with UL 1283, **as directed**, and UL 1449.
5. Comply with NFPA 70.

F. Project Conditions

1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - a. Notify Owner no fewer than two days in advance of proposed electrical service interruptions.
 - b. Do not proceed with interruption of electrical service without Owner's written permission.
2. Service Conditions: Rate TVSS devices for continuous operation under the following conditions unless otherwise indicated:
 - a. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - b. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
 - c. Humidity: 0 to 85 percent, noncondensing.
 - d. Altitude: Less than 20,000 feet (6090 m) above sea level.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within Five years from date of Final Completion.



2. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

1.2 PRODUCTS

A. Service Entrance Suppressors

1. Surge Protection Devices:

- a. Non-modular.
- b. LED indicator lights for power and protection status.
- c. Audible alarm, with silencing switch, to indicate when protection has failed.
- d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

OR

Surge Protection Devices:

- e. Comply with UL 1449.
 - f. Modular design (with field-replaceable modules) **OR** Non-modular design, **as directed**.
 - g. Fuses, rated at 200-kA interrupting capacity.
 - h. Fabrication using bolted compression lugs for internal wiring.
 - i. Integral disconnect switch (if a fused switch or circuit breaker is not provided for the TVSS in the panelboard and the TVSS will not have a direct bus bar connection).
 - j. Redundant suppression circuits.
 - k. Redundant replaceable modules.
 - l. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
- #### OR
- Arrangement with wire connections to phase buses, neutral bus, and ground bus.
- m. LED indicator lights for power and protection status.
 - n. Audible alarm, with silencing switch, to indicate when protection has failed.
 - o. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - p. Four **OR** Six, **as directed**, -digit transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 320 kA per mode/640 kA **OR** 240 kA per mode/480 kA **OR** 160 kA per mode/320 kA, **as directed**, per phase.
 3. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2
 - a. Line to Neutral: 70,000 A.
 - b. Line to Ground: 70,000 A.
 - c. Neutral to Ground: 50,000 A.
 4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V **OR** 208Y/120 V **OR** 600Y/347 V, **as directed**, 3-phase, 4-wire circuits shall be as follows:
 - a. Line to Neutral: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
 - b. Line to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
 - c. Neutral to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.

OR

Protection modes and UL 1449 SVR for 240/120 V, single-phase, 3-wire circuits shall be as follows:



- a. Line to Neutral: 400 V.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:

- a. Line to Neutral: 400 V, 800 V from high leg.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

- a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- b. Line to Ground: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.

B. Panelboard Suppressors**1. Surge Protection Devices:**

- a. Non-modular.
- b. LED indicator lights for power and protection status.
- c. Audible alarm, with silencing switch, to indicate when protection has failed.
- d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

OR

Surge Protection Devices:

- a. Comply with UL 1449.
 - b. Modular design (with field-replaceable modules) **OR** Non-modular design, **as directed**.
 - c. Short-circuit current rating complying with UL 1449, and matching or exceeding the panelboard short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
 - d. Fuses, rated at 200-kA interrupting capacity.
 - e. Fabrication using bolted compression lugs for internal wiring.
 - f. Integral disconnect switch (if a fused switch or circuit breaker is not provided for the TVSS in the panelboard and the TVSS will not have a direct bus bar connection).
 - g. Redundant suppression circuits.
 - h. Redundant replaceable modules.
 - i. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - j. LED indicator lights for power and protection status.
 - k. Audible alarm, with silencing switch, to indicate when protection has failed.
 - l. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - m. Four **OR** Six, **as directed**, -digit transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA **OR** 120 kA per mode/240 kA **OR** 80 kA per mode/160 kA, **as directed**, per phase.
 3. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2:
 - a. Line to Neutral: 70,000 A.
 - b. Line to Ground: 70,000 A.
 - c. Neutral to Ground: 50,000 A.
 4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V **OR** 208Y/120 V **OR** 600Y/347 V, **as directed**, 3-phase, 4-wire circuits shall be as follows:
 - a. Line to Neutral: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.



- b. Line to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
- c. Neutral to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.

OR

Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:

- a. Line to Neutral: 400 V.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:

- a. Line to Neutral: 400 V, 800 V from high leg.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

- a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

C. Enclosures

- 1. Indoor Enclosures: NEMA 250 Type 1 **OR** Type 12, **as directed**.
- 2. Outdoor Enclosures: NEMA 250 Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.

1.3 EXECUTION

A. Installation

- 1. Install TVSS devices at service entrance on load side, with ground lead bonded to service entrance ground.
- 2. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - a. Provide multiple, 30 **OR** 60 **OR** 100, **as directed**, -A circuit breaker as a dedicated disconnecting means for TVSS unless otherwise indicated.

B. Field Quality Control

- 1. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- 2. Tests and Inspections:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
 - b. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.
 - c. Complete startup checks according to manufacturer's written instructions.
- 3. TVSS device will be considered defective if it does not pass tests and inspections.
- 4. Prepare test and inspection reports.

C. Startup Service



-
- a. Do not energize or connect service entrance equipment **OR** panelboards **OR** control terminals **OR** data terminals, **as directed**, to their sources until TVSS devices are installed and connected.
 - b. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.
- D. Demonstration
- a. Train Owner's maintenance personnel to maintain TVSS devices.

END OF SECTION 26 43 13 00



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Task	Specification	Specification Description
26 51 13 00	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 51 13 00	02 84 16 00a	Interior Lighting
26 51 13 00	02 84 16 00b	Exterior Lighting
26 53 00 00	02 84 16 00a	Interior Lighting



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SECTION 26 55 61 00 - STAGE LIGHTING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for stage lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Dimmer racks.
 - b. Control console and control devices.
 - c. Lighting fixtures and accessories.
 - d. Distribution components.

C. Performance Requirements

1. Seismic Performance: Dimmer racks shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed**.

D. Submittals

1. Product Data: For each type of product indicated.
2. Seismic Qualification Certificates: For **<Insert equipment,>** accessories, and components, from manufacturer.
3. Field quality-control reports.
4. Operation and maintenance data.
5. Software and Firmware Operational Documentation.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NECA 1.
3. Comply with NFPA 70.

F. Software Service Agreement (if allowed)

1. Technical Support: Beginning with Final Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Plug Connectors

1. Pin Type: USITT S3, two-pole, three-wire, 20-A.
2. Twist-Locking Type: NEMA WD 6, two-pole, three-wire, 20-A.



B. Lighting Fixtures And Accessories

1. General:
 - a. Comply with UL 1573 and listed and labeled by an NRTL.
 - b. Fixtures: Equipped with pigtail, yoke with pipe clamp, safety cable for batten mounting, and filter holder.
 - c. Metal Parts: Free of burrs, sharp corners, and edges.
 - d. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
 - e. Fixture Doors and Their Internal Access: Smooth operating, free of light leakage under operating conditions, and arranged to permit relamping without use of tools. Doors, lenses, diffusers, and other pieces arranged to prevent accidental falling during relamping and when secured in operating position.
 - f. Pigtail: Factory wired, 36-inch- (900-mm-) long, three-wire cord and plug connector assembly with cord encased in woven fiberglass or silicone tubing.
 - g. Lamp Sockets: Relampable without disturbing alignment or focus adjustment.
 - h. Fixture Ventilation Openings: Baffled against light leaks.
 - i. Fixture Operating Controls and Handles: Thermally insulated.
 - j. Lenses: Borosilicate glass in silicone mountings.
 - k. Framing Shutters: Stainless steel, four way; with each blade in a separate plane under adjustable tension mounting. Blades adjust plus or minus 30 degrees of rotation in gate, for 120-degree-minimum total angular rotation between adjacent blades.
 - l. Color Filter Frame Holder: Attached to front of fixture.
 - m. Fixture Yoke: Rigid metal, arranged for vertical aiming of unit and equipped with T-bolt or hand screw to lock alignment.
2. Ellipsoidal Spotlights: Fixtures with an elliptical reflector mounted in a fixed relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.
 - a. Tag: ES-1:
 - 1) Lamp: 1000 W Q1000/4CL, ANSI FEL.
 - 2) Pattern Holders: Three for each fixture, with framing shutters.
 - 3) Color Frame: Black, metal.
 - 4) Minimum Cosine Illumination Performance Ratings When Operated with ANSI C78 Series, FEL Lamp:
 - a) 171,000 beam candlepower at 20-degree field angle.
 - b) 48,000 beam candlepower at 40-degree field angle.
3. Zoom Ellipsoidal Spotlights: Fixtures with an elliptical reflector mounted in an adjustable relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.
 - a. Tag: ZES-1:
 - 1) Lamp: 1000 W Q1000/4CL, ANSI FEL.
 - 2) Pattern Holders: Three for each fixture, with framing shutters.
 - 3) Operator adjustable from 25- to 50-degree field angle.
 - 4) Field-angle adjustment scale label on instrument housing for field reference.
 - 5) Minimum Cosine Illumination Performance Rating When Operated with ANSI C78 Series, FEL Lamp: 82,000 beam candlepower at 35-degree field angle.
4. Fresnel Lens Spotlights:
 - a. Die-cast extruded-aluminum housing, with hinged front for relamping.
 - b. Tag: FLS-1.
 - 1) Lamp: 1000 W Q1000T7/4CL, ANSI EGT.
 - 2) Lens: 6 inches (152 mm).
 - 3) Illumination Performance Rating When Operated with ANSI C78 Series, EGT Lamp:
 - a) 175,000 beam candlepower at 12.5-degree field angle in spot focus.
 - b) 12,000 beam candlepower at 74.6-degree field angle in flood focus.
 - 4) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
5. Follow Spotlights:



- a. Tag: FS-1:
 - 1) Lamp: Metal halide, G22 medium bi-post, CRI: 90, color: 6000 K, life: 750 hours, HMI 575 W/GS 95 V.
 - 2) Adjustable lenses in metal housing.
 - 3) Lamp: Quartz-projector type, Adjustable, underslung base stand mounted on 3-inch (75-mm), locking-type, rubber-tired, ball-bearing casters.
 - 4) Adjustable lamp holder and socket assembly with precision tuning adjustment; relampable without tools.
 - 5) Three-leaf, full-range mechanical dimmer.
 - 6) Adjustable iris and framing shutters.
 - 7) Automatic color boom.
 - 8) Removable power cable, 25 feet (8 m) long.
 - 9) Iris Open, Spot-Focus Performance: 800,000, **as directed**, beam candlepower at 7.2, **as directed**, -degree field angle.
 - 10) Iris Open, Flood-Focus Performance: 330,000, **as directed**, beam candlepower at 12.2, **as directed**, -degree field angle.
6. PAR Lamp Holders:
 - a. Tag: PLH-1:
 - 1) Lamp: 300 W PAR 38.
 - 2) Housing: Steel or aluminum, flat black color, **as directed**, with porcelain-plated shell socket.
 - 3) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
 - b. Tag: **<Insert drawing designation>**.
 - 1) Lamp: 575 W tungsten halogen, 90 GLA 575 W, 230 V, color: 3200 K, ANSI GKV.
 - 2) Housing: Steel or aluminum, with porcelain-plated shell socket and color frame, **as directed**.
 - 3) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
 - 4) With Lens Holder and Replaceable Lenses:
 - a) **<Insert drawing designation>**: Very narrow spot.
 - b) **<Insert drawing designation>**: Narrow spot.
 - c) **<Insert drawing designation>**: Medium flood.
 - d) **<Insert drawing designation>**: Wide flood.
 - e) **<Insert drawing designation>**: Very wide.
 - 5) Motorized **OR** Manual, **as directed**, color wheel.
7. Borderlight Units: Compartmented, three-circuit striplight with nine 150-W, PAR 38/SP **OR** 150-W, PAR 38/FL **OR** 250-W, PAR 38/SP **OR** 150-W, R40/FL, **as directed**, lamps in porcelain sockets and steel sheet housing, 90 inches (2286 mm) long. Compartments shall be in line and wired on two **OR** three **OR** four, **as directed**, alternate circuits, each producing a different color.
 - a. Front Door: Spring loaded; designed to hold either filter frames or color roundels.
 - b. Color Roundels: One for each lamp; alternating red, blue, and clear, **as directed**.
 - 1) Additional Roundels: **<Insert number>** amber and **<Insert number>** green.
 - c. Hanger: Adjustable, steel-strap type equipped at each end with pipe clamp and safety cable for suspension from a batten.
8. Cyclorama Lights: Suitable for lighting cycloramas from above.
 - a. Tag: CL-1:
 - 1) Lamp: 1000 W Q1000T3/1CL, ANSI FFT.
 - 2) Housing: Aluminum or steel, **as directed**, flat black color, **as directed**, with color frame, **as directed**.
9. Black Lights: Portable, producing a wash of UV light for special effects.
 - a. Tag: BL-1:
 - 1) Lamp: 250 W blacklight flood, H37KB-250, with integral filter to eliminate far-UV effect while maximizing the near-UV effect.
 - 2) Housing: Steel or aluminum, **as directed**, flat black color, **as directed**, with carry handle.
 - 3) C-clamp for using on light pipe.
10. Moving Lights:



- a. Tag: ML-1:
 - 1) General: 700-W, 120-V, metal halide, motorized remote-controlled lighting instrument; NRTL listed.
 - 2) Lamp: Short-arc metal halide, 14,500 lumens; color temperature of 5600 K, CRI of 80.
 - 3) Color System: Three-filter CYM (cyan, yellow, magenta) cross-fading mechanism, and 11 standard colors on a fixed wheel.
 - 4) Optics: Zoom optics with continuously variable field angle from 18.5 to 42 degrees, programmable over a timed range of 2 seconds to 20 minutes; with a mechanical iris for beam-size control. Variable beam focus to soften the edges of gobos and light beams. Zoom combined with iris can project a beam with a field angle of 8 degrees.
 - 5) Dimming: Coated glass dimmer wheel, with controls to provide smooth timed fades.
 - 6) Strobe for strobe lighting effects.
 - 7) Gobo: One rotating wheel with five rotatable wheel positions and one open position. One fixed gobo wheel with 11 pattern positions and one open position.
 - 8) Beam Orientation Control: Smooth pan and tilt using a three-phase stepper motor system. Pan, 540 degrees; tilt, 270 degrees at 0.3-degree repeatability on either axis.
 - 9) Control: ANSI E1.11 (USITT DMX512-A) protocol using five pin connectors.

C. Distribution Components

1. Connector Strip: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly.
 - a. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
 - b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
 - c. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.
OR
Receptacles: Flush mounted in wireway cover.
 - d. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
 - e. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
 - f. Mounting Hardware: Furnished with each unit; permits surface, single-pipe-bracket, or double-pipe-bracket mounting.
 - g. Finish: Semigloss or matte black.
2. Plug-in Boxes: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly, 24 inches (600 mm) long unless otherwise indicated; with the following features:
 - a. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
 - b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
 - c. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.
OR
Receptacles: Flush mounted in wireway cover.
 - d. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
 - e. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
 - f. Surface or Grid Mounting: With accessories for surface mounting or with pipe-mounting accessory bracket.
 - g. Recessed Mounting: With flanged cover suitable for recessed mounting in wall.
 - h. Finish: Semigloss or matte black.
3. Gridiron Junction Boxes: Listed and labeled by an NRTL; factory wired with terminal strips and concentric knockouts on all sides.
 - a. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.



- b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable, and brackets for surface or pipe mounting.
 - c. Finish: Semigloss or matte black.
 - 4. Floor Pockets: Listed and labeled by an NRTL; flush-mounted, receptacle outlet assembly.
 - a. Box: 0.0598-inch (1.5-mm) steel sheet, 10 inches (250 mm) deep.
 - b. Cover Plate: Steel, cast iron, or cast aluminum with nonskid safety tread surface and self-closing, hinged door with cable notches.
 - c. Barrier for allowing installation of low-voltage control receptacle for console input or handheld remotes.
- D. Wire And Cable
- 1. Building Wire in Raceways: Comply with requirements specified in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
 - 2. Portable Power Cable: Listed and labeled by an NRTL; flexible stage and lighting power cable; Type SC, SCE, or SCT; 600 V; multiconductor; 60 deg C temperature rating.
 - 3. Ethernet Cabling: Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables".
 - a. For 10/100BaseT, comply with provisions for UTP cable and hardware.
 - b. For 10Base-FL, comply with provisions for 50/125 **OR** 62.5/125, **as directed**,-micrometer, multimode, optical-fiber cable and hardware.
 - 4. ANSI E1.11 (USITT DMX512-A) Control Cabling: Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables".
 - a. Standard Cable: NFPA 70, Type CM **OR** Type CMG, **as directed**.
 - 1) Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, No. 22 AWG **OR** No. 24 AWG, **as directed**, stranded, tinned-copper conductors.
 - 2) PE insulation.
 - 3) Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
 - 4) Outer Shield: 90 percent coverage, tinned-copper braid.
 - 5) Outer Shield Drain Wire: Stranded, tinned copper.
 - 6) PVC jacket.
 - 7) Flame Resistance: Comply with UL 1581.
 - b. Plenum-Rated Cable: NFPA 70, Type CMP.
 - 1) Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, No. 22 AWG **OR** No. 24 AWG, **as directed**, stranded, tinned-copper conductors.
 - 2) Insulation: Foam fluoridated ethylene propylene.
 - 3) Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
 - 4) Outer Shield: 90 percent coverage, tinned-copper braid.
 - 5) Outer Shield Drain Wire: Stranded, tinned copper.
 - 6) Low-smoke PVC jacket.
 - 7) Flame Resistance: Comply with NFPA 262.
 - 5. Low-Voltage Control Cabling:
 - a. Control-Cable Conductors:
 - 1) Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway; complying with UL 83.
OR
Class 1 Control Circuits: Stranded copper, Type THHN, in raceway; complying with UL 44.
 - 2) Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**; complying with UL 83.
OR
Class 2 Control Circuits: Stranded copper, Type THHN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**; complying with UL 44.



- 3) Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF; complying with UL 83.
- b. Paired Cable: NFPA 70, Type CMG.
 - 1) One pair, twisted, No. 16 AWG, stranded, tinned-copper conductors.
 - 2) PVC insulation.
 - 3) Unshielded.
 - 4) PVC jacket.
 - 5) Flame Resistance: Comply with UL 1581.
- c. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - 1) One pair, twisted, No. 16 AWG, stranded (19x29), tinned-copper conductors.
 - 2) PVC insulation.
 - 3) Unshielded.
 - 4) PVC jacket.
 - 5) Flame Resistance: Comply with NFPA 262.
- d. Paired Cable: NFPA 70, Type CMG.
 - 1) One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
 - 2) PVC insulation.
 - 3) Unshielded.
 - 4) PVC jacket.
 - 5) Flame Resistance: Comply with UL 1581.
- e. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - 1) One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
 - 2) Fluorinated ethylene propylene insulation.
 - 3) Unshielded.
 - 4) Plastic jacket.
 - 5) Flame Resistance: Comply with NFPA 262.

E. Lighting Control System

1. Description: Microprocessor-based modular system consisting of dimmer and control modules operated from remote-control stations and a control console.
 - a. Comply with UL 508.
 - b. Comply with USITT AMX192 **OR** ANSI E1.11 (USITT DMX512-A), **as directed**, for data transmission.
2. Dimmer Racks: Listed and labeled by an NRTL; dead-front, front-access, wall-mounted **OR** freestanding, **as directed**, rack for mounting modular dimmers; formed-steel or extruded-aluminum structural members; completely enclosed with steel or aluminum panels. Painted with manufacturer's standard corrosion-resistant primer and finish coats, and having the following features:
 - a. Primary Circuit Breaker: Fault-current withstand rating of the rack; not less than 10,000 **OR** 50,000, **as directed**, A, symmetrical.
 - b. Hinged, locking front door, with openings to allow air intake across the face of all dimmer modules.
 - c. Individual rack sections shall not exceed 84 inches high by 25 inches deep by 30 inches wide (2134 mm high by 635 mm deep by 762 mm wide). Multisection racks shall be interconnected with busbars.
 - d. For each module position, provide support rails and control-pin configurations, constructed for precise alignment of dimmer modules into power and signal connector sockets.
 - e. Forced-air cooling of each rack for maintaining operating temperature at each dimmer, assuming full load, in ambient temperature not to exceed 40 deg C. Exhaust rates shall be variable, using temperature sensors and fan-speed control electronics. Individual control of multiple fans is acceptable in lieu of fan-speed control. Fan(s) shall start and stop automatically. Fan noise at full load shall be less than 3.1 sones.
 - f. Each rack shall have an automatic air-temperature sensor to shut off all dimmers in the rack should the internal temperature rise above maximum safe operating limits. In an



- overheat condition, the fan shall continue operating. When a safe operating temperature is restored, the system shall automatically reset to allow normal user control.
- g. Fabricate and test dimmer racks to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Dimmers: Modular solid-state units that operate smoothly over their operating ranges without audible lamp noise or radio-frequency interference at any setting. Modules shall be dead-front, draw-out type with floating line, load, and control sockets for smooth insertion and withdrawal; with load-side thermal-magnetic circuit breaker, speed-controlled cooling fan, and overtemperature sensor.
 - a. Non-Dim Units: On-off relay control only. Capable of serving inductive loads such as motors or high-intensity-discharge fixtures.
 - b. Surge Protection: Modules shall withstand power-line surges of 6000 V/3000 A according to IEEE C62.41.1 and IEEE C62.41.2.
 - c. Filter each dimmed circuit to provide a minimum 350-mic.sec., current-rise time at a 90-degree conduction angle at 50 percent of rated dimmer capacity. At any load within rating, rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load current waveform.
 4. Control System: Microprocessor-based control system, ANSI E1.11 (USITT DMX512-A) protocol, with a nonvolatile system memory to adjust dimmer channel settings for different scenes, to patch dimmers to channels, and to manually or automatically change dimmer settings from one preset scene to another.
 - a. Control shall support Ethernet-based LAN at every control device.
 - b. Provide means to create and monitor show data on a PC using software by console manufacturer. Software shall be capable of the following:
 - 1) Creating show and providing for use of USITT show files.
 - 2) Playing back show in a console-simulation mode.
 - 3) Accessing all remote-control stations associated with the console and control system.
 - 4) Providing standard Ethernet connection between the console control system and the PC.
 - c. Display the following system status information on a color, 17-inch (430-mm) LCD monitor associated with the control console:
 - 1) Current channel intensities.
 - 2) Cue information.
 - 3) Monitor.
 - d. Moving Lights: Include a standard control library, a program patch specific to fixture(s) provided, and selective programming with ANSI E1-11 (USITT DMX512-A) addressing of fade, focus points, beam, image, color, <Insert attributes> and position.
 5. Control Console: Tabletop unit with manual and computer-based programming controls, memory units, indicating devices, and the following features:
 - a. Servicing access through hinged top panel.
 - b. Grand-master level control.
 - c. Blackout switch.
 - d. 12 submaster level controls with overlapping pile-on performance.
OR
24 submaster level controls with overlapping pile-on performance.
 - e. Bump buttons for momentary control of channels or submasters, one for each submaster level control.
 - f. Two cross-fade controls for split dipless fade between scenes, each with its own fade progress indicator.
 - g. One set of scene level controls for each scene when used in two-scene preset mode. Second set of scene level controls to allow setting levels into memory for expanded single scenes when used in multiple single-channel scene mode. Each set shall have same quantity of scene level controls as is used for submaster level controls.
 - h. Multibutton keypad for programming in multiscene memory mode.



- i. Fade time control for assigning fade time to cues, with individual cue adjustment from one second to five minutes, minimum.
 - j. Light-emitting diode **OR** LCD **OR** Computer monitor cathode-ray tube, **as directed**, with associated display controls, for displaying operating menus and memory readout.
 - k. Controls for setting levels into memory.
 - l. Cord and connector for connecting console to outlets for console power and control.
6. System Operation: Selectable between multichannel two-scene preset and four-channel single-scene memory. Console features include electronic patching of control signals for up to 512 dimmers and off-line data storage using internal, 3-1/2-inch (90-mm) disk-drive unit. Operational capability includes the following:
- a. Live and blind programming.
 - b. Special effects programmability for automatic operation of lights in pulsating, sequential dimming and brightening, and other special operating modes. Special effects menu displays operator guidance for programming and individual step levels.
 - c. Signal from fire-alarm control panel that automatically brings selected circuits to fully on or fully bright condition, overriding normal dimming and on-off controls.
 - d. Inserting cues between designated cues without renumbering.
 - e. Out-of-sequence playback of cues.
 - f. Controlling houselights and stage lights from console by assigning their dimmers or non-dim on-off controls to a channel.
 - g. Retaining programmed cues in memory for minimum of one year after power outage.
 - h. Automatic sequential execution of programmed cues.
 - i. Printing cues using parallel or serial printer port, cable, and printer. Cable and printer are not included with this system.
7. PC: Standard, unmodified, with accessories and peripherals that are configured to install and run control-console manufacturer's written requirements, but not less than the following:
- a. CPU operating speed shall be at least 1.6 GHz.
 - b. Memory: 1024 MB.
 - c. Serial Ports: Provide two for general use.
 - d. Parallel Port: Enhanced.
 - e. LAN Adapter: 10/100/1000 Mbps, internal network interface card.
 - f. Three USB 2.0 ports.
 - g. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
 - h. Color Monitor: Not less than 17 inches (430 mm), with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm. Video card shall support at least 256 colors at a resolution of 1280 by 1024 pixels at a minimum refresh rate of 70 Hz.
 - i. Keyboard: With a minimum of 64 characters; standard ASCII character set based on ANSI INCITS 154 (formerly ANSI X3.154).
 - j. Mouse: Standard, compatible with installed software.
 - k. Disk storage shall include the following, each with appropriate controller:
 - 1) Minimum 60 GB hard disk, 5400 rpm.
 - 2) Floppy Disk Drive: High density, 3-1/2-inch (90-mm) size.
 - 3) **<Insert disk drives>**.
 - l. CD-ROM Drive: 24x/10x/24x CD-RW/8x DVD combination.
8. Console Power and Control Outlets: Multiple receptacles matched to connector on console connector cord.
9. House Lighting Control Station: Architectural-type, multichannel, remote-dimmer-control station with the following features:
- a. System controls designated houselights, stage lights, and other lights.
 - b. Stage lighting controls compatible with dimming and control system.
 - c. Flush mounting.
 - d. Brushed-aluminum wall plate.
 - e. Five **OR** Six, **as directed**, channels, each with slider potentiometer control.



- f. Master-slider potentiometer that controls lights on all channels proportionally from completely dimmed to degree of brightness that corresponds to individual slider positions.
 - g. Fully on switch that turns all channels on at full brightness regardless of slider position.
 - h. Take-control/off switch that places station in control of channels and sets lighting to levels dictated by channel and master-slider controls.
 - i. Legend on face of wall plate that identifies items as "House Lighting Control Station" and identifies functions of each slider and switch position, with slider positions individually graduated from zero to 10.
 - j. Illuminated push buttons for activating preset scenes of house lighting and labeled "Entry" **OR** "Panic" **OR** "Entry" and "Panic," **as directed**.
 - k. Flush wall mounted unless otherwise indicated.
10. Entry Station: Push button activates or deactivates indicating light and presets scene of house lighting control system.
 - a. Light-emitting-diode indicating light illuminates when preset command is executed.
 - b. Labeled "Entry."
 - c. Flush wall mounted unless otherwise indicated.
 11. Key-Entry Station: Key-operated switch controls station to activate or deactivate indicating light and presets scene of lighting control system.
 - a. Light-emitting-diode indicating light illuminates when preset command is executed.
 - b. Labeled "Entry."
 - c. Flush wall mounted unless otherwise indicated.
 12. Emergency Lighting Control Station: Key-operated, **as directed**, push button activates indicating light and brings selected dimmers to fully bright condition, i.e., the "Panic" preset. Operating push button a second time returns dimmers to previous setting.
 - a. Emergency mode indicating light.
 - b. Labeled "Emergency Lights."
 - c. Flush wall mounted unless otherwise indicated.

F. Rigging Components

1. Pipe Clamps: Malleable iron, suitable for clamping fixtures or items to pipe from 3/4 to 2 inches (20 to 51 mm) in OD. Arranged for horizontal rotation of yoke for aiming; equipped with T-bolt to lock alignment.
2. Safety Cables: Heavy-duty, flexible steel; 30-inch (762-mm) nominal length, with spring clip at one end and steel ring at the other end.
3. Cable Grips: Stainless **OR** Galvanized, **as directed**, steel; basket-weave type for supporting stage cables.

1.3 EXECUTION

A. Installation

1. Set permanently mounted items level, plumb, and square with ceilings and walls.
2. Indicated mounting heights are to bottom of unit for suspended items and to center of unit for wall-mounted items.
3. Mount and connect fixtures, and install and connect distribution devices.
 - a. If arrangement is not indicated, install so each fixture, dimmer, house lighting circuit, control channel, and outlet circuit can be operated, and complete system demonstrated, in all operating modes.
 - b. Install safety cables secured to stage rigging or gridiron for all pipe-mounted electrical fixtures and equipment.
4. Dimmer Rack Mounting: Install and anchor dimmer racks level on 4-inch- (100-mm-) high concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
 - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.



- b. For dimmer racks, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to dimmer racks.
5. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".

B. Wiring

1. Power Wiring:
 - a. Install wiring as specified in Division 26 Section "Low-voltage Electrical Power Conductors And Cables" for hardwired connections. Install wiring in raceways except cable and plug connections.
 - b. Install power wiring with a separate neutral for each output circuit from main dimmer and for each house and stage lighting circuit.
2. Signaling, Remote-Control, and Power-Limited Circuits:
 - a. Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables" for installation of wiring. Install wiring in raceways except cable and plug connections.
 - b. Comply with the following unless otherwise indicated:
 - 1) Size conductors according to lighting control device manufacturer's written instructions.
 - 2) Select cable insulation, shielding, drain wire, and jacket complying with lighting control device manufacturer's written instructions.
 - 3) Install circuits to eliminate radio-frequency interference and electromagnetic interference.
 - c. Remote-control circuits associated with emergency lighting control shall be installed complying with Class 1 Circuit standards in NFPA 70.
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points.
4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes and in terminal cabinets and equipment enclosures.
5. Remove wall plates and protect devices and assemblies during painting.
6. Support lighting fixtures, distribution components, and accessories as specified in Division 26 Section "Hangers And Supports For Electrical Systems". Equip all pipe-mounted equipment with safety cables that are secured to supporting pipe.
7. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".

C. Identification

1. Identify components, power, and control wiring according to Division 26 Section "Identification For Electrical Systems".
2. Label each fixture, lighting outlet, distribution device, and dimmer module with unique designation. Labels on elevated components shall be readable from the floor.

D. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
 - a. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
 - b. Visual and Mechanical Tests and Inspections:
 - 1) Inspect each fixture, outlet, module, control, and device for defects, finish failure, corrosion, physical damage, labeling by an NRTL, and nameplate.
 - 2) Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's written instructions.
 - 3) Check tightness of electrical connections with torque wrench.



- 4) Verify proper protective device settings, fuse types, and ratings.
 - 5) Record results of tests and inspections.
 - c. Electrical Tests: Perform tests according to manufacturer's written instructions.
 - 1) Continuity tests of circuits.
 - 2) Operational Tests: Connect each outlet to a fixture and a dimmer output circuit so each dimmer module, dimmer control and output circuit, outlet, and fixture in a typical operating mode will be sequentially tested. Set and operate controls to demonstrate fixtures, outlets, dimmers, and controls in a sequence that cues and reproduces actual operating functions for a typical system of the size and scope installed. Include operation and control of houselights and stage lights from each control location and station including optional plug-in, control-console outlet locations. Record fixture and outlet assignments, control settings, operations, cues, and observations of performance.
 - d. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible organization and individual.
 3. Stage lighting will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.
 - a. Prepare a schedule of lighting outlets by number; indicate circuits, dimmers, connected fixtures, and control-channel assignments. Prepare a schedule of control settings and circuit assignments for house control channels. Prepare written reports of tests and observations. Report defective materials, workmanship, and unsatisfactory test results. Include records of repairs and adjustments made.
- E. Adjusting
1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 26 55 61 00



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Task	Specification	Specification Description
26 56 13 00	01 22 16 00	No Specification Required
26 56 13 00	02 84 33 00	Overhead Electrical Distribution
26 56 13 00	02 84 16 00b	Exterior Lighting
26 56 19 00	02 84 16 00b	Exterior Lighting
26 56 23 00	01 22 16 00	No Specification Required
26 56 23 00	02 84 33 00	Overhead Electrical Distribution
26 56 23 00	02 84 16 00a	Interior Lighting
26 56 23 00	02 84 16 00b	Exterior Lighting
26 56 26 00	01 22 16 00	No Specification Required
26 56 26 00	02 84 16 00b	Exterior Lighting
26 56 33 00	02 84 16 00a	Interior Lighting
26 56 33 00	02 84 16 00b	Exterior Lighting
26 56 36 00	02 84 16 00b	Exterior Lighting



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SECTION 26 56 68 00 - SPORTS LIGHTING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for exterior athletic lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes lighting for the following outdoor sports venues:
 - a. Baseball fields.
 - b. Softball fields.
 - c. Football fields.
 - d. Soccer fields.
 - e. Outdoor tennis courts.

C. Definitions

1. CV: Coefficient of variation; a statistical measure of the weighted average of all relevant illumination values for the playing area, expressed as the ratio of the standard deviation for all illuminance values to the mean illuminance value.
2. Delegated-Design Submittals: Documents, including drawings, calculations, and material and product specifications prepared as a responsibility of Contractor to obtain acceptance by the Owner and authorities having jurisdiction.
3. Illuminance: The metric most commonly used to evaluate lighting systems. It is the density of luminous flux, or flow of light, reaching a surface divided by the area of that surface.
 - a. Horizontal Illuminance: Measurement in foot-candles (lux), on a horizontal surface 36 inches (914 mm) above ground unless otherwise indicated.
 - b. Target Illuminance: Average maintained illuminance level, calculated by multiplying initial illuminance by LLF.
 - c. Vertical Illuminance: Measurement in foot-candles (lux), in two **OR** four, **as directed**, directions on a vertical surface, at an elevation coinciding with plane height of horizontal measurements.
4. LC: Lighting Certified.
5. Light Trespass: Light spill into areas and properties outside the playing areas, which is either annoying or unwanted.
6. LLD: Lamp lumen depreciation, which is the decrease in lamp output as the lamp ages.
7. LLF: Light loss factor, which is the product of all factors that contribute to light loss in the system.
8. Luminaire: Complete lighting fixture, including ballast housing if integral.
9. UG: Uniformity gradient; the rate of change of illuminance on the playing field, expressed as a ratio between the illuminances of adjacent measuring points on a uniform grid.

D. Performance Requirements

1. Facility Type: Professional **OR** College **OR** Semiprofessional **OR** Sports club **OR** Amateur league **OR** High school **OR** Training facility **OR** Elementary school **OR** Recreational or social facility, **as directed**.
2. Illumination Criteria:
 - a. Minimum average target illuminance level for each lighted area for each sports venue and for the indicated class of play according to IESNA RP-6.
 - b. CV and maximum-to-minimum uniformity ratios for each lighted area equal to or less than those listed in IESNA RP-6 for the indicated class of play.
 - c. UG levels within each lighted area equal to or less than those listed in IESNA RP-6 for the indicated speed of sport.



3. Illumination Criteria:
 - a. Minimum Average Target Illumination: **<Insert value>**.
 - b. CV: **<Insert value>**.
 - c. Maximum-to-Minimum Uniformity Ratio: **<Insert value>**.
 - d. UG Level: **<Insert value>**.
4. Illumination Calculations: Computer-analyzed point method complying with IESNA RP-6 to optimize selection, location, and aiming of luminaires.
 - a. Grid Pattern Dimensions: For playing areas of each sport and areas of concern for spill-light control, correlate and reference calculated parameters to the grid areas. Each grid point represents the center of the grid area defined by the length and width of the grid spacing.
 - b. Spill-Light Control: Minimize spill light for each playing area on adjacent and nearby areas.
 - 1) Prevent light trespass on properties near Project as defined by **<Insert name(s) of authorities having jurisdiction>**.
 - 2) For areas indicated on Drawings as "spill-light critical," limit the level of illuminance directed into the area from any luminaire or group of luminaires, and measured 36 inches (914 mm) above grade to the following:
 - a) Maximum Horizontal Illuminance: 0.25 fc (2.7 lux) **OR** 0.5 fc (5.4 lux) **OR** 0.75 fc (8.1 lux), **as directed**.
 - b) Maximum Vertical Illuminance from the Direction of the Greatest Contribution of Light: 1.0 fc (10.8 lux) **OR** 2.0 fc (21.5 lux) **OR** 3.0 fc (32.3 lux), **as directed**.
 - 3) Calculate the horizontal and vertical illuminance due to spill light for points spaced 20 feet (6 m) apart in areas indicated on Drawings as "spill-light critical," to ensure that design meets the above limits.
 - c. Glare Control: Design illumination for each playing area to minimize direct glare in adjacent and nearby areas.
 - 1) Design source intensity of luminaires that may be observed at an elevation of 60 inches (1524 mm) above finished grade from nearby properties to be less than 12,000 **OR** 20,000 **OR** 30,000, **as directed**, candela when so observed.
 - 2) Design source intensity of luminaires that may be observed at an elevation of 60 inches (1524 mm) above finished grade from designated "spill-light critical" areas to be less than 12,000 **OR** 20,000 **OR** 30,000, **as directed**, candela when so observed.
 - d. Determine LLF according to IESNA RP-6 and manufacturer's test data.
 - 1) Use LLD at 100 percent of rated lamp life. LLF shall be applied to initial illumination to ensure that target illumination is achieved at 100 percent of lamp life and shall include consideration of field factor.
 - 2) LLF shall not be higher than 70 percent, and may be lower when determined by manufacturer after application of the ballast output and optical system output according to IESNA RP-6.
 - e. Luminaire Mounting Height: Comply with IESNA RP-6, with consideration for requirements to minimize spill light and glare.
 - f. Luminaire Placement: Luminaire clusters shall be outside the glare zones defined by IESNA RP-6.
5. Baseball Fields:
 - a. IESNA RP-6, Class of Play: **I OR II OR III OR IV, as directed**.
 - b. Speed of Sport: **Fast OR Moderate OR Slow, as directed**.
 - c. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).
6. Softball Fields:
 - a. IESNA RP-6, Class of Play: **I OR II OR III OR IV, as directed**.
 - b. Speed of Sport: **Fast OR Moderate OR Slow, as directed**.
 - c. Grid Pattern Dimensions: 20 by 20 feet (6 by 6 m).
7. Football Fields:
 - a. IESNA RP-6, Class of Play: **I OR II OR III OR IV, as directed**.



- b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
- c. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).
8. Soccer Fields:
 - a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.
 - b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
 - c. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).
9. Outdoor Tennis Courts:
 - a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.
 - b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
 - c. Grid Pattern Dimensions: 10 by 10 feet (3 by 3 m).
10. Egress Lighting: In case of power failure, provide a minimum of 1.0-fc (10.8-lux) illumination, within 30 seconds, measured at grade in spectator and spectator egress areas.
 - a. Duration of emergency illumination shall be not less than 15 minutes.
 - b. Momentary Power Interruptions: Provide emergency illumination immediately following restoration of power to the lighting circuits. Emergency illumination shall automatically extinguish after 15 minutes.
11. Lighting Control: Manual, low voltage, or digital; providing the following functions, integrated into a single control station, with multiple subcontrol stations as indicated:
 - a. Control Station: Key-operated master switch, manual push-button controls, and system status indicator lights. Test switch of egress lighting system, **as directed**.
 - b. Light Levels: Two levels of control - 100/50 percent of minimum target illumination.
12. Electric Power Distribution Requirements:
 - a. Electric Power: 208 **OR** 230 **OR** 480, **as directed**, V; three phase.
 - 1) Include roughing-in of service indicated for nonsports improvements on Project site.
 - 2) Balance load between phases. Install wiring to balance three phases at each support structure.
 - 3) Include required overcurrent protective devices and individual lighting control for each sports field or venue.
 - 4) Include indicated feeder capacity and panelboard provisions for future lighted sports field construction.
13. Maximum Total Load: **<Insert number> A**.
 - a. Maximum Total Voltage Drop from Source to Load: 5 percent, including voltage drops in branch circuit, subfeeder, and feeder.
14. Seismic Performance: Luminaires, ballasts, and support structures shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
15. Life-Cycle Cost Criteria:
 - a. Estimated life-cycle cost of lighting system for period of **<Insert number>** years based on the parameters below:
 - 1) Energy Cost: **<Insert value>** {Calculate energy costs by multiplying (number of luminaires) x (kilowatt demand per luminaire) x (power cost at \$/kilowatts) x (number of annual usage hours) x (number of years)}.
 - 2) Lamp Replacement Cost: **<Insert value>** (Calculate replacement costs by multiplying (cost to replace a lamp) x (number of luminaires) x (number of relamps over the period of years used in calculating the energy cost)).
 - 3) General Maintenance: **<Insert value>** (Calculate maintenance costs by multiplying (number of repairs) x (cost per repair) over the life cycle).

OR

Life-Cycle Cost Criteria: **<Insert value>** (Calculate according to Federal Energy Management Program's "Building Life-Cycle Cost").

E. Submittals

1. Product Data: For each type of lighting product indicated. Include the following:



- a. Lamp life, output, and energy-efficiency data. Lamp data certified by NVLAP or NRTL; comply with IESNA LM-47.
 - b. Photometric data based on laboratory tests of each luminaire type, complete with lamps, ballasts, and accessories; comply with IESNA LM-5.
 - 1) Photometric data shall be certified by a qualified independent testing agency.

OR

Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
 2. Delegated-Design Submittal: For exterior athletic lighting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Drawings and specifications for construction of lighting system.
 - b. Manufacturer's determination of LLF used in design calculations.
 - c. Lighting system design calculations for the following:
 - 1) Target illuminance.
 - 2) Point calculations of horizontal and vertical illuminance, CV, and UG at minimum grid size and area.
 - 3) Point calculations of horizontal and vertical illuminance in indicated areas of concern for spill light.
 - 4) Calculations of source intensity of luminaires observed at eye level from indicated properties near the playing fields.
 - d. Electrical system design calculations for the following:
 - 1) Short-circuit current calculations for rating of panelboards.
 - 2) Total connected and estimated peak-demand electrical load, in kilowatts, of lighting system.
 - 3) Capacity of feeder **OR** service, **as directed**, required to supply lighting system.
 - e. Wiring requirements, including required conductors and cables and wiring methods.
 - f. Structural analysis data and calculations used for pole selection.
 - 1) Manufacturer Wind-Load Strength Certification: Submit certification that selected total support system, including poles, complies with AASHTO LTS-4-M for location of Project.
 3. Qualification Data: For qualified Installer, manufacturer, professional engineer, luminaire photometric data testing laboratory and field testing agency.
 4. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 5. Manufacturer Certificates: For support structures, including brackets, arms, appurtenances, bases, anchorages, and foundations, from manufacturer.
 6. Welding certificates.
 7. Field quality-control reports.
 8. Operation and Maintenance Data: For sports lighting system components to include in emergency, operation, and maintenance manuals.
 9. Warranty: Sample of special warranty.
- F. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 2. Manufacturer Qualifications: Manufacturer's responsibilities include fabricating sports lighting and providing professional engineering services needed to assume engineering responsibility.



- a. Engineering Responsibility: Preparation of delegated-design submittals and comprehensive engineering analysis by a qualified professional engineer who is additionally LC by the National Council on Qualifications for the Lighting Professions, **as directed**.
3. Luminaire Photometric Data Testing Laboratory: By manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
4. Luminaire Photometric Data Testing Laboratory: By an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL.
5. Field Testing Agency Qualifications: An independent testing agency that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, or an NRTL as defined in 29 CFR 1910, with the experience and capability to conduct field testing according to IESNA LM-5.

OR

Field Testing Agency Qualifications: A qualified independent professional engineer not associated with Contractor or lighting equipment manufacturer, who is additionally LC by the National Council on Qualifications for the Lighting Professions, **as directed**.

6. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel" and AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
7. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of luminaires, lamps, and luminaire alignment products and to correct misalignment that occurs subsequent to successful acceptance tests. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, and unauthorized repairs and alterations from special warranty coverage.
 - a. Luminaire Warranty: Luminaire and luminaire assembly (excluding fuses and lamps) shall be free from defects in materials and workmanship for a period of five years from date of Final Completion.
 - b. Lamp Warranty:
 - 1) Replace lamps and fuses that fail within 12 months from date of Final Completion.
 - 2) Provide replacement lamps for lamps that fail within the second 12 months from date of Final Completion.
 - c. Alignment Warranty: Accuracy of alignment of luminaires shall remain within specified illuminance uniformity ratios for a period of five years from date of successful completion of acceptance tests.
 - 1) Realign luminaires that become misaligned during the warranty period.
 - 2) Replace alignment products that fail within the warranty period.
 - 3) Verify successful realignment of luminaires by retesting as specified in "Field Quality Control" Article.

1.2 PRODUCTS

A. Luminaires, Lamps, And Ballasts

1. Luminaires: Listed and labeled, by an NRTL acceptable to authorities having jurisdiction, for compliance with UL 1598 for installation in wet locations.
 - a. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without using tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent their accidental falling during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lens.
 - b. Exposed Hardware: Stainless-steel latches, fasteners, and hinges.



- c. Spill-Light Control Devices: Internal louvers and external baffles furnished by manufacturer and designed for secure attachment to specific luminaire.
 - d. Luminaires for tennis courts shall be bracket-mounted, full-cutoff type with integral ballasts.
 - e. Lamps for Tennis Court Luminaires: Metal halide, rated 1000 W.
2. Ballast Mounting: Grouped in cabinets, remote from **OR** At, **as directed**, location of associated luminaires unless otherwise indicated.

B. Support Structures

1. Support-Structure Wind-Load Strength: Poles and other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall comply with AASHTO LTS-4-M and shall be certified by manufacturers to withstand winds up to 100 mph (160 km/h) without permanent deflection or whipping.
2. Support-Structure Seismic Strength: Poles or other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall be designed to prevent separation of components or fracture of poles, luminaire supports, or pole foundations during a seismic event.
3. Mountings, Fasteners, and Appurtenances:
 - a. Corrosion resistant, compatible with support components, and which shall not cause galvanic action at contact points.
 - 1) Steel Components: Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M.
 - 2) Mounting Hardware Fasteners: Hot-dip galvanized, complying with ASTM A 153/A 153M, or minimum 18-8 grade stainless steel.
 - b. Accommodate attachments and wiring of other indicated systems.
4. Concrete for Pole Foundations: 3000-psi (20.7-MPa), 28-day minimum compressive strength. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete".
5. Direct-buried steel structures or poles shall not be used.

C. Power Distribution And Control

1. Wiring Method for Feeders, Subfeeders, Branch Circuits, and Control Wiring: Underground nonmetallic raceway; No. 10 AWG minimum conductor size for power wiring.
2. Overhead-, pole-, or structure-supported wiring and transformers are **OR** are not, **as directed**, permitted.
3. Electrical Enclosures Exposed to Weather: NEMA 250, Type 3R enclosure constructed from stainless steel **OR** corrosion-resistant material, **as directed**, with hinged doors fitted with padlock hasps or lockable latches.

D. Surge Protection

1. Surge Protection: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" and include surge suppressors with the following requirements:
 - a. Panelboard type.
 - b. Nonmodular, with digital indicator lights and one set of dry contacts, **as directed**.
 - c. Peak Single-Impulse Surge Current Rating: **<Insert number>** kA per phase.

E. Pole And Base Protection

1. Pole Pads: Wraparound pad, with 4 inches (100 mm) of extra-firm polyfoam, 360-degree coverage of ground-mounted poles and supports, continuous hook-and-loop fastening, and not less than 72 inches (1820 mm) high.

1.3 EXECUTION

A. Installation



1. Use web fabric slings (not chain or cable) to raise and set structural members. Protect equipment during installation to prevent corrosion.
 2. Install poles and other structural units level, plumb, and square.
 3. Except for embedded structural members, grout void between pole base and foundation. Use nonshrinking or expanding concrete grout firmly packed in entire void space. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole. Nonshrink grout is specified in Division 05 Section "Metal Fabrications".
 4. Install pole pads at all poles inside playing field boundaries and when located within 20 feet (6 m) of the field boundary.
 5. Extend cast-in-place bolted base foundations 36 inches (914 mm) above grade, minimum.
 6. Install protective pipe bollards on two **OR** three, **as directed**, sides of each embedded pole installed in paved areas. See Division 05 Section "Metal Fabrications" for pipe bollards.
 7. Install controls and ballast housings in cabinets mounted on support structure at least 10 feet (3 m) above finished grade.
- B. Field Quality Control
1. Perform tests, inspections, and analysis according to IESNA RP-6 and IESNA LM-5 where applicable.
 2. Tests and Inspections:
 - a. After installing sports lighting system and after electrical circuits have been energized, perform proof-of-performance field measurements and analysis for compliance with requirements.
 - b. Playing and Other Designated Areas: Make field measurements at intersections of grids, dimensioned and located as specified in "Performance Requirements" Article and as described below:
 - 1) Baseball Fields: Measure at least 25 points of the infield and 87 points of the outfield. Extend the grid 15 feet (5 m) outside the foul lines, extending to outfield boundary or fence.
 - 2) Softball Fields: Measure at least 16 points of the infield and 48 points of the outfield. Extend the grid 15 feet (5 m) outside the foul lines, extending to outfield boundary.
 - 3) Football Fields: Lighted area is 180 by 360 feet (55 by 110 m). Measure at least 91 points.
 - 4) Soccer Fields: Lighted area is 210 by 370 feet (64 by 113 m). Measure at least 91 points.
 - 5) Tennis Courts: Measure at least 30 points for a double court.
 - c. Make field measurements at established test points in areas of concern for spill light and glare.
 - d. Perform analysis to demonstrate correlation of field measurements with specified illumination quality and quantity values and corresponding computer-generated values that were submitted with engineered design documents. Submit a report of the analysis. For computer-generated values, use manufacturer's lamp lumens that are adjusted to lamp age at time of field testing.
 3. Correction of Illumination Deficiencies for Playing Areas: Make corrections to illumination quality or quantity, measured in field quality-control tests, that varies from specified illumination criteria by plus or minus 10 percent.
 - a. Add or replace luminaires, or change mounting height, revise aiming, or install louvers, shields, or baffles.
 - b. If luminaires are added or mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
 - c. Do not replace luminaires with units of higher or lower wattage without the Owner's approval.
 - d. Retest as specified above after repairs, adjustments, or replacements are made.
 - e. Report results in writing.



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4. Correction of Excessive Illumination in Spill-Light-Critical Areas: If measurements indicate that specified limits for spill light are exceeded, make corrections to illumination quantity, measured in field quality-control tests, that reduce levels to within specified maximum values.
 - a. Replace luminaires, or change mounting heights, revise aiming, or install louvers, shields, or baffles.
 - b. Obtain the Owner's approval to replace luminaires with units of higher or lower wattage.
 - c. If mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
 - d. Retest as specified above after repairs, adjustments, or replacements are made.
 - e. Report results in writing.
 5. Sports lighting will be considered defective if it does not pass tests and inspections.
 6. Prepare test and inspection reports.

C. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain exterior athletic lighting.

END OF SECTION 26 56 68 00



SECTION 33 01 10 58 - REPAIR AND MAINTENANCE OF IMHOFF TANKS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for repair and maintenance of sewage treatment plant Imhoff tanks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Coatings:

1. Epoxy-Filler Compound for concrete surfaces shall comply with Fed. Spec. MMM-A-001993.
2. Coal-Tar Epoxy shall comply with SSPC-PAINT 16.
3. Epoxy Paint shall comply with Mil. Spec. MIL-P-24441.
4. Red-Lead Base Paint shall comply with Fed. Spec. TT-P-86, Type I.
5. Aluminum Finish Paint shall comply with Fed. Spec. TT-P-38.

- #### B. Steel Tank Repair Material for minor leaks shall be a two-component epoxy sealing compound. For badly corroded areas, a steel plate of the same composition and thickness as the original tank shall be used.

- #### C. Pipe and Fittings for replacement shall be equivalent to the existing pipe and fittings.

1.3 EXECUTION

- #### A. Preparation: Drain the contents of the tank and dispose of the sludge and sewage.

B. Leak Repair:

1. Concrete Tanks: Repair concrete tank leaks by cleaning and chipping or sandblasting the area of the leak and applying two-component epoxy concrete sealant.
2. Steel Tanks: Repair steel tank leaks by cleaning, scraping, chipping, or sandblasting the area of the leak and applying epoxy steel sealant. Repair badly corroded areas of steel tanks by cutting out the corroded area and welding a section of new steel plate in place. Welding shall be in compliance with AWS D1.1.

- #### C. Pipe and Fittings: Replace pipe and fittings as required.

D. Cleaning and Coatings:

1. Interior Concrete Surfaces of the tank shall be cleaned with high pressure water or steam to remove dirt and residue, allowed to dry, and brush sandblasted.
2. Holes and Voids in the concrete surfaces left from the blast cleaning shall be filled by means of troweling and squeeze application of epoxy filler. Two coats of coal-tar epoxy shall be applied to the surface after the epoxy has cured.
3. Submerged Ferrous Metal Surfaces such as piping and equipment that are exposed to the sewage shall be sandblasted and coated with two coats of coal-tar epoxy.



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4. Exterior Concrete Surfaces of the tank shall be cleaned by means of brush sandblast. The surfaces shall be blown down with air to remove the blasting residue and dust, and two coats of epoxy-polyamide paint shall be applied.
 5. Ferrous Metal Surfaces that are not submerged shall be cleaned by means of sandblasting. Coat surfaces with one coat of red-lead base paint. After the base paint has dried sufficiently, apply two coats of aluminum finish paint.

END OF SECTION 33 01 10 58



SECTION 33 01 10 58a - SEWER LINE CLEANING**1.1 GENERAL****A. Description Of Work**

1. This specification covers sewer line cleaning. Cleaning procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

- B. Submittals: Submit product data and manufacturer's instruction.

1.2 PRODUCTS

- A. All materials shall be clean, free of defects, corrosion, and damage. All items shall be of proper type, size, design, and characteristics for the use intended. Unless otherwise specified, all items shall be factory-made.

- B. Portable Cleaning Equipment: Equipment used in the cleaning of sewer lines shall be as required to complete the work for the size, length, and conditions of the sewer. Portable and mobile equipment shall comply with Water Pollution Control Federation Manual No. 7.

- C. Chemicals shall be of the strength required to perform the work. The chemicals shall not be damaging to pipe materials, manholes, pumping equipment, nor treatment process and shall not be contaminated by foreign substances.

1.3 EXECUTION**A. Preparation**

1. Protection required to prevent damage to adjacent materials, equipment, fixtures, and finishes shall be provided. Necessary protective clothing and accessories for personnel working with chemicals shall be provided.
2. Ventilation of Sewers: Contractor shall provide proper ventilation for personnel working in the sewer.
3. Alternate Sewage Discharge: Contractor shall provide an alternate routing of sewage discharge to a downstream manhole.
4. Traffic: Contractor shall provide all traffic signs required to safely direct traffic at and around work areas.

B. Installation

1. Direction of Work: Sewer line cleaning work, with the exception of hydraulic scouring, shall proceed in the downstream direction. Cleaning by hydraulic scouring shall proceed in the upstream direction.
2. Testing: Upon completion of cleaning operation, test sewer lines for proper operation and observe for a period of 24 hours. Clean out all stoppages and the retest the line for proper operation.

END OF SECTION 33 01 10 58a



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Task	Specification	Specification Description
33 01 10 58	22 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 11	01 22 16 00	No Specification Required
33 01 30 41	33 01 10 58a	Sewer Line Cleaning
33 01 30 42	22 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 42	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 42	33 01 10 58a	Sewer Line Cleaning



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SECTION 33 01 30 51 - REPAIR AND MAINTENANCE OF SIPHON TANK AND SIPHONS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for the repair and maintenance of sewage treatment plant dosing siphon tanks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

- A. Tank Repair Material shall be epoxy type grout complying with Fed. Spec. MMM-A-001993.

B. Concrete Coatings:

1. Outside and Above Grade shall be epoxy type in compliance with Mil. Spec. MIL-P-24441.
2. Inside and Below Grade shall be coal-tar epoxy type in compliance with SSPC-PAINT 16.

- C. Steel Repair Material shall be steel plate or epoxy cement and fiberglass cloth.

- D. Corroded or Defective Siphons: Replace those parts corroded or defective with new parts compatible with the unit, as recommended by the manufacturer.

E. Steel Coatings:

1. Red-Lead Base Coat shall comply with Fed. Spec. TT-P-86, Type I.
2. Aluminum Paint shall comply with Fed. Spec. TT-P-38.

1.3 EXECUTION

- A. Corroded or Broken Pipe and Fittings: Replace as required.

- B. Minor Leaks: Repair minor leaks in the tank using material and surface preparation and application methods recommended by the material manufacturer.

- C. Spalled Areas: Repair as required.

D. Cleaning and Coating:

1. Interior Concrete Surfaces of the tank shall be cleaned with high pressure water or steam to remove all dirt and residue, allowed to dry, and brush sandblasted in compliance with SSPC-SP 7.
2. The Exterior Concrete Surfaces of the tank shall be cleaned by means of brush sandblasting in compliance with SSPC-SP 7. The surfaces shall be blown down with air to remove the blasting residue and dust, and two coats of epoxy-polyamide paint shall be applied.
3. Holes and Voids in the concrete surfaces left from the blast cleaning shall be filled by means of troweling and squeeze application of an epoxy filler. The surfacing material shall be allowed to cure overnight, and then two coats of coal-tar epoxy complying with SSPC-PAINT 16 shall be applied.



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4. Submerged Ferrous Metal Surfaces that are exposed to the sewage shall be sandblasted in compliance with SSPC-SP 10 and coated with two coats of coal-tar epoxy.
 5. Ferrous Metal Surfaces that are not submerged shall be cleaned by means of sandblasting in compliance with SSPC-SP 6. Surfaces inaccessible to sandblasting shall be power tool cleaned in compliance with SSPC-SP 3. Surfaces shall be coated with one coat of red-lead base paint. After the base paint has dried sufficiently, two coats of aluminum finish paint shall be applied.

END OF SECTION 33 01 30 51



Task	Specification	Specification Description
33 01 30 51	01 22 16 00	No Specification Required
33 01 30 51	22 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 51	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 61	01 22 16 00	No Specification Required



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**SECTION 33 01 30 79 - PIPE LINING**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of pipe lining. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 PRODUCTS

A. Lining Material:

1. Polyethylene Pipe: Extruded, flexible industrial grade, high density (Type 3 or 4) in 40 foot lengths, complying with ASTM D 2239 and D 2447.
 - a. Diameter: Outside diameter shall be as large as possible while allowing for ease of pulling into the existing pipes. Pipe dimensions shall comply with ASTM D 2447 and D 2837.
 - b. Liner Thickness and Class shall be suitable for the use intended. The tolerance on the pipe wall thickness shall be as noted in Table 2 of ASTM D 2447.
 - c. Gravity Sanitary, Gravity Storm, and Gravity Industrial Sewers shall be Schedule 40.
 - d. Gravity Thermal Discharge Sewers shall be Schedule 80.
 - e. Low Pressure Sewers shall be Schedule 40, complying with ASTM D 2239.
 - f. High Pressure Sewers shall be Schedule 80, complying with ASTM D 2239 and D 2837.
 - g. Chemical Resistance: Pipe liner shall be resistant to chemical attack, erosion, and corrosion.
 - h. Fittings shall be fabricated from polyethylene pipe. The polyethylene fittings shall have the same pressure rating as the pipe and shall comply with ASTM D 3261.
2. Cement-Mortar Lining:
 - a. Portland Cement shall comply with ASTM C 150, Type 1.
 - b. Pozzolan Cement shall comply with ASTM C 618 and shall not comprise more than 20 percent of total cement amount, by weight.
 - c. Sand shall be well graded, clean, free from organic and extraneous matter. One hundred percent shall pass the 16-mesh size screen.
 - d. Lining Thickness: Cement lining shall be not less than 1/8 inch for pipe sizes 4 to 14 inches, not less than 3/16 inch for pipe sized 16 inches and larger, and not less than 1/4 inch for steel pipe 16 inches and larger.
3. Reinforced Mortar Pipe Slip-Lining:
 - a. Gravity Sewers: Slip-lining shall be of glass fiber reinforced polyester mortar pipe, complying with ASTM D 3262.
 - b. Pressure Sewers (Force Mains): Slip-lining shall be of glass fiber reinforced polyester mortar pipe complying with ASTM D 2517.
 - c. Diameter: Outside diameter shall be as large as possible while allowing for ease of pulling into existing pipes, as recommended by the manufacturer.
 - d. Chemical Resistance: Pipe liner shall be resistant to chemical attack, erosion, and corrosion.
4. Fittings: Fittings shall be manufactured of the same materials as is the glass fiber reinforced polyester mortar pipe.
5. Epoxy-Mortar Lining:
 - a. Epoxy compound shall comply with ASTM D 1763.
 - b. Admixtures shall be well graded with one hundred percent passing. The 16-mesh size screen. All admixtures shall improve the workability, density, and strength of the mortar.



- c. Lining Thickness: For pipe sizes 4 to 14 inches, epoxy mortar lining thickness shall be not less than 1/8 inch. For pipe sizes 16 inches and larger, epoxy mortar lining shall be not less than 3/16 inch.

B. Joint:

1. Slip-Lining:

- a. Polyethylene Pipe Butt Joints: Pipe lengths, fittings, and flanged connections to be joined by thermal butt fusion shall be of the same time, grade, and class of polyethylene compound and supplied by pipe supplier.
- b. Flanged Joints shall consist of a polyethylene flange, thermally butt fused to the ends of the pipe. The companion flange shall be steel or cast iron and nylon-coated.
- c. Lateral Service Connections: Sidewall connections shall be made with polyethylene pipe sections of the same material, grade, and class as the liner material and shall have the same pressure ratings. Lateral connections shall be watertight.

2. Reinforced Mortar Lining:

- a. Bell and spigot joints shall be the inverted type.
- b. Manhole Joints and Connections shall be oakum ring and grout as required.

1.3 EXECUTION:

A. Slip-Lining, Polyethylene Pipe:

- 1. Insertion of Liner: Liner shall be laid at a constant line and grade as the existing pipe, without undulations or damage. Where the existing pipe is not at constant grade, the liner shall follow as true a constant grade as possible.
- 2. Grouting: At manholes, annular space shall be packed with oakum and expansion grout or nonshrink grout as required. At existing line, after liner has been inserted, grout wherever existing pipe has failed structurally.
- 3. Concrete Encasement: Crown of liner shall be encased in concrete a minimum thickness of 6 inches for the entire length of the excavated trench and out at least 6 inches each side of the bottom half of the original pipe remaining down to firm soil. Wherever existing concrete encasement has been removed, the liner shall be encased in the same manner as the original pipe.
- 4. Thrust Blocks: Concrete thrust blocks shall be provided as required.

B. Cement Mortar and Epoxy Mortar Lining:

- 1. Cement Mortar Mixing: One part cement to one and one-half parts of sand by volume.
- 2. Application of Lining: The lining shall be applied to produce a smooth, uniform thickness throughout the interior of the pipe line.
- 3. Curing of the Cement Mortar Lining: Immediately upon completion of the lining of a length of pipe between access openings or at the end of a day's run, the section of pipe shall be closed at each end, the access openings covered to prevent the circulation of air, and the atmosphere kept moist.
- 4. Reconnection of Pipes After Lining: Close and make watertight all openings in the lines.
- 5. Pressure Test and Leaks: Hydrostatic and leakage tests shall be conducted on all pipe that is cleaned and lined.

C. Reinforced Mortar Pipe Lining:

- 1. Joining of Pipe Ends: Liner sections containing bell and spigot joints shall be joined using an O-ring.
- 2. Grouting Work shall be accomplished following the same techniques as described in paragraph Slip-Lining, Polyethylene Pipe.

D. Cement Mortar Lining:



1. Epoxy Mortar Lining: Excessive mortar shall be removed from the manhole walls and bottom. Manhole bottom shall receive special care in making all transitions smooth.
2. Work at Service Connections: Plugs or caps shall be placed at the access point of the service connection to the lines and shall be removed once the mortar has set. The completed lining shall not be damaged.
3. Reinforced Mortar Pipe Lining: Joining of fiberglass reinforced polyester mortar pipe shall be carried out in the trench, with the first section of liner already inserted.
4. Lateral Connections: Service to connections shall be provided for and continued after installation of the lining.
5. Testing: Upon completion of lining operation, the sewer line shall be tested for proper operation and shall be observed for a period of 24 hours. All deficiencies shall be corrected.
6. Pavement Restoration: All disturbed pavement shall be restored to its original condition and shall match existing adjacent.
7. Inspection: Large diameter sewers shall be inspected from inside to ensure that all lateral connections and joints are in proper order. Sewers that have been cement-lined may be inspected for a smooth finish, while plugs and caps are being removed.

END OF SECTION 33 01 30 79



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Task	Specification	Specification Description
33 01 30 79	01 22 16 00	No Specification Required
33 01 30 79	22 05 23 00	Piped Utilities Basic Materials And Methods



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SECTION 33 01 30 81 - UNDERGROUND DUCTS AND UTILITY STRUCTURES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for underground ducts and utility structures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs\.
 - b. Handholes and pull boxes.
 - c. Manholes.

C. Definition

1. RNC: Rigid nonmetallic conduit.

D. Submittals

1. Product Data: For the following:
 - a. Duct-bank materials, including separators and miscellaneous components.
 - b. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - c. Accessories for manholes, handholes, pull boxes, and other utility structures.
 - d. Warning tape.
 - e. Warning planks.
2. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
 - a. Duct entry provisions, including locations and duct sizes.
 - b. Reinforcement details.
 - c. Frame and cover design and manhole frame support rings.
 - d. Ladder **OR** Step, **as directed**, details.
 - e. Grounding details.
 - f. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
 - g. Joint details.
3. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
 - a. Duct entry provisions, including locations and duct sizes.
 - b. Cover design.
 - c. Grounding details.
 - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
4. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
 - a. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - b. Drawings shall be signed and sealed by a qualified professional engineer.
5. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
6. Qualification Data: For qualified professional engineer and testing agency.
7. Source quality-control reports
8. Field quality-control test reports.



- E. Quality Assurance
 - 1. Comply with IEEE C2.
 - 2. Comply with NFPA 70.

- F. Delivery, Storage, And Handling
 - 1. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
 - 2. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
 - 3. Lift and support precast concrete units only at designated lifting or supporting points.

- G. Project Conditions
 - 1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical service.
 - b. Do not proceed with interruption of electrical service without the Owner's written permission.

1.2 PRODUCTS

- A. Conduit
 - 1. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
 - 2. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

- B. Nonmetallic Ducts And Duct Accessories
 - 1. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
 - 2. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type DB-60-PVC and Type DB-120-PVC, ASTM F 512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
 - 3. Duct Accessories:
 - a. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
 - b. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification For Electrical Systems".
 - c. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 76 mm) in size, manufactured from 6000-psi (41-MPa) concrete.
 - 1) Color: Red dye added to concrete during batching.
 - 2) Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

- C. Precast Concrete Handholes And Pull Boxes
 - 1. Comply with ASTM C 858 for design and manufacturing processes.
 - 2. Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A153 (ASTM A153M) and ASTM A123 (ASTM A123M).
 - 3. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.



- a. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - b. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - c. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
 - 1) Cover Hinges: Concealed, with hold-open ratchet assembly.
 - 2) Cover Handle: Recessed.
 - d. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing stainless-steel bolts.
 - 1) Cover Hinges: Concealed, with hold-open ratchet assembly.
 - 2) Cover Handle: Recessed.
 - e. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - f. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** As indicated for each service, **as directed**.
 - g. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed**, bottom, unless otherwise indicated.
 - h. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - 1) Extension shall provide increased depth of 12 inches (300 mm).
 - 2) Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
 - i. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
 - 1) Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 - 2) Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - 3) Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
 - j. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - 1) Type and size shall match fittings to duct or conduit to be terminated.
 - 2) Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
 - k. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
- D. Handholes and Pull Boxes Other Than Precast Concrete
1. Description: Comply with SCTE 77.
 - a. Color: Gray **OR** Green, **as directed**.
 - b. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed**, bottom, unless otherwise indicated.
 - c. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 - d. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - e. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** As indicated for each service, **as directed**.
 - f. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 - g. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 - h. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.



2. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
3. Fiberglass Handholes and Pull Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
4. Fiberglass Handholes and Pull Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete **OR** reinforced concrete **OR** cast iron **OR** hot-dip galvanized-steel diamond plate **OR** fiberglass, **as directed**.
5. High-Density Plastic Pull Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be polymer concrete **OR** hot-dip galvanized-steel diamond plate **OR** plastic, **as directed**.

E. Precast Manholes

1. Comply with ASTM C 858, with structural design loading as specified in Para. 1.3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.
 - a. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
 - 1) Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 - 2) Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - 3) Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
 - b. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - 1) Type and size shall match fittings to duct or conduit to be terminated.
 - 2) Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.
2. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.
3. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

F. Cast-In-Place Manholes

1. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.
2. Materials: Comply with ASTM C 858 and with Division 03 Section "Cast-in-place Concrete".
 - a. Concrete shall have a minimum compressive strength of 3000 psi (20 MPa).
3. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

G. Utility Structure Accessories

1. Ferrous metal hardware, where indicated, shall be hot-dip galvanized complying with ASTM A 153 (A 153M) and A 123 (A 123M).
2. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
 - a. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B **OR** cast aluminum, **as directed**, with milled cover-to-frame bearing surfaces; diameter, 26 inches (660 mm) **OR** 29 inches (737 mm), **as directed**.
 - 1) Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.



- 2) Special Covers: Recess in face of cover designed to accept finish material in paved areas.
- b. Cover Legend: Cast in. Selected to suit system.
 - 1) Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
 - 2) Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
 - 3) Legend: "SIGNAL" for communications, data, and telephone duct systems.
- c. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
 - 1) Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
3. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
4. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.
 - a. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
5. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (32-mm-) diameter eye, rated 2500-lbf (11-kN) minimum tension.
6. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
 - a. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
7. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (32 mm) minimum at base.
 - a. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
8. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.
9. Cable Rack Assembly: Steel, hot-rolled **OR** hot-dip, **as directed**, galvanized, except insulators.
 - a. Stanchions: T-section or channel; 2-1/4-inch (57-mm) nominal size; punched with 14 holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
 - b. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (460 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
 - c. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
10. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
 - a. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of 9 holes for arm attachment.
 - b. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (508 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.
11. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
12. Fixed Manhole Ladders: Arranged for attachment to roof or wall **OR** and floor, **as directed**, of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin **OR** hot-dip galvanized steel, **as directed**.



13. Portable Manhole Ladders: UL-listed, heavy-duty wood **OR** fiberglass, **as directed**, specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches (900 mm). One required.
14. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater **OR** Light duty, designed for lifts less than 60 lbf (270 N), **as directed**. Two required.

H. Source Quality Control

1. Test and inspect precast concrete utility structures according to ASTM C 1037.
2. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and pull boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - a. Engage a qualified testing agency to evaluate nonconcrete handholes and pull boxes.
 - b. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

1.3 EXECUTION

A. Corrosion Protection

1. Aluminum shall not be installed in contact with earth or concrete.

B. Underground Duct Application

1. Ducts for Electrical Cables Over 600 V: RNC, NEMA Type EPC-80 **OR** EPC-40 **OR** EB-20, **as directed**, -PVC, in concrete-encased duct bank, unless otherwise indicated.
2. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 **OR** EPC-40 **OR** EB-20, **as directed**, -PVC, in concrete-encased duct bank, unless otherwise indicated.
3. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 **OR** EPC-40 **as directed**, -PVC, in direct-buried duct bank, unless otherwise indicated.
4. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80 **OR** EPC-40, **as directed**, -PVC, in direct-buried duct bank, unless otherwise indicated.
5. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40 **OR** EB-20, **as directed**, -PVC, in concrete-encased duct bank, unless otherwise indicated.
6. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC **OR** Underground plastic utilities duct, NEMA Type DB-60-PVC **OR** Underground plastic utilities duct, NEMA Type DB-120-PVC, **as directed**, installed in direct-buried **OR** concrete-encased, **as directed**, duct bank, unless otherwise indicated.
7. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40 **OR** DB-60 **OR** DB-120, **as directed**, -PVC, in direct-buried duct bank, unless otherwise indicated.
8. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EB-20-PVC, in concrete-encased duct bank, unless otherwise indicated.
9. Underground Ducts Crossing Paved Paths **OR** Walks and Driveways **OR** Roadways and Railroads, **as directed**: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

C. Underground Enclosure Application

1. Handholes and Pull Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
 - a. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-10 **OR** H-20, **as directed**, structural load rating.
 - b. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 **OR** Polymer concrete, SCTE 77, Tier 15 **OR** Fiberglass enclosures with polymer concrete frame and cover, SCTE 77, Tier 15 **OR** Fiberglass-reinforced polyester resin, SCTE 77, Tier 15 **OR** High-density plastic, SCTE 77, Tier 15, **as directed**, structural load rating.



- c. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 **OR** Polymer concrete units, SCTE 77, Tier 8 **OR** Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8 **OR** High-density plastic, SCTE 77, Tier 8, **as directed**, structural load rating.
 - d. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin **OR** High-density plastic, **as directed**, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
 2. Manholes: Precast or cast-in-place concrete.
 - a. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
 - b. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.
- D. Earthwork
1. Excavation and Backfill: Comply with Division 31 Section "Earth Moving", but do not use heavy-duty, hydraulic-operated, compaction equipment.
 2. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
 3. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Section(s) "Turf And Grasses" AND "Plants".
 4. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting And Patching".
- E. Duct Installation
1. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
 2. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1220 mm) **OR** 12.5 feet (4 m) **OR** 25 feet (7.5 m), **as directed**, both horizontally and vertically, at other locations, unless otherwise indicated.
 3. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
 4. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.
 - a. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
 - b. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
 - c. Grout end bells into structure walls from both sides to provide watertight entrances.
 5. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results For Electrical".
 6. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
 7. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.
 8. Concrete-Encased Ducts: Support ducts on duct separators.
 - a. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 **OR** 5, **as directed**, spacers per 20 feet (6 m) of duct. Secure



- separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
- b. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - 1) Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
 - 2) If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
 - c. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
 - d. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 - e. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 - f. Minimum Space between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and signal ducts.
 - g. Depth: Install top of duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
 - h. Stub-Ups:
 - 1) Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
OR
Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b) Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
 - i. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.
9. Direct-Buried Duct Banks:
- a. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 - b. Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 **OR** 5, **as directed**, spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement



due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.

- c. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
- d. Install backfill as specified in Division 31 Section "Earth Moving".
- e. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving".
- f. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and signal ducts.
- g. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade, unless otherwise indicated.
- h. Set elevation of bottom of duct bank below the frost line.
- i. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

OR

Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

- 1) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - 2) For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
- j. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried ducts and duct banks, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.

F. Installation Of Concrete Manholes, Handholes, And Pull Boxes

1. Cast-in-Place Manhole Installation:
 - a. Finish interior surfaces with a smooth-troweled finish.
 - b. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
 - c. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 Section "Cast-in-place Concrete".
2. Precast Concrete Handhole and Manhole Installation:
 - a. Comply with ASTM C 891, unless otherwise indicated.
 - b. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
 - c. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
3. Elevations:
 - a. Manhole Roof: Install with rooftop at least 15 inches (380 mm) below finished grade.
 - b. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
 - c. Install handholes with bottom below the frost line, below grade.



- d. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
 - e. Where indicated, cast handhole cover frame integrally with handhole structure.
 4. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
 5. Manhole Access: Circular opening in manhole roof; sized to match cover size.
 - a. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
 - b. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
 6. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Section(s) "Elastomeric Sheet Waterproofing" OR "Thermoplastic Sheet Waterproofing", **as directed**. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
 7. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Division 07 Section "Bituminous Dampproofing". After ducts have been connected and grouted, and before backfilling, dampproof joints and connections and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
 8. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
 9. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
 10. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (98 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
 11. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.
- G. Installation Of Handholes And Pull Boxes Other Than Precast Concrete
1. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
 2. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
 3. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
 4. Install handholes and pull boxes with bottom below the frost line, below grade.
 5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
 6. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
 7. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - a. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Section "Cast-in-place Concrete", with a troweled finish.



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- b. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).
- H. Grounding
 - 1. Ground underground ducts and utility structures according to Division 26 Section "Grounding And Bonding For Electrical Systems".
 - I. Field Quality Control
 - 1. Perform the following tests and inspections:
 - a. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 - b. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
 - c. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding And Bonding For Electrical Systems".
 - 2. Correct deficiencies and retest as specified above to demonstrate compliance.
 - 3. Prepare test and inspection reports.
 - J. Cleaning
 - 1. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
 - 2. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 33 01 30 81



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SECTION 33 01 30 81a - SEWAGE TREATMENT LAGOONS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for the repair and maintenance of sewage treatment lagoons. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS**A. Materials**

1. Concrete Block shall comply with ASTM C 129.
2. Concrete Grout shall comply with Fed. Spec. MMM-A-001993.
3. Riprap Stone shall comply with AREA-01.
4. Concrete Repair Material shall comply with Fed. Spec. MMM-A-001993.
5. Sand shall comply with ASTM C 33.
6. Portland Cement shall comply with ASTM C 150, Type V.
7. Rubble shall consist of broken concrete or broken stone.

1.3 EXECUTION

- A. Algae Removal shall be by mechanical or manual methods and shall include, but not be limited to, skimming, pumping through a screen, raking, or draining and cleaning the lagoon.
- B. Slope and Dike Reconstruction shall be made to re-establish the original design configuration and grades. Place riprap, where required, so that its angle of repose is not exceeded.
- C. Liner Reconstruction and Repair shall be made with materials compatible with the existing liner and compatible with the wastewater and sludge to be contained therein.
- D. Repairs to Elastomeric Membrane Liners shall be made with like material and shall overlap all cuts, tears, fractures or other defects a minimum of 4 inches. Cut repair pieces square or rectangular. The method of bonding the new material to existing material shall be similar to the original joint banding method, except when the original joints have failed. In this case, the material supplier shall demonstrate that an alternate jointing system shall be satisfactory to the Owner. Replace earth or sand cover removed during repair or replacement of plastic liner to the same thickness as the original installation.
- E. Repairs to Non-Elastomeric Membrane Liners shall be made by cutting out defective areas back to sound liner material and replacing with similar material. Joints shall be watertight.

END OF SECTION 33 01 30 81a



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Task	Specification	Specification Description
33 01 30 81	01 22 16 00	No Specification Required
33 01 30 81	22 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 81	22 05 76 00	Sanitary Sewerage
33 01 30 81	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 81	33 01 30 51	Repair And Maintenance Of Siphon Tank And Siphons
33 01 30 81	33 42 11 00	Storm Drainage
33 01 30 82	01 22 16 00	No Specification Required
33 01 30 82	22 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 82	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 82	33 01 30 51	Repair And Maintenance Of Siphon Tank And Siphons
33 01 30 86	01 22 16 00	No Specification Required
33 01 30 86	22 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 86	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 86	33 01 30 51	Repair And Maintenance Of Siphon Tank And Siphons
33 01 34 13	22 05 23 00	Piped Utilities Basic Materials And Methods
33 01 34 13	33 01 30 51	Repair And Maintenance Of Siphon Tank And Siphons



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SECTION 33 05 07 13 - TRENCHLESS EXCAVATION USING MICROTUNNELING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of trenchless excavation using microtunneling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Design Requirements

1. Pipe Casing: Provide pipe casing in thickness indicated of polyvinyl chloride (PVC) plastic **OR** clay tile **OR** concrete **OR** steel, **as directed**, pipe. Provide utility line accessories, valves, connections, and manholes as specified and where indicated. Submit design calculations of pipe casing.

C. Submittals: Submit the following:

1. Preconstruction Submittals: Microtunneling Boring Machine equipment to be used.
2. Product Data
 - a. Piping casing, joints, fittings, valves, and couplings
 - b. Bentonite
 - c. Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.
3. Design Data: Design calculations of pipe casing
4. Certificates
 - a. Piping casing piping, fittings, joints, valves, and coupling
 - b. Shop-applied linings
 - c. Certificates shall attest that tests set forth in each applicable referenced publication have been performed, whether specified in that publication to be mandatory or otherwise and that production control tests have been performed at the intervals or frequency specified in the publication. Other tests shall have been performed within 3 years of the date of submittal or certificates on the same type, class, grade, and size of material as is being provided for the project.
5. Manufacturer's Instructions: Installation procedures for pipe casing

D. Delivery, Storage, and Handling:

1. Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, and valves free of dirt and debris.
2. Handle pipe, fittings, valves, hydrants, and other accessories in a manner to ensure delivery to the excavation in sound undamaged condition. Take special care to avoid injury to coatings and linings on pipe and fittings; make satisfactory repairs if coatings or linings are damaged. Carry, do not drag pipe to the excavation. Store plastic piping, jointing materials and rubber gaskets that are not to be installed immediately, under cover out of direct sunlight. Handle steel pipe with coal-tar enamel **OR** coal-tar epoxy, **as directed**, coating in accordance with the provisions for handling coal-tar enamel coated pipe in AWWA C203.

E. Quality Assurance

1. Design Calculations of Pipe Casing: Submit design calculations of pipe casing demonstrating that the pipe casing selected has been designed to support the maximum anticipated earth loads and superimposed live loads, both static and dynamic, which may be imposed on the pipe casing.



1.2 PRODUCTS

A. Piping Casing Materials

1. Ductile-Iron Piping
 - a. Pipe and Fittings: Pipe, except flanged pipe, ANSI/AWWA C151/A21.51 Pressure Class and/or Thickness Class as required to meet Project requirements. The outside diameter of ductile iron microtunneling pipe shall be in accordance with AWWA C150/A21.50.
 - b. Joints and Jointing Material: Joints: Pressure and gravity microtunneling pipe shall have either an integral-bell push-on or rubber gasket coupled joint meeting the following criteria:
 - 1) Integral-bell push-on joint microtunneling pile shall consist of a rubber-gasket joint manufactured to conform with AWWA C111/A21.11 and the dimensions shown in ANSI/AWWA C151/A21.51. The exterior of the pipe shall be coated with a durable cement-mortar or concrete coating applied in such a manner as to provide a uniform outside diameter.
 - 2) Cement-mortar or concrete strength, reinforcement and method of placement shall be in accordance with manufacturer's recommendations. Durable Coatings of other types may be substituted provided they maintain a uniform outside diameter and they are approved by the designer. Rubber gasket coupled microtunneling joint shall be manufactured so as to provide a joint which has the same nominal outside diameter as the pipe barrel.
2. Polyvinyl Chloride Pipe (PVC): ASTM F 794. ASTM D 3212 for gasketed joint systems. ASTM F 477 for gasket materials.
3. Reinforced Concrete Pipe
 - a. Nominal dimensions: Typical nominal dimensions for reinforced concrete pipe are detailed in ASTM standards ASTM C 76 (ASTM C 76M), ASTM C 361 (ASTM C361M), ASTM C 655 (ASTM C 655M), ASTM C 822. Pipe meeting these requirements is generally acceptable for jacking. The permissible variation allowed with respect to these and other dimensions shall be in accordance with the variations listed in the section.
 - b. Joints and Jointing Material: Joint shall be formed entirely of concrete and as detailed in the contract drawings, may **OR** shall, **as directed**, utilize a rubber gasket or mastic to provide the seal. Incorporate an assembly of steel bands or steel bell ends and spigot rings and rubber gaskets in accordance with contract drawings.
4. Steel Pipe
 - a. Steel pipe shall be in conformance with ASTM A 139, Grade B with a minimum yield strength of 35,000 psi (242 MPa) **OR** AWWA C200 **OR** API SPEC 5L Grade B **OR** ASTM A 53 **OR** ASTM A 716 **OR** ASTM A 746, **as directed**. Steel pipe shall be welded, seamless, square cut with even lengths and shall comply of Articles 4.2, 4.3, and 4.4 of the API SPEC 5L.
 - b. Joints: The connection of adjacent pieces of microtunneling steel pipe may be accomplished by field butt welding, internal weld sleeves, integral press fit connectors, as long as loading and installation design criteria are met.
5. Fiberglass Pipe
 - a. Pipe: Fiberglass pipe shall meet the requirements of ASTM D 3262, Type 1, Liner 2, Grade 3. The method of the manufacture shall be centrifugal casting resulting in a controlled outside diameter. Minimum wall thickness shall be +1.5 inches (+38 mm).
 - b. Joints: The pipes shall be connected by gasket-sealed bell-spigot joints. The gasket material shall meet requirements of ASTM F 477. The joint shall meet the requirements of ASTM D 4161 and shall be leak-free under the following conditions:
 - 1) External pressures up to 2 bars, 29 psi (200 kPa) from bentonite injection, slurry system operation or groundwater head.
 - 2) Internal air testing up to 5 psi (35 kPa).
 - 3) Gaps between the pipe ends up to two percent of the diameter (maximum of 1-inch (25 mm)).



- c. The liner shall consist of a minimum thickness of 0.04 inch (1.2 mm) of reinforced polyester resin. The outside pipe coating shall have a minimum thickness of 0.03 inches (one mm) and shall consist of thermosetting polyester resin and sand.
6. Vitrified Clay Pipe: ASTM C 700.
 - a. Pipe: Vitrified clay pipe shall be manufactured from fire clay, shale, surface clay, or a combination that can meet three edge bearing strength for nominal diameters ranging from 4 inches 2000 lb/linear foot (100 mm 2980 kg/m) to 42 inches 7000 lb/linear foot (1050 mm 10430 kg/m).
 - b. Joints: Joints shall be capable of supporting a shear load of 50 pounds per inch (8755 N/m) of nominal diameter uniformly applied over an arc of not less than 120 degrees (2.09 rad) and along a distance of 12 inches (300 mm) adjacent to the joint. Apply an internal 10 foot (3 m) head 4.3 psi (30 kPa) of water pressure for a period of one hour. Joints shall fully comply with ASTM C 1208 (ASTM C 1208M).
7. Concrete: Concrete shall be 3000 psi (25 MPa) and conform with Division 03 Section "Cast-in-place Concrete".
8. Bentonite: Bentonite shall conform with API SPEC 13A and have the capacity of mixing with water to form a stable and homogeneous suspension.
9. Backfill: Reuse excavated sand for backfill that conforms with Division 31 Section "Earth Moving".

1.3 EXECUTION

A. Preparation

1. Access Shafts

- a. Construction methods required to provide access shafts for microtunneling shall be subject to approval of the Owner. Acceptable construction methods may include the use of interlocked steel sheet piling or precast circular concrete segments lowered in place during excavation.
- b. Final dimensions of access shafts selected by the Contractor shall be modified as required following installation of pipe casings to the size and shape of acceptable manhole designs shown on the Contract Drawings to permit installation of conveyance piping.
- c. Shafts shall be of a size commensurate with safe working practices and located as shown on plans. With the approval of the Owner, the Contractor may relocate shafts to better suit the capabilities of the microtunneling method proposed. Where no locations are given, the Contractor shall determine such officer.
- d. Shaft locations shall, where possible, be kept clear of road intersections and within a single traffic lane, in order to minimize disruption to the flow of traffic. Support equipment, spoil piles, and materials shall also be located such as to minimize disruption to traffic and are subject to the approval of the Owner.
- e. The Contractor shall properly support all excavations and prevent movement of the soil, pavement, utilities or structures outside of the excavation. The Contractor shall furnish, place and maintain sheeting, bracing, and lining required to support the sides and floor of all pits and to provide adequate protection of the work, personnel, and the general public. Design loads on the sides of the jacking and receiving pit walls are dependent on the construction method and flexibility of the wall systems.
- f. Construct a starter shaft to accommodate the installation of pipe casings, slurry shield and piping jacking device. Install thrust block as required and consolidate the ground (grout) where the casings exit the shaft.
- g. Construct a receiver shaft to accommodate the installation of pipe casings and the slurry shield. Consolidate the ground (grout) where the casings enter the shaft.
- h. The Contractor shall furnish, install, and maintain equipment to keep the jacking shaft free of excess water. The Contractor shall also provide surface protection during the period of construction to ensure that surface runoff does not enter driving shaft(s). Groundwater dewatering shall comply with the approved dewatering plan and shall not affect



surrounding soils or structures beyond the tolerances stated in paragraph entitled "Settlement, Alignment and Tolerances."

- i. Provide security fence around all access shaft areas and provide shaft cover(s) when the shaft area is not in use.
- j. Design of the jacking and receiving pit supports should also take into account the loading from shield or pipe jacking where appropriate, as well as special provisions and reinforcement around the breakout location. The base of the pits shall be designed to withstand uplift forces from the full design head of water, unless approved dewatering or other ground modification methods are employed.
- k. Where a thrust block is required to transfer jacking loads into the soil, it shall be properly designed and constructed by the Contractor. The backstop shall be normal (square) with the proposed pipe alignment and shall be designed to withstand the maximum jacking pressure to be used with a factor of safety of at least 2.0. It shall also be designed to minimize excessive deflections in such a manner as to avoid disturbance of adjacent structures or utilities or excessive ground movement. If a concrete thrust block or treated soil zone is utilized to transfer jacking loads into the soil, the tunnel boring is not to be jacked until the concrete or other materials have attained the required strength.
- l. Pit Backfill and Compaction: Upon completion of the pipe drive and approval of the installed pipeline by the Owner, remove all equipment, debris, and unacceptable materials from the pits and commence backfilling operation. Backfilling, compaction and pavement repairs shall be completed in accordance with Division 31 Section "Earth Moving".
- m. If tremie concrete sealing slabs are placed within the earth support system to prevent groundwater inflow when access shafts are dewatered, the sealing slabs shall be of sufficient thickness to provide a factor of safety equal to 1.2 against hydrostatic uplift in order to prevent bottom blowout when the excavation is completely dewatered.

B. Installation

1. Installation of Tracer Wire: Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such a manner that will not be displaced during construction operations.
2. Connections to Existing Lines: Make connections to existing lines after the Owner approval is obtained and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped.
3. Minimum depth of cover over the pipe being installed shall be 6 feet (1.8 m) or 1.5 times the outer diameter of the pipe being installed.
4. Settlement, Alignment and Tolerances
 - a. Settlement or heave of ground surface along centerline of microtunneling alignments during and after installation of pipe casings shall not exceed 1 inch (25 mm).
 - b. No more than 1 inch (25 mm) lateral and 1 inch (25 mm) vertical deviation shall be permitted in the position of the completed jacked pipe casings. Water shall be free draining between any two points at the pipe invert. No reverse grades will be allowed.
 - c. Overcut shall not exceed 1 inch (25 mm) on the radius of the pipe being installed. The annular space created by the overcut must be filled with the lubrication material that is used to reduce soil friction drag on the pipe.
5. Microtunneling
 - a. Using Unmanned Tunneling Machine
 - 1) The microtunneling boring machine shall be an unmanned mechanical type earth pressure counter-balanced bentonite slurry shield system. The machine shall be laser guided and monitored continuously, with a closed circuit television system. The machine shall be capable of fully supporting the face both during excavation and during shutdown and shall have the capability, of positively measuring the earth pressure at the face. Excavation face pressure shall be maintained at all times between the measured active earth pressure and 50 percent of the computed passive earth pressure. Fluid pressure applied at the face to stabilize the



- excavation shall be maintained at a level slightly in excess of normal hydrostatic pressure and shall be monitored continuously. The machine shall be operated so as to prevent either surface heave or loss of ground during tunneling and shall be steerable and capable of controlling the advance of the heading to maintain line and grade within the tolerances specified in paragraph entitled "Settlement, Alignment and Tolerances." The machine shall be capable of handling and removing materials of high water content from the machine head.
- 2) Each pipe casing section shall be jacked forward as the excavation progresses in such a way to provide complete and adequate, ground support at all times. A bentonite slurry (driller's mud) shall be applied to the external surface of the pipe to reduce skin friction. A jacking frame shall be provided for developing a uniform distribution of jacking forces around the periphery of the pipe. A plywood spacer shall be placed on the outer shoulder of the pipe casing joint. The thrust reaction backstop shall be properly designed and constructed.
 - 3) The backstop shall be normal (square) with the proposed pipe casing alignment and shall be designed to support the maximum obtainable jacking pressure with a safety factor at least 2.0.
 - 4) The jacking system shall be capable of continuously monitoring the jacking pressure and rate of advancement. Special care shall be taken when setting the pipe guard rails in the starter shaft to ensure correctness of the alignment, grade and stability.
- b. Using Tunneling Shields
- 1) Only tunneling equipment capable of fully supporting the face of the tunnel shall be used for pipe jacking work described.
 - 2) Tunneling equipment selected for the project shall be compatible with the geotechnical information contained in this contract. The tunneling equipment shall be capable of tunneling through mixed face conditions without exceeding the settlement tolerances specified in paragraph "Settlement, Alignment and Tolerances."
 - 3) Face pressure exerted at the heading by the tunneling machine shall be maintained as required to prevent loss of ground, groundwater inflows, and settlement or heave of the ground surface by balancing soils and groundwater pressures present.
 - 4) Dewatering for groundwater control shall be allowed at the jacking and receiving pits only.
- c. Do not jack pipe casing until the concrete thrust block and tremie seal (if selected), and grouted soil zone in starter and receiving shafts have attained the required strength.
- d. The pipe casing shall be jacked in place without damaging the pipe casing joints or completed pipe casing section.
- e. After completion of the jacking operation between starter and receiver shafts, the lubricate material shall be displaced from between the pipe casing exterior and the surrounding ground by a cement grout. Pressure and the amount of grout shall be controlled to avoid pipe damage and displacement of the pipe and soil beyond the tolerances specified in paragraph "Settlement, Alignment and Tolerances." Grouting shall be accomplished promptly after pipe installation has been completed to prevent any surface settlement due to movement of soil material into the void space or loosened zone around the pipe casing.
- f. Any pipe casing which has been damaged during installation shall be replaced by the Contractor at no additional cost. If a new replacement pipe casing is required extending from the starter to the receiver shaft, it shall be installed in conformance with the contract drawings and this section.
- g. Steel pipe casing joints shall be continuously welded with butt joint per AWS D1.1. The welds shall attain the full strength of the pipe and shall result in a full watertight section. The inner face of internal weld seam shall be flush with the pipe to facilitate the installation of the conveyance pipe in the pipe casing.
- h. Perform all welding in accordance with requirements for shielded metal arc welding of AWS D1.5 for bridges and AWS D1.1 for buildings and other structures.
- i. Fiberglass pipe casing joints shall be fully watertight and shall attain the full strength of the pipe. Casing joints shall be field connected with sleeve couplings or bell and spigot type



- joints that utilize elastomeric sealing gaskets as the sole means to maintain joint water tightness.
- j. The joint shall have the same outside diameter as the pipe so when the pipelines are assembled such that the joints are flush with the pipe inside and outside surface to facilitate installation of it conveyance pipe in the pipe casing.
 - k. All excavated material from tunnel and shaft construction shall be disposed of away from the construction site. On-site storage of material must comply with Division 01 requirements and must be stored in areas shown on site drawings or as directed. Stockpiling shall be permitted on the construction site and material shall be removed at regular intervals as directed by the Owner.
 - l. Monitor ground movements associated with the project and make suitable changes in the construction methods that control ground movements and prevent damage or detrimental movement to the work and adjacent structures and pavements.
 - m. Install instrumentation, take readings and provide the Owner with weekly reports containing measurements data with weekly reports to inspector. These actions are meant to supplement the Contractor's monitoring system and do not relieve the Contractor of its responsibility, nor place on the Owner, responsibility for control of ground movement and protection of the project and adjacent structures. Instrumentation readings shall be continued for a period of time as directed by the Owner after pipe casings have been installed to establish that detrimental settlement has not occurred.
 - n. Unprotected mining of the tunnel bore is not permitted. The tunnel face and bore shall be fully supported at all times.
 - o. A topographic survey will be performed by the Contractor before and after microtunneling and at intervals as directed by the Owner. Survey markers will be installed by the contractor at grid points located as directed by the Owner centered on the proposed tunnel alignments. Perform all remedial work including repaired if heave or settlement greater than 1 inch (25 mm) is recorded.
 - p. Approval by the Owner of the topographic survey and final set of readings provided by the Contractor will constitute partial approval of the microtunneling phase of work.
6. Ventilation: Adequate ventilation shall be provided for all cased tunnels and shafts. Follow confined space entry procedures. Local burn permit regulations must be obeyed and complied with. The design of ventilating system shall include such factors as the volume required to furnish fresh air in the shafts, and the volume to remove dust that may be caused by the cutting of the face and other operations which may impact the laser guidance system.
 7. Lighting: Adequate lighting shall be provided for the nature of the activity being conducted by workers for the microtunneling. Both power and lighting circuits shall be separated and thoroughly insulated with ground fault interrupters are required. Lights shall comply with requirements with regards to shatter resistance and illumination requirements.
 8. Spoil Transportation: The soil transportation system shall match the excavation rate with rate of spoil removal. The system must also be capable of balancing groundwater pressures and adjustment to maintain face stability for the particular soil conditions of this project.
 9. Pipe Jacking Equipment: The main jacking equipment installed must have a capacity greater than the anticipated jacking load. Intermediate jacking stations shall be provided by the Contractor when the total anticipated jacking force needed to complete the installation may exceed the capacity of the main jacks or the designed maximum jacking force for the pipe. The jacking system shall develop a uniform distribution of jacking forces on the end of the pipe by use of thruster rings and cushioning material.
 10. Jacking Pipe: In general, pipe used for jacking shall be smooth, round, have an even outer surface, and joints that allow for easy connections between pipes. Pipe ends shall be square and smooth so that jacking loads are minimized when the pipe is jacking. Pipe used for pipe jacking shall be capable of withstanding the jacking forces that will be imposed by the process or installation, as well as the final place loading conditions. The driving ends of the pipe and intermediate joints shall be protected from damage.



- a. Any pipe showing signs of failure may be jacked through to the receiving shaft and removed. Other methods of repairing the damaged pipe may be used, as recommended by the manufacturer and subject to approval by the Owner.
 - b. The pipe manufacturer's design jacking loads shall not be exceeded during the installation process. The pipe shall be designed to take full account of all temporary installation loads.
- C. Field Quality Control
1. Field Tests and Inspections: The Contractor shall perform field tests, and provide labor, equipment, and incidentals required for testing. The Contractor shall produce evidence, when required, that any item of work has been constructed in accordance with drawings and specifications.
 2. Testing Requirements: For pressure test, use a hydrostatic pressure 50 percent greater than the maximum working pressure of the system. Hold this pressure for not less than 2 hours. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

END OF SECTION 33 05 07 13



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Task	Specification	Specification Description
33 05 07 23	33 05 07 13	Trenchless Excavation Using Microtunneling
33 05 07 24	33 05 07 13	Trenchless Excavation Using Microtunneling
33 05 61 00	01 22 16 00	No Specification Required
33 05 61 00	22 05 76 00	Sanitary Sewerage
33 05 61 00	33 42 11 00	Storm Drainage
33 05 62 00	22 05 76 00	Sanitary Sewerage
33 05 62 00	33 42 11 00	Storm Drainage
33 05 63 00	33 01 30 81	Underground Ducts And Utility Structures
33 05 84 00	01 22 16 00	No Specification Required
33 05 84 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 05 84 00	22 05 76 00	Sanitary Sewerage
33 05 84 00	33 01 30 81	Underground Ducts And Utility Structures
33 05 84 00	33 42 11 00	Storm Drainage
33 05 84 00	33 01 30 81a	Sewage Treatment Lagoons



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SECTION 33 11 13 00 - WELL REPAIR**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of materials for repair and maintenance of water wells. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

- A. Repair and Replacement Parts shall be clean, free of rust and scale, and of proper size and design for the specific well repair to be made.

1.3 EXECUTION

- A. Cement Grout may be hand mixed at the site.
- B. Level and Re-Sod Area, after heavy equipment has been used or if chemicals have been spilled.
- C. Abandoned Wells shall be sealed in accordance with AWWA A100.
- D. Disinfect well, after repair, in accordance with AWWA A100.

END OF SECTION 33 11 13 00



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Task	Specification	Specification Description
33 11 13 00	01 22 16 00	No Specification Required
33 11 13 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 11 13 00	23 11 23 00a	Monitoring Wells
33 11 13 00	22 11 23 23	Water Supply Wells
33 14 00 00	21 05 19 00	Water Distribution
33 14 11 00	21 05 19 00	Water Distribution
33 14 13 00	21 05 19 00	Water Distribution



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**SECTION 33 14 13 13 - CONCRETE-FILLED STEEL PILES**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for concrete-filled steel piles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes concrete-filled steel shell and pipe piles.

C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For composite piles. Show fabrication and installation details for piles, including splices and tip details.
 - a. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
 - b. Indicate locations, sizes, type, and arrangement of reinforcement.
 - c. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Design Mixes: For each concrete mix. Include revised mix proportions when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
5. Material Certificates: For steel shell piles and accessories, steel pipe piles and accessories, steel reinforcement and concrete admixtures, from manufacturer.
6. Material Test Reports: For concrete materials.
7. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
 - a. Include mandrel type and details.
8. Static Pile Test Reports: Submit within three days of completing each test.
9. Pile-Driving Records: Submit within three days of driving each pile.
10. Field quality-control reports.
11. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

D. Quality Assurance

1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
2. Comply with requirements in ACI 301, "Specifications for Structural Concrete."
3. Welding Qualifications: Qualify procedures and personnel according to the following:
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel"
 - b. AWS D1.3, "Structural Welding Code - Sheet Steel."
4. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling

1. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent physical damage.
 - a. Painted Piles: Protect finish and touch up damage before driving piles.

F. Project Conditions



1. Protect structures, underground utilities, and other construction from damage caused by pile driving.
2. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Provide photographs **OR** video, **as directed**, of conditions that might be misconstrued as damage caused by pile driving.

1.2 PRODUCTS

A. Steel Shell Piles

1. Fluted Pile Shells: Manufacturer's standard, vertically fluted pile shells; cold formed from steel sheet; 50,000-psi (345-MPa) minimum yield strength after forming. Fabricate watertight, uniformly tapered sections with forged-steel conical nose welded to tip.
 - a. Constant Diameter Extensions: Fabricate with splice overlap capable of telescoping into tapered section.
 - b. Taper: 0.14 inch in 12 inches (1:86) **OR** 0.25 inch in 12 inches (1:48) **OR** 0.40 inch in 12 inches (1:30), **as directed**.
 - c. Thickness: 0.150 inch (3.80 mm) **OR** 0.179 inch (4.55 mm) **OR** 0.209 inch (5.31 mm) **OR** 0.239 inch (6.07 mm), **as directed**.
2. Helically Corrugated Pile Shells: Manufacturer's standard, helically corrugated, uniform-diameter, steel sheet shell piles; of sufficient strength and thickness to remain watertight and resist distortion and buckling due to soil pressure, internal mandrel operation, or re-driving. Fabricate in one-piece lengths with 3/16-inch- (4.76-mm-) thick, minimum steel-plate boot continuously welded to tip and as follows:
 - a. Nominal Diameter: 8-5/8 inches (219 mm) **OR** 10-5/8 inches (270 mm) **OR** 11-1/8 inches (283 mm) **OR** 12-1/4 inches (311 mm) **OR** 14 inches (350 mm) **OR** 16-1/8 inches (410 mm), **as directed**.
 - b. Thickness: 0.048 inch (1.21 mm), minimum **OR** 0.060 inch (1.52 mm), minimum **OR** 0.075 inch (1.90 mm), minimum **OR** 0.105 inch (2.66 mm), **as directed**.

B. Steel Pipe Piles

1. Steel Pipe: ASTM A 252, Grade 2 **OR** Grade 3, **as directed**; seamless or welded.

C. Steel Reinforcement

1. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.
2. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M.
3. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:
 - a. Steel Reinforcement: ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**; deformed.
4. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M, as follows:
 - a. Steel Reinforcement: ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**; deformed.
5. Plain Steel Wire: ASTM A 82/A 82M, as drawn **OR** galvanized, **as directed**.
6. Deformed-Steel Wire: ASTM A 496/A 496M.
7. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated, plain **OR** deformed, **as directed**.

D. Concrete Materials

1. Portland Cement: ASTM C 150, Type I or II.
 - a. Fly Ash: ASTM C 618, Class C or F.
 - b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
2. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag **OR** Type IP, portland-pozzolan **OR** Type I (PM), pozzolan-modified portland **OR** Type I (SM), slag-modified Portland, **as directed**, cement.



3. Normal-Weight Aggregates: ASTM C 33, Class 4S **OR** Class 4M **OR** Class 1N, **as directed**, uniformly graded, 3/4-inch (19-mm) maximum aggregate size. Provide aggregates from a single source.
 4. Water: Potable, complying with ASTM C 94/C 94M requirements.
 5. Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent chloride ions by mass of cementitious material.
 - a. Air-Entraining Admixture: ASTM C 260.
 - b. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 - c. Retarding Admixture: ASTM C 494/C 494M, Type B.
 - d. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 - e. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 - f. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 - g. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
- E. Pile Accessories
1. Driving Points: Manufacturer's standard 60-degree conical driving point, with integral reinforcing ribs, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
 2. Inside Cutting Shoes: Manufacturer's standard, inside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
 3. Outside Cutting Shoes: Manufacturer's standard, outside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
 - a. Carbon-Steel Castings: ASTM A 27/A 27M, Grade 65-35 (Grade 450-240), heat treated **OR** Grade N1, **as directed**.
 - b. High-Strength Steel Castings: ASTM A 148/A 148M, Grade 80-40 (Grade 550-275) **OR** Grade 90-60 (Grade 620-415), **as directed**.
 4. Splice Coupling: Manufacturer's standard splice coupling, rolled from ASTM A 36/A 36M, carbon-steel bar or cast from heat-treated carbon steel, ASTM A 27/A 27M, Grade 65-35 (Grade 450-240), with interior stop and internally tapered for friction fit driving.
- F. Paint
1. Paint: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, black **OR** red **OR** manufacturer's standard color, **as directed**.
- G. Concrete Mixes
1. Prepare concrete design mixes according to ACI 301, determined by either laboratory trial batch or field test data basis.
 - a. Use a qualified testing agency for preparing and reporting proposed mix designs determined by laboratory trial batch.
 2. Proportion mixes according to ACI 301 to provide normal-weight concrete suitable for piles with the following properties:
 - a. Compressive Strength (28 Days): 5000 psi (34.5 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3000 psi (20.7 MPa), **as directed**.
 - b. Maximum Water-Cementitious Material Ratio at Point of Placement: 0.45 **OR** 0.50, **as directed**.
 - c. Slump Limit: 5 inches (127 mm) **OR** 8 inches (203 mm), **as directed**, plus or minus 1 inch (25 mm).
 3. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content of 6.0 percent, plus or minus 1.5 **OR** 2.5 to 4.5, **as directed**, percent.
 4. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.
 5. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 **OR** 0.30, **as directed**, percent by weight of cement.
 6. Concrete-mix design adjustments may be considered if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant. Resubmit and obtain approval from the Owner of proposed changes to concrete-mix proportions.



H. Fabrication

1. Fabricate and assemble piles in shop to greatest extent possible.
2. Fabricate full-length piles to eliminate splicing during driving.
OR
Fabricate full-length piles by splicing pile lengths together. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.
 - a. Splice Coupling: Fit splice coupling into position and weld to adjoining steel pipe pile sections according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
 - b. Welded Splices: Accurately mill meeting ends of steel pipe piles and bevel for welding. Continuously weld pile according to AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
 - c. Welded Splices: Continuously weld steel shell pile according to manufacturer's written instructions and AWS D1.1/D1.1M and AWS D1.3, **as directed**, for procedures, appearance and quality of welds, and methods used in correcting welding work.
 - d. Splice piles during fabrication or field installation.
3. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
OR
Fit and weld cutting shoes to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
4. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1.52-m) intervals. Maintain markings on piles until driven.

I. Shop Painting, **as directed**

1. General: Shop paint steel pile surfaces, except for surfaces to be encased in concrete, as follows:
 - a. Extend painting to a depth of 60 inches (1.52 m) below finished grade **OR** low-tide level, **as directed**, to top of exposed pile.
2. Surface Preparation: Clean surfaces to be painted. Remove loose rust and loose mill scale, and remove spatter, slag, or flux deposits. Prepare surfaces according to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
3. Painting: Immediately after surface preparation, apply coat of paint according to manufacturer's written instructions to provide a dry film thickness of not less than 8 mils (0.2 mm).
 - a. Apply second coat to provide a dry film thickness of not less than 8 mils (0.2 mm), resulting in a two-coat paint system thickness of not less than 16 mils (0.4 mm).
 - b. Apply second and third coats with each coat having a dry film thickness of not less than 8 mils (0.2 mm), resulting in a three-coat paint system thickness of not less than 24 mils (0.6 mm).
 - c. Mark pile lengths after shop painting.

J. Concrete Mixing

1. Ready-Mixed Concrete: Comply with ASTM C 94/C 94M.
 - a. Do not add water to concrete mix after mixing.
 - b. Maintain concrete temperature to not exceed 90 deg F (32 deg C).

1.3 EXECUTION

A. Examination



1. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of 6 to 12 inches (152 to 305 mm) above bottom of footing or pile cap.
- B. Driving Equipment
1. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
 2. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
 3. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that will hold full length of pile firmly in position and in axial alignment with hammer.
 4. Mandrel: Expandable mandrel, capable of distributing driving energy throughout length of steel shell pile.
- C. Static Pile Tests, **as directed**
1. General: Static pile tests will be used to verify driving criteria and pile lengths and to confirm allowable load of piles.
 - a. Furnish test piles 60 inches (1.52 m) longer than production piles.
 - b. Determination of actual length of piles will be based on results of static pile tests.
 2. Pile Tests: Arrange and perform the following pile tests:
 - a. Axial Compressive Static Load Test: ASTM D 1143.
 - b. Axial Tension Static Load Test: ASTM D 3689.
 - c. Lateral Load Test: ASTM D 3966.
 3. Equip each test pile with two telltale rods, according to ASTM D 1143, for measuring deformation during load test.
 4. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify the Owner at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
 - a. Allow a minimum of seven days to elapse after driving test piles before starting pile testing.
 - b. Number of Test Piles: One pile **OR** As indicated, **as directed**.
 5. Driving Test Piles: Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
 - a. Pile Design Load: As indicated **OR as directed**.
 6. Approval Criteria: Allowable load shall be the load acting on the test pile when the lesser of, **as directed**, the following criteria are met, divided by a factor of safety of 2:
 - a. Net settlement, after deducting rebound, of not more than 0.01 inch/ton (0.25 mm/907 kg) of test load.
 - b. Total settlement exceeds the pile elastic compression by 0.15 inch (4 mm), plus 1.0 percent of the tip diagonal dimension.
 - c. A plunging failure or sharp break in the load settlement curve.
 7. Test Pile-Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified professional engineer, **as directed**. Include same data as required for driving records of permanent piles.
 8. Test piles that comply with requirements, including location tolerances, may be used on Project.
- D. Steel Reinforcement
1. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
 2. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
 3. Fabricate and install reinforcement cages symmetrically about axis of pile shell **OR** pipe, **as directed**, in a single unit.



4. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover on reinforcement.
5. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

E. Concrete Placement

1. Do not place concrete until other piles within a radius of 20 feet (6 m) have been driven and approved.
2. Inspection: Before placing concrete, allow testing and inspecting agency to visually inspect and verify that each pile shell **OR** pipe, **as directed**, is clean, watertight, plumb, and free of distortion or other defects.
3. Place concrete in a continuous operation and without segregation immediately after cleaning out pile shell **OR** pipe, **as directed**.
4. Place concrete by means of bottom discharge bucket, flexible drop chute, steep-sided funnel hopper, or tremie or pump concrete into place.
5. Place concrete in a dry pile shell **OR** pipe, **as directed**, unless placement underwater is approved by the Owner.
 - a. Place concrete underwater by tremie method or pumping. Control placement operations to ensure tremie is embedded no less than 60 inches (1.52 m) into concrete, and flow of tremied concrete is continuous from bottom to top of pile shell **OR** pipe, **as directed**.
 - b. Other methods of depositing concrete may be used if approved by the Owner.
6. Consolidate final 10 feet (3 m) of concrete during placement to ensure that concrete is thoroughly worked around steel reinforcement and into corners.
7. Screed concrete level at cutoff elevation and apply a scoured, rough finish.

F. Driving Piles

1. General: Continuously drive piles to elevations or penetration resistance indicated or established by static load testing of piles, **as directed**. Establish and maintain axial alignment of leads and piles before and during driving.
2. Predrilling, **as directed**: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
 - a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
3. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
4. Pile Splices: Splice piles during installation and align pile segments concentrically.
5. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
 - a. Location: 4 inches (102 mm) from location indicated after initial driving, and 6 inches (152 mm) after pile driving is completed.
 - b. Plumb: Maintain 1 inch (25 mm) in 4 feet (1.2 m) from vertical, or a maximum of 4 inches (102 mm), measured when pile is aboveground in leads.
 - c. Batter Angle: Maximum 1 inch (25 mm) in 4 feet (1.2 m) from required angle, measured when pile is aboveground in leads.
6. Excavation: Clean out steel pipe pile by removing soil and debris from inside pile before placing steel reinforcement or concrete.
7. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.
 - a. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding 72 inches (1.83 m).

OR

Fill holes left by withdrawn piles as directed by the Owner.

OR



Abandon and cut off rejected piles as directed by the Owner. Leave rejected piles in place and install new piles in locations as directed by the Owner.

8. Cutting Off: Cut off tops of driven piles square with pile axis and at elevations indicated.
9. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer, **as directed**. Include the following data:
 - a. Project name and number.
 - b. Name of Contractor.
 - c. Pile location in pile group and designation of pile group.
 - d. Sequence of driving in pile group.
 - e. Pile dimensions.
 - f. Ground elevation.
 - g. Elevation of tips after driving.
 - h. Final tip and cutoff elevations of piles after driving pile group.
 - i. Records of re-driving.
 - j. Elevation of splices.
 - k. Type, make, model, and rated energy of hammer.
 - l. Weight and stroke of hammer.
 - m. Type of pile-driving cap used.
 - n. Cushion material and thickness.
 - o. Actual stroke and blow rate of hammer.
 - p. Pile-driving start and finish times, and total driving time.
 - q. Time, pile-tip elevation, and reason for interruptions.
 - r. Number of blows for every 12 inches (305 mm) of penetration, and number of blows per 1 inch (25 mm) for the last 6 inches (152 mm) of driving.
 - s. Pile deviations from location and plumb.
 - t. Preboring, jetting, or special procedures used.
 - u. Unusual occurrences during pile driving.

G. Field Quality Control

1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
 - a. Pile foundations.
2. Testing Agency: Engage a qualified independent testing agency to perform tests and inspections.
3. Tests and Inspections:
 - a. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D 4945 during initial driving and during restriking on 5 single piles **OR** 3 percent of piles, **as directed**.
 - b. Low-strain integrity measurement shall be performed and reported for each pile.
 - c. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1/D1.1M and the inspection procedures listed in subparagraphs below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
 - 1) Liquid Penetrant Inspection: ASTM E 165.
 - 2) Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - 3) Radiographic Inspection: ASTM E 94; minimum quality level "2-2T."
 - 4) Ultrasonic Inspection: ASTM E 164.
 - d. Concrete: Sampling and testing of concrete for quality control shall include the following:
 - 1) Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94/C 94M.
 - a) Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test, but no fewer than one test for each concrete load.
 - b) Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (5 deg C) and below or when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.



- c) Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
 - d) Compressive-Strength Tests: ASTM C 39/C 39M; one set for each truck load. One specimen shall be tested at seven days, two specimens shall be tested at 28 days, and one specimen shall be retained in reserve for later testing if required.
- 2) When frequency of testing will provide fewer than five strength tests for a given class of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 - 3) When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing in-place concrete.
 - 4) Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than 500 psi (3.45 MPa).
 - 5) Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, concrete type and class, location of concrete batch in piles, design compressive strength at 28 days, concrete-mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
 - 6) Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as sole basis for acceptance or rejection.
 - 7) Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate concrete strengths or other requirements have not been met.

H. Touchup Painting, **as directed**

1. Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC-PA 1. Use same paint and apply same number of coats as specified for shop painting.
 - a. Apply touchup paint before driving piles to surfaces that will be immersed or inaccessible after driving.

I. Disposal

1. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

END OF SECTION 33 14 13 13



Task	Specification	Specification Description
33 14 13 13	01 22 16 00	No Specification Required
33 14 13 13	22 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 13	21 05 19 00	Water Distribution
33 14 13 13	22 05 76 00	Sanitary Sewerage
33 14 13 13	33 42 11 00	Storm Drainage



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SECTION 33 14 13 23 - SAND DRAINS**1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of sand drains. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

- A. Galvanized Perforated Corrugated Metal Pipe: AASHTO M36.

- B. Perforated Polyvinyl Chloride (PVC) Plastic Pipe: ASTM D 1784.

- C. Aggregate shall be sand, gravel, crushed rock, or chat that is clean, sound, and of a good quality. Gradation shall conform to the following table:

Retained on the 1-inch sieve	0%
Retained on the 3/8-inch sieve	0-15%
Retained on the No. 8 sieve	40-60%
Retained on the No. 30 sieve	70-95%
Retained on the No. 100 sieve	98-100%

1.3 EXECUTION

- A. Pipe Bedding: Aggregate shall be placed in uniform layers on level excavation.

- B. Perforated Pipe shall be installed with securely aligned joints to lines and grades, which will allow proper drainage.

- C. Perforated Pipe shall be embedded with a minimum coverage of two feet of aggregate or as directed.

END OF SECTION 33 14 13 23



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SECTION 33 14 13 23a - SEPTIC TANK SYSTEMS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for septic tank systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following:
 - a. Septic tanks.
 - b. Distribution boxes.
 - c. Pipe and fittings.
 - d. Absorption systems

C. Submittals

1. Product Data: For each type of product indicated.
 - a. Include construction details, material descriptions, dimensions of individual components, and profiles.
 - b. Include manhole openings, covers, and pipe connections.
2. Shop Drawings: For [trench absorption systems] [bed absorption systems].
 - a. Include manhole openings, covers, pipe connections, and accessories.
 - b. Include piping with sizes and invert elevations.
 - c. Include underground structures.
 - d. Include other utilities.

1.2 PRODUCTS

A. Septic Tanks

1. Precast Concrete Septic Tanks: ASTM C 1227, single-chamber **OR** two-chamber, **as directed**, precast, reinforced-concrete tank with internal baffle, **as directed**, and covers.
 - a. Design: For A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed**, traffic loading according to ASTM C 890.
 - b. Manholes: 20-inch- (508-mm-) **OR** 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed**, minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.
 - c. Filter Access: Reinforced-concrete access hole, large enough to remove filter, over filter position.
 - d. Inlet and Outlet Access: 12-inch- (300-mm-) minimum diameter, reinforced-concrete access lids with steel lift rings. Include access centered over inlet and outlet.
 - e. Resilient Connectors: ASTM C 923 (ASTM C 923M), of size required for piping, fitted into inlet and outlet openings.
2. Fiberglass Septic Tanks: UL 1316, single-chamber, FRP construction; fabricated for septic tank application with at least one access riser and manhole.
 - a. Manholes: 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed**, minimum diameter opening with FRP access risers to grade and cover.
 - b. Filter Access: Include access hole, large enough to remove filter, over filter position.
 - c. Resilient Connectors: ASTM C 923 (ASTM C 923M) or other watertight seal, of size required for piping, fitted into inlet and outlet openings.
3. Polyethylene Septic Tanks: Single-chamber, molded, HDPE or PE construction; fabricated for septic tank application, with baffle, **as directed**, and at least one access riser and manhole.



4. Polyethylene Septic Tanks: Two-chamber, molded, HDPE or PE construction; fabricated for septic tank application, with access risers and manholes.
 - a. Manholes: 18-inch- (457-mm-) **OR** 20-inch- (508-mm-) **OR** 22-inch- (559-mm-), **as directed**, minimum diameter opening with HDPE or PE access risers to grade and cover.
 - b. Filter Access: Include access hole, large enough to remove filter, over filter position.
 - c. Resilient Connectors: ASTM C 923 (ASTM C 923M) or other watertight seal, of size required for piping, fitted into inlet and outlet openings.
- B. Filters
1. Description: Removable, septic-tank-outlet filter that restricts discharge solids to 1/8 inch (3.2 mm).
 - a. Housing: HDPE or PVC.
 - b. Outlet Size: NPS 4 (DN 100) **OR** NPS 6 (DN 150), **as directed**.
- C. Dosing Tanks
1. Dosing Tanks: Comply with ASTM C 913 for precast, reinforced-concrete tank and cover; designed for structural loading according to ASTM C 890.
 - a. Design: For effluent pump, **OR** automatic siphon, **as directed**, installation and A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed**, traffic loading according to ASTM C 890.
 - b. Manholes: 20-inch- (508-mm-) **OR** 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed**, minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.
 - c. Resilient Connectors: ASTM C 923 (ASTM C 923M), of size required for piping, fitted into inlet and outlet openings.
- D. Automatic Siphons
1. Description: Manufactured siphon assembly of molded-HDPE trap, pipe, and bell, with PVC vent piping and stainless-steel bolts.
- E. Distribution Boxes
1. Description: Precast concrete, single-chamber box and cover.
 - a. Design: Made according to ASTM C 913, and for A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed**, traffic loading according to ASTM C 890. Include baffle opposite inlet.
 - b. Manholes: 20-inch- (508-mm-) **OR** 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed**, minimum diameter opening with reinforced-concrete risers to grade and cover with steel lift rings in center of distribution box cover.
 - c. Pipe Connections: ASTM C 923 (ASTM C 923M) resilient connectors, of size required for piping, fitted into inlet and outlet openings. Include watertight plugs in outlets not required.
 2. Description: Molded-HDPE or -PE, single-chamber box and cover.
 - a. Manholes: 18-inch- (457-mm-) **OR** 20-inch- (508-mm-) **OR** 22-inch- (559-mm-), **as directed**, minimum diameter opening with HDPE or PE access risers to grade and cover. Access for PE distribution boxes may be a removable plastic cover and is usually small. **OR** Manufacturer's standard cover or other access opening of size that permits access to distribution-box inlet and outlets.
 - b. Pipe Connections: With seal that prevents leakage. Include watertight plugs in outlets not required.
- F. Leaching Pipes And Fittings
1. Pipe: PE, complying with ASTM F 810, perforated.
 - a. Fittings: ASTM D 2729 PVC for loose joints; ASTM D 3034, PVC for gasketed joints; or ASTM D 2751, ABS for gasketed joints.



2. Tube and Fittings: PE, complying with ASTM F 405, perforated corrugated tube with solid-wall fittings.
 - a. Couplings: PE band, matching tube and fitting dimensions.
 3. Pipe and Fittings: PVC, complying with ASTM D 2729, perforated, for solvent-cement joints.
 - a. Solvent Cement: ASTM D 2564. Include primer according to ASTM F 656
 4. Drainage Tile: Clay drain tile, complying with ASTM C 4, Standard class, drain tile with regular and smooth ends, for open joints.
- G. Nonpressure-Type Pipe Couplings
1. Description: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - a. Sleeve Materials:
 - 1) For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
 - 2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 3) For Vitrified-Clay Pipes: ASTM C 425, rubber.
 - 4) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- H. Leaching Chambers
1. Description: Arched, molded-PE structures with solid top, perforated sides, open ends, and open bottom.
 - a. End Pieces: Solid and solid with pipe opening types.
 - b. Effluent Distribution Piping: PE or PVC pipe, with holes or slots along pipe, attached to underside of top of chambers.
- I. Trench **OR** Bed, **as directed**, Absorption-System Materials
1. Filtering Material: ASTM D 448, Size No. 24, 3/4 to 2-1/2 inches (19 to 63 mm), washed, crushed stone or gravel; or broken, hard-burned clay brick.
 2. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m) **OR** Untreated building paper or similar porous material, **as directed**.
 3. Cover for Distribution Pipe: Geotextile woven filter fabric, in 1 or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m).
 4. Fill Material: Soil removed from trench.
- J. Mound Absorption-System Materials
1. Sand Filtering Material: 25 percent or more of very coarse, coarse, or medium sand or combination; maximum of 50 percent fine or very fine sand or combination; and silt and clay combination not to exceed 25 percent. If clay exceeds 60 percent in combination with silt, mixture cannot exceed 15 percent of sand filtering material.
 2. Aggregate Filtering Material: Coarse, 1/2 to 2-1/2 inches (13 to 63 mm).
 3. Cap: Clay, silt, or combination of clay and silt.
 4. Topsoil: Good quality, free of stones, metal, and glass.
 5. Vegetation Cover: Grass compatible with adjacent ground cover. No shrubs or trees.
 6. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m) **OR** Untreated building paper or similar porous material, **as directed**.
 7. Cover for Distribution Pipe: Geotextile woven filter fabric, in 1 or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m).
- K. Chamber Absorption-System Materials
1. Chamber: Arched, molded-PE structures with solid top, perforated sides, open ends, and open bottom.
 2. End Pieces: Blank without opening for distribution pipe at end of last chamber in row, and with opening for distribution pipe where pipe penetrates chamber.



3. Retain first paragraph below to run piping through chambers to improve distribution.
4. Effluent Distribution Piping: PE or PVC pipe, with holes or slots along pipe, attached to underside of top of chambers.

L. Seepage Pit Absorption-System Materials

1. Constructed-in-Place-Type Seepage Pit: Include the following materials.
 - a. Pit Lining: ASTM C 62, Type SW, clay bricks; ASTM C 55, concrete bricks; ASTM C 90, hollow, concrete masonry units; or precast concrete rings with notches or weep holes.
 - b. Filtering Material: ASTM D 448, Size No. 24, 3/4 to 2-1/2 inches (19 to 63 mm), washed, crushed stone or gravel; or broken, hard-burned clay brick.
 - c. Cover: Precast concrete slab; designed for A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed**, traffic loading according to ASTM C 890 and made according to ASTM C 913. Include slab dimensions that will extend minimum of 12 inches (300 mm) beyond edge of excavation. Cast cover with opening for manhole in center.
 - d. Manholes: 20-inch- (508-mm-) **OR** 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed**, minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings.

1.3 EXECUTION

A. Earthwork

1. Excavating, trenching, and backfilling for piping and seepage pits are specified in Division 31 Section "Earth Moving".
 - a. Stockpile topsoil for reuse in finish grading without intermixing with other excavated material. Stockpile materials away from edge of excavation and do not store within drip line of remaining trees.
 - b. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
2. Excavating and Backfilling for Septic and Dosing Tanks:
 - a. Excavate sufficient width and length for tanks to depth determined by tank inlet elevation. Provide level bottom.
 - b. Backfill with excavated soil, mounding soil above original grade without compacting.
3. Excavating and Backfilling for Trench **OR** Bed, **as directed**, Absorption Fields:
 - a. Excavate for trench absorption fields 30 inches (760 mm) wide and 24 inches (600 mm) deep, minimum.
 - b. Backfill trench absorption fields with excavated soil, mounding soil above original grade without compacting.
 - c. Excavate for bed absorption fields of width indicated and 24 inches (600 mm) deep, minimum.
 - d. Backfill bed absorption fields with excavated soil, mounding soil above original grade without compacting.

B. Excavating and Backfilling for Chamber Absorption Systems:

1. Excavate for trench-type chamber absorption systems **30 inches (762 mm)** wide and **24 inches (610 mm)** deep, minimum.
2. Excavate for bed-type chamber absorption systems of width indicated and **24 inches (610 mm)** deep, minimum.
3. Backfill chamber absorption systems with excavated soil, mounding soil above original grade without compacting.

C. Excavating and Backfilling for Seepage-Pit Absorption Systems:

1. Excavate sufficient hole diameter for pits to depth determined by tank inlet and bottom elevations. Provide level bottom.
2. Backfill with excavated soil, mounding soil above original grade without compacting.



- D. Septic Tank Installation
1. Install precast concrete septic tanks level according to ASTM C 891.
 2. Install septic tanks level.
 3. Connect septic tank to concrete ballast pad.
 4. Install filter in septic tank outlet. Secure filter to septic tank wall. Make direct connections to distribution piping.
 5. Install insulation on exterior sides and top of septic tank.
 6. Fill septic tank with water.
- E. Dosing Tank Installation
1. Install dosing tanks level and according to ASTM C 891.
 2. Install automatic siphons embedded in precast concrete dosing tank. Make direct connections to distribution piping.
 3. Set submersible effluent pumps on dosing tank floor. Make direct connections to distribution piping.
 4. Fill dosing tanks with water.
- F. Distribution Box Installation
1. Install precast concrete distribution boxes according to ASTM C 891 and at invert elevations indicated. Set level and plumb.
 2. Install PE distribution boxes at invert elevations indicated and according to manufacturer's written instructions. Set level and plumb.
- G. Piping Installation
1. Install leaching piping according to the following:
 - a. Use perforated pipe and fittings for trench **OR** bed **OR** mound, **as directed**, absorption fields with perforations at bottom.
 - b. PE Tube and Fittings: ASTM F 481.
 - c. PVC Sewer Pipe and Fittings: ASTM F 481.
- H. Pipe Joint Construction
1. Basic piping joint construction is specified in Division 33 Section "Common Work Results For Utilities". Where specific joint construction is not indicated, follow piping manufacturer's written instructions.
 2. Join distribution piping with or according to the following:
 - a. Install leaching pipe and fittings for trench **OR** bed **OR** mound, as directed, absorption fields with closed joints, unless otherwise indicated.
 - b. PE Tube and Fittings: With PE band couplings.
 - c. PVC Sewer Pipe and Fittings: With solvent-cemented joints according to ASTM F 402 and ASTM D 2321.
 3. Join dissimilar pipe materials according to ASTM D 5926, with couplings and gaskets compatible with pipe materials being joined.
- I. Cleanout Installation
1. Install cleanouts according to the following:
 - a. Inlet and Outlet of Septic Tanks: Cast-iron cleanouts.
 - b. Inlet and Outlet of Dosing Tanks: Cast-iron cleanouts.
 - c. Inlet and Outlet of Distribution Boxes: Cast-iron **OR** PVC cleanouts.
 - d. At Each Change in Direction of Sewer Piping: Cast-iron **OR** PVC cleanouts.
 - e. At Ends of Each Row and at Each Change in Direction of Distribution Piping: Cast-iron **OR** PVC cleanouts.
 2. Cast-Iron Cleanouts: Install with PVC fitting riser from distribution and leaching piping to cast-iron cleanout housing at grade. Use NPS 4 (DN 100) PVC sewer pipe and fittings with solvent-cemented joints for risers. Attach riser to cleanout housing with rubber gasket or coupling.



3. PVC Cleanouts: Install with PVC riser from distribution and leaching piping to PVC cleanout at grade. Use NPS 4 (DN 100) PVC sewer pipe and fittings with solvent-cemented joints for risers and cleanout fitting.
 4. Cleanout Support: Set cleanouts in concrete blocks 18 by 18 by 12 inches (457 by 457 by 305 mm) deep, unless location is in concrete pavement. Formwork, reinforcement, and concrete are specified in Division 03 Section "Cast-in-place Concrete".
 5. Set top of cleanout 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**, above surrounding rough grade, or set flush with grade if installed in pavement.
- J. Trench **OR** Bed **OR** Absorption-Field, **as directed**, Installation
1. Filtering Material: Place supporting layer of filtering material over the compacted trench **OR** bed, **as directed**, base to a compacted depth not less than 6 inches (150 mm) below bottom of pipe.
 2. Refer to Part 1.3 "Piping Installation" and "Pipe Joint Construction" articles for specific piping material installation.
 3. Install distribution piping at minimum slope of 1 percent and maximum slope of 2 percent.
 4. Install leaching piping solidly bedded in filtering material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.
 - a. Install perforated pipe with perforations down and joints tightly closed. Install collars and couplings as required.
 - b. Install open-joint pipe with 1/2-inch (13-mm) space, maximum, between ends, unless otherwise indicated. Cover top two-thirds of joint opening with joint cover, and tie with corrosion-resistant wire. Commercial joint-cover assemblies may be provided.
 - c. Install elbow fittings with tight joints.
 - d. Place additional filtering material around sides to a minimum compacted depth of 8 inches (200 mm) above the top of leaching piping.
 5. Install filter mat over filter material before backfilling.
 6. Install leaching chambers with no slope in bottom of trench **OR** bed, **as directed**.
 - a. Install leaching chamber distribution piping with tight joints throughout chambers.
 7. Backfill according to Part 1.3 "Earthwork" Article.
- K. Mound Absorption-Field Installation
1. Plow top 6 inches (150 mm) of surface.
 2. Place layers of sand, aggregate, **as directed**, cap, and topsoil above plowed area. Provide grass topping to match adjacent vegetation. Provide side slope not steeper than 3:1. Tie slope toe smoothly into existing grade.
 3. Refer to Part 1.3 "Piping Installation" and "Pipe Joint Construction" articles for specific piping material installation.
 4. Provide solid vent pipe with vent cap extending 12 inches (300 mm) above top of mounds.
 5. Install distribution piping with no slope for pressurized effluent system.
 6. Install distribution piping at a minimum slope of 1 percent and a maximum slope of 2 percent for gravity effluent system.
 7. Install leaching piping solidly bedded in filtering material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.
 - a. Install perforated pipe with perforations down and joints tightly closed. Install collars and couplings as required.
 - b. Install open-joint pipe with 1/2-inch (13-mm) space, maximum, between ends, unless otherwise indicated. Cover top two-thirds of joint opening with joint cover, and tie with corrosion-resistant wire. Commercial joint-cover assemblies may be provided.
 - c. Install elbow fittings with tight joints.
 8. Install leaching chambers with no slope above plowed area.
 - a. Install leaching chamber distribution piping with tight joints throughout chambers.
 9. Provide adequate grading around mound absorption field to prevent storm runoff from washing away a portion of mound absorption field and to prevent exposing pipes.
- L. Seepage Pit Installation



1. Excavate hole to minimum diameter of 6 inches (150 mm) greater than outside of pit lining.
 2. Do not extend pit depth into ground-water table.
 3. Install constructed-in-place seepage pits according to the following procedure if no requirements of authorities having jurisdiction apply:
 - a. Install brick pit lining material dry and laid flat with staggered joints for seepage.
 - b. Install block pit lining material dry with staggered joints and a minimum of 20 percent of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage.
 - c. Extend pit lining material so top of manhole will be approximately 8 inches (200 mm) below finished grade.
 - d. Backfill bottom of inside of pit with filtering material at least 12 inches (300 mm) above bottom of lining material.
 - e. Extend effluent inlet pipe 12 inches (300 mm) into seepage pit and terminate into side of tee fitting.
 - f. Backfill around outside of pit lining with filtering material to top of lining.
 - g. Install manhole risers from top of pit to grade. Support cover on undisturbed soil. Do not support cover on pit lining.
- M. Identification
1. Identification materials and their installation are specified in Division 31 Section "Earth Moving". Arrange for installation of green warning tape directly over piping (including absorption-field piping), at outside edges of underground structures, and at outside edges of absorption fields.
 2. Use detectable warning tape over piping, over edges of underground structures, and over edges of absorption fields.
- N. Field Quality Control
1. System Tests: Perform testing of completed septic tank system piping and structures according to authorities having jurisdiction.
 2. Additional Tests: Fill underground structures with water and let stand overnight. If water level recedes, locate and repair leaks and retest. Repeat tests and repairs until no leaks exist.
- O. Cleaning
1. Clear interior of piping and structures of dirt and other superfluous material as work progresses.
 2. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of workday or when work stops.

END OF SECTION 33 14 13 23a



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SECTION 33 14 13 23b - HYDRONIC DISTRIBUTION

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for hydronic distribution. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes underground piping outside the building for distribution of heating hot and chilled water.

C. Performance Requirements

1. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:
 - a. Hot-Water Piping: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
 - b. Chilled-Water Piping: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
 - c. Condenser-Water Piping: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.

D. Submittals

1. Product Data
2. Shop Drawings
3. Welding certificates.
4. Source quality-control test reports.
5. Field quality-control test reports.

E. Quality Assurance

1. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.
2. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

F. Project Conditions

1. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed utility interruptions.
 - b. Do not proceed with utility interruptions without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials

1. Refer to Part 1.3 "Piping Application" Article for applications of pipes, tubes, fittings, and joining methods.
2. Refer to Division 33 Section "Common Work Results For Utilities" for commonly used joining materials.

B. Steel Pipes And Fittings

1. Steel Pipe: ASTM A 53/A 53M, Type E, Grade B, Standard Weight; with plain ends.
2. Nipples: ASTM A 733, Standard Weight, seamless, carbon-steel pipe complying with ASTM A 53/A 53M.



3. Malleable-Iron, Threaded Fittings: ASME B16.3, Classes 150 **OR** 300, **as directed**, with threads according to ASME B1.20.1.
4. Cast-Iron, Threaded Fittings: ASME B16.4, Classes 125 **OR** 250, **as directed**, standard pattern, with threads according to ASME B1.20.1.
5. Steel Welding Fittings: ASME B16.9 **OR** ASTM A 234/A 234M, **as directed**, seamless or welded.
6. Ductile-Iron, Grooved-End Fittings: ASTM A 536, ductile-iron casting with dimensions matching piping.
7. Steel-Pipe, Keyed Couplings: AWWA C606 for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for hot water, and bolts and nuts.

C. Conduit Piping

1. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade B with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
 - a. Mineral-Wool Pipe Insulation: ASTM C 547, Type I, molded.
 - 1) Apparent Thermal Conductivity (k-Value): 0.31 at 200 deg F (0.044 at 93 deg C) mean temperature.
 - 2) Density: Maximum 10 lb/cu. ft. (160 kg/cu. m) average.
 - 3) Compressive Strength: 10 psig (69 kPa) minimum at 5 percent deformation.
 - 4) Bands: ASTM A 666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.
 - b. Calcium Silicate Pipe Insulation: ASTM C 533, Type I; preformed, incombustible, inorganic, with non-asbestos fibrous reinforcement.
 - 1) Thermal Conductivity (k-Value): 0.60 at 500 deg F (0.087 at 260 deg C).
 - 2) Dry Density: 15 lb/cu. ft. (240 kg/cu. m) maximum.
 - 3) Compressive Strength: 60 psig (414 kPa) minimum at 5 percent deformation.
 - 4) Bands: ASTM A 666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.
 - c. Polyisocyanurate Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
 - 1) Thermal Conductivity (k-Value): 0.14 at 75 deg F (0.020 at 24 deg C).
 - 2) Service Temperature: Minus 250 to plus 400 deg F (Minus 156 to plus 204 deg C).
 - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
 - 4) Minimum 90 percent closed cell.
 - 5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
 - 6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
 - 7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
 - d. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
 - 1) Thermal Conductivity (k-Value): 0.13 at 75 deg F (0.019 at 24 deg C).
 - 2) Service Temperature: Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C).
 - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
 - 4) Minimum 90 percent closed cell.
 - 5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
 - 6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
 - 7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
4. Minimum Clearance:
 - a. Between Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
 - b. Between Insulation of Multiple Carrier Pipes: 3/16 inch (4.75 mm).
 - c. Between Bottom of Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
 - d. Between Bottom of Bare, Carrier Pipe and Casing: 1-3/8 inches (35 mm).



5. Conduit: Spiral wound, steel. Finish conduit with 2 coats of fusion-bonded epoxy, minimum 20 mils (0.50 mm) thick. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article, **as directed**.
OR
Conduit: Spiral wound, bare steel. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article.
6. Carrier Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of 10 feet (3 m).
7. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees shall be factory fabricated and insulated, and shall be compatible with the carrier pipe.
8. Expansion Offsets and Loops: Size casing to contain piping expansion.
9. Conduit accessories include the following:
 - a. Water Shed: Terminal end protector for carrier pipes entering building through floor, 3 inches (75 mm) deep and 2 inches (50 mm) larger than casing; terminate casing 20 inches (500 mm) above the floor level.
 - b. Guides and Anchors: Steel plate welded to carrier pipes and to casing, complete with vent and drainage openings inside casing.
 - c. End Seals: Steel plate welded to carrier pipes and to casing, complete with drain and vent openings on vertical centerline.
 - d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of casing, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
 - e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.
10. Source Quality Control: Factory test the conduit to 15 psig (105 kPa) for a minimum of 2 minutes with no change in pressure. Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

D. Cased Piping

1. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade B with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
 - a. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
 - 1) Thermal Conductivity (k-Value): 0.13 at 75 deg F (0.019 at 24 deg C).
 - 2) Service Temperature: Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C).
 - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
 - 4) Minimum 90 percent closed cell.
 - 5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
 - 6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
 - 7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
4. Casing: High-density polyethylene **OR** Filament-wound, fiberglass-reinforced polyester resin **OR** PVC, **as directed**.
5. Casing accessories include the following:
 - a. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
 - b. Expansion Blanket: Elastomeric foam, formed to fit over piping.
 - c. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.
6. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

E. Loose-Fill Insulation

1. Granular, Loose-Fill Insulation: Inorganic, nontoxic, nonflammable, sodium potassium aluminum silicate with calcium carbonate filler. Include chemical treatment that renders insulation hydrophobic.



- a. Thermal Conductivity (k-Value): 0.60 at 175 deg F (0.087 at 79 deg C) and 0.65 at 300 deg F (0.094 at 149 deg C).
 - b. Application Temperature Range: 35 to 800 deg F (2 to 426 deg C).
 - c. Dry Density: 40 to 42 lb/cu. ft. (640 to 672 kg/cu. m).
 - d. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).
2. Powder, Loose-Fill Insulation: Inert, nontoxic, nonflammable, calcium carbonate particles. Include chemical treatment that renders insulation hydrophobic.
- a. Thermal Conductivity (k-Value): ASTM C 177, 0.58 at 100 deg F (0.084 at 37 deg C) and 0.68 at 300 deg F (0.098 at 149 deg C).
 - b. Application Temperature Range: Minus 273 to plus 480 deg F (Minus 169 to plus 250 deg C).
 - c. Dry Density: Approximately 60 lb/cu. ft. (960 kg/cu. m).
 - d. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).

1.3 EXECUTION

- A. Earthwork: Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
- B. Piping Application
1. Hot-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, loose-fill insulation.
OR
 Hot-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
 - a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.**OR**
 Hot-Water Piping: Cased piping with polyurethane carrier-pipe insulation.
 2. Chilled-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel welding fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.
OR
 Chilled-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
 - a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.**OR**
 Chilled-Water Piping: Cased piping with polyurethane carrier-pipe insulation.
 3. Condenser-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel welding fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.
OR
 Condenser-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
 - a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.**OR**
 Condenser-Water Piping: Cased piping with polyurethane carrier-pipe insulation.
- C. Piping Installation



1. General Locations and Arrangements: Drawings indicate general location and arrangement of piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved.
 2. Remove any standing water in the bottom of trench.
 3. Bed the pipe on a minimum 6-inch (150-mm) layer of granular fill material with a minimum 6-inch (150-mm) clearance between the pipes.
 4. Do not insulate piping or backfill piping trench until field quality-control testing has been completed and results approved.
 5. Install piping at uniform grade of 0.2 percent upward in direction of flow or as indicated.
 6. Install components with pressure rating equal to or greater than system operating pressure.
 7. Install piping free of sags and bends.
 8. Install fittings for changes in direction and branch connections.
 9. Refer to Division 23 Section "Common Work Results For Hvac" for sleeves and mechanical sleeve seals through exterior building walls.
 10. Secure anchors with concrete thrust blocks. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
 11. Connect to hydronic piping where it passes through the building wall. Hydronic piping inside the building is specified in Division 23 Section "Hydronic Piping".
- D. Loose-Fill Insulation Installation
1. Do not disturb the bottom of trench, or compact and stabilize it to ensure proper support.
 2. Remove any standing water in the bottom of trench.
 3. Form insulation trench by excavation or by installing drywall side forms to establish required height and width of the insulation.
 4. Support piping with proper pitch, separation, and clearance to backfill or side forms using temporary supporting devices that can be removed after back filling with insulation.
 5. Place insulation and backfill after field quality-control testing has been completed and results approved.
 6. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. Refer to Division 03 Section "Cast-in-place Concrete" for concrete and reinforcement.
 7. Wrap piping at expansion loops and offsets with mineral-wool insulation of thickness appropriate for calculated expansion amount.
 8. Pour loose-fill insulation to required dimension agitating insulation to eliminate voids around piping.
 9. Remove temporary hangers and supports.
 10. Cover loose-fill insulation with polyethylene sheet a minimum of 4 mils (0.10 mm) thick, and empty loose-fill insulation bags on top.
 11. Manually backfill 6 inches (150 mm) of clean backfill. If mechanical compaction is required, manually backfill to 12 inches (300 mm) before using mechanical-compaction equipment.
- E. Joint Construction
1. Refer to Division 33 Section "Common Work Results For Utilities" for basic piping joint construction.
 2. Keyed-Coupling Joints: Cut- or roll-groove pipes. Assemble joints with keyed couplings, gaskets, lubricant, and bolts.
 3. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation, exterior jacket sleeve, and apply shrink-wrap seals as required by manufacturer's written installation instructions.
- F. Identification: Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic distribution piping. Locate 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping. Refer to Division 31 Section "Earth Moving" for warning-tape materials and devices and their installation.
- G. Field Quality Control



1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:
 - a. Leave joints, including welds, uninsulated and exposed for examination during test.
 - b. Isolate equipment. Do not subject equipment to test pressure.
 - c. Install relief valve set at pressure no more than one-third higher than test pressure.
 - d. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
 - e. Use vents installed at high points to release trapped air while filling system.
2. Test hydronic piping as follows:
 - a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
 - b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
3. Test conduit as follows:
 - a. Seal vents and drains and subject conduit to 15 psig (105 kPa) for 4 hours with no loss of pressure. Repair leaks and retest as required.
4. Prepare a written report of testing.

END OF SECTION 33 14 13 23b



SECTION 33 14 13 23c - GROUND-LOOP HEAT-PUMP PIPING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for ground-loop, heat-pump piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes piping for horizontal or vertical, direct-buried, ground-loop, heat-pump systems that operate between 23 and 104 deg F (minus 5 and plus 40 deg C).

C. Performance Requirements

1. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
 - a. Ground-Loop, Heat-Pump Piping: 160 psig (1100 kPa) **OR** 200 psig (1380 kPa), **as directed**

D. Submittals

1. Product Data: For the following:
 - a. Pipe and fittings.
 - b. Joining method and equipment.
 - c. Propylene glycol solution.
2. Field quality-control test reports.

1.2 PRODUCTS

A. Pipes And Fittings

1. PE Pipe: ASTM D 2239, SIDR Numbers 5.3, 7, 9, or 11.5; with PE compound number required to achieve required system working pressure.
 - a. Molded PE Fittings: ASTM D 2683 or ASTM D 3261, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.
2. U-Bend Assembly: Factory fabricated with embossed depth stamp every 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed** from U-bend.

B. Borehole Backfill

1. Surface Seal: Bentonite **OR** Cement, **as directed**, with thermal conductivity greater than 1.2 Btu/h x sq. ft. x deg F (0.7 W/sq. m x K).
2. Backfill below Surface Seal: Natural or manufactured sand specified in Division 31 Section "Earth Moving".

C. Antifreeze Solution

1. Propylene Glycol: Minimum 99 percent propylene glycol with corrosion inhibitors and environmental stabilizer additives to be mixed with water to protect the piping circuit and connected equipment from physical damage from freezing or corrosion.
2. Quantity: Sufficient solution for initial system startup and for preventive maintenance for one year from date of Final Completion.
3. Dilution Water: Chloride content shall be less than 25 ppm, sulfate less than 25 ppm, and hardness less than 100 ppm.



1.3 EXECUTION

A. Earthwork

1. Excavating, trenching, warning tape, and backfilling are specified in Division 31 Section "Earth Moving".

B. Horizontal Piping Installation

1. Separate trenches by 10 feet (3 m) minimum, unless otherwise indicated. Remove rocks in trenches that could contact pipe.
2. Backfill to 24 inches (600 mm) above pipe with mud developed from excavated rock-free soil or with sand, pea gravel, or fly ash. Backfill from slurry level to grade with excavated soil, compacting as specified for pipe burial in Division 31 Section "Earth Moving".
3. Extend pipe from trench onto the bottom of the body of water at an elevation that is at least 12 inches (300 mm) below frost line. Seal membrane or impervious liner under the body of water after installing piping.
4. Install PE piping in trenches according to ASTM D 2774 or ASTM F 645.
 - a. Clean PE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
5. Purge, flush, and pressure test piping before backfilling trenches.
6. Install continuous detectable warning tape for underground piping. Locate tape a minimum of 24 inches (600 mm) below finished grade, directly over piping. Underground warning tapes are specified in Division 31 Section "Earth Moving".
7. Common piping installation requirements are specified in Division 23 Section "Common Work Results For Hvac".

C. Vertical Piping Installation

1. Install PE piping in boreholes according to ASTM D 2774 or ASTM F 645.
 - a. Clean PE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
2. Purge, flush, and pressure test piping before backfilling boreholes.
3. After installation of loop pipe in borehole, fill piping loop with water or antifreeze solution, and pump backfill into borehole to discharge at base of borehole.
4. Fill borehole with backfill to a point at least 60 inches (1524 mm) below grade and backfill remainder with surface seal material.
5. Extend piping and connect to water-source, ground-loop, heat-pump piping systems at outside face of building wall in locations and pipe sizes indicated.
 - a. Terminate water-service piping at building wall until building water-source, ground-loop, heat-pump piping systems are installed. Terminate piping with caps. Make connections to building water-source, ground-loop, heat-pump piping systems when those systems are installed.
6. Wall sleeves are specified in Division 23 Section "Common Work Results For Hvac".
7. Mechanical sleeve seals are specified in Division 22 Section "Common Work Results For Plumbing".

D. Antifreeze Solution Fill

1. Fill system with required quantity of propylene glycol and water to provide minus 10 deg F (minus 23 deg C) freezing temperature.
2. Test the dilute solution using gas chromatography to verify concentration of propylene glycol, and forward report to the Owner.

E. Connections

1. Drawings indicate general arrangement of piping, fittings, and specialties.

F. Field Quality Control



1. Piping Tests: Fill piping 24 hours before testing and apply test pressure to stabilize piping. Use potable water only.
2. Hydrostatic Tests: Test at not less than 1-1/2 times the pipe working-pressure rating allowing for static pressure of borehole depth.
 - a. Increase pressure in 50-psig (345-kPa) increments and inspect each joint between increments. Hold at test pressure for 30 minutes. Slowly increase to next test pressure increment and hold for 30 minutes. After testing at maximum test pressure, reduce pressure to 30 psig (207 kPa). Hold for 90 minutes, and measure pressure at 30-minute intervals. Repair leaks and retest until no leaks exist.
3. Prepare reports of testing activity.

END OF SECTION 33 14 13 23c



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SECTION 33 14 13 23d - SUBDRAINAGE

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for subdrainage. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Perforated-wall pipe and fittings.
 - b. Drainage conduits.
 - c. Drainage panels.
 - d. Geotextile filter fabrics.

C. Submittals

1. Drainage conduits, including rated capacities.
2. Drainage panels, including rated capacities.
3. Geotextile filter fabrics.

1.2 PRODUCTS

A. Perforated-Wall Pipes And Fittings

1. Perforated PE Pipe and Fittings:
 - a. NPS 6 (DN 150) and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
 - b. NPS 8 (DN 200) and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
 - c. Couplings: Manufacturer's standard, band type.
2. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.
3. Perforated Clay Pipe and Fittings: ASTM C 700, Standard- and Extra-Strength classes, unglazed, socket-and-spigot ends, for gasketed joints.
 - a. Gaskets: ASTM C 425, rubber.
4. Perforated Concrete Pipe and Fittings: ASTM C 444 (ASTM C 444M), Type 1, and applicable requirements in ASTM C 14 (ASTM C 14M), Class 2, socket-and-spigot ends for gasketed joints.
 - a. Gaskets: ASTM C 443 (ASTM C 443M), rubber.

B. Drainage Conduits

1. Molded-Sheet Drainage Conduits: Prefabricated geocomposite with cusped, molded-plastic drainage core wrapped in geotextile filter fabric.
 - a. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.
 - 1) Minimum In-Plane Flow: 30 gpm (114 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - b. Nominal Size: 18 inches (457 mm) high by approximately 1 inch (25 mm) thick.
 - 1) Minimum In-Plane Flow: 45 gpm (170 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - c. Filter Fabric: PP geotextile.
 - d. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.



2. Multipipe Drainage Conduits: Prefabricated geocomposite with interconnected, corrugated, perforated-pipe core molded from HDPE complying with ASTM D 1248 and wrapped in geotextile filter fabric.
 - a. Nominal Size: 6 inches (152 mm) high by approximately 1-1/4 inches (31 mm) thick.
 - 1) Minimum In-Plane Flow: 15 gpm (57 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - b. Nominal Size: 12 inches (305 mm) high by approximately 1-1/4 inches (31 mm) thick.
 - 1) Minimum In-Plane Flow: 30 gpm (114 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - c. Nominal Size: 18 inches (457 mm) high by approximately 1-1/4 inches (31 mm) thick.
 - 1) Minimum In-Plane Flow: 45 gpm (170 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - d. Filter Fabric: Nonwoven, needle-punched geotextile.
 - e. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
 - f. Couplings: HDPE.
3. Single-Pipe Drainage Conduits: Prefabricated geocomposite with perforated corrugated core molded from HDPE complying with ASTM D 3350 and wrapped in geotextile filter fabric.
 - a. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.
 - 1) Minimum In-Plane Flow: 30 gpm (114 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - b. Nominal Size: 18 inches (457 mm) high by approximately 1 inch (25 mm) thick.
 - 1) Minimum In-Plane Flow: 45 gpm (170 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - c. Filter Fabric: Nonwoven, PP geotextile.
 - d. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
 - e. Couplings: Corrugated HDPE band.
4. Mesh Fabric Drainage Conduits: Prefabricated geocomposite with plastic-filament drainage core wrapped in geotextile filter fabric. Include fittings for bends and connection to drainage piping.
 - a. Nominal Size: 6 inches (2-mm) high by approximately 0.9 inch (23 mm) thick.
 - 1) Minimum In-Plane Flow: 2.4 gpm (9.1 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - b. Filter Fabric: Nonwoven geotextile made of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.
5. Ring Fabric Drainage Conduits: Drainage conduit with HDPE-rings-in-grid-pattern drainage core, for field-applied geotextile filter fabric. Include fittings for bends and connection to drainage piping.
 - a. Nominal Size: 18 inches (0.5 m) high by 1 inch (25 mm) thick.
 - 1) Minimum In-Plane Flow: 82 gpm (310 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - b. Nominal Size: 36 inches (1 m) high by 1 inch (25 mm) thick.
 - 1) Minimum In-Plane Flow: 164 gpm (621 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
 - c. Filter Fabric: Specified in Part 1.2 "Geotextile Filter Fabrics" Article.

C. Drainage Panels

1. Molded-Sheet Drainage Panels: Prefabricated geocomposite, 36 to 60 inches (915 to 1525 mm) wide with drainage core faced with geotextile filter fabric.
 - a. Drainage Core: Three-dimensional, nonbiodegradable, molded PP.
 - 1) Minimum Compressive Strength: 10,000 lbf/sq. ft. (479 kPa) **OR** 15,000 lbf/sq. ft. (718 kPa) **OR** 18,000 lbf/sq. ft. (862 kPa) **OR** 21,000 lbf/sq. ft. (1005 kPa), **as directed**, when tested according to ASTM D 1621.



- 2) Minimum In-Plane Flow Rate: 2.8 gpm/ft. (35 L/min. per m) **OR** 7 gpm/ft. (87 L/min. per m) **OR** 15 gpm/ft. (188 L/min. per m), **as directed**, of unit width at hydraulic gradient of 1.0 and compressive stress of 25 psig (172 kPa) when tested according to ASTM D 4716.
- b. Filter Fabric: Nonwoven needle-punched geotextile, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with the following properties determined according to AASHTO M 288:
 - 1) Survivability: Class 1 **OR** 2 **OR** 3, **as directed**.
 - 2) Apparent Opening Size: No. 40 (0.425-mm) **OR** No. 60 (0.25-mm) **OR** No. 70 (0.212-mm), **as directed**, sieve, maximum.
 - 3) Permittivity: 0.5 **OR** 0.2 **OR** 0.1, **as directed**, per second, minimum.
- c. Filter Fabric: Woven geotextile fabric, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation less than 50 percent; complying with the following properties determined according to AASHTO M 288:
 - 1) Survivability: Class 1 **OR** 2 **OR** 3, **as directed**.
 - 2) Apparent Opening Size: No. 40 (0.425-mm) **OR** No. 60 (0.25-mm) **OR** No. 70 (0.212-mm) **OR** No. 30 (0.6-mm), **as directed**, sieve, maximum.
 - 3) Permittivity: 0.5 **OR** 0.2 **OR** 0.1 **OR** 0.02, **as directed**, per second, minimum.
- d. Film Backing: Polymeric film bonded to drainage core surface.
2. Mesh Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.
 - a. Drainage Core: Open-construction, resilient, approximately 0.4-inch- (10.2-mm-) thick, plastic-filament mesh.
 - 1) Minimum In-Plane Flow Rate: 2.4 gpm/ft. (30 L/min. per m) of unit width at hydraulic gradient of 1.0 and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.
 - b. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.
3. Net Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.
 - a. Drainage Core: 3-dimensional, PE nonwoven-strand geonet, approximately 0.25-inch- (6-mm-) thick.
 - 1) Minimum In-Plane Flow Rate: 2.4 gpm/ft. (30 L/min. per m) **OR** 5 gpm/ft. (62 L/min. per m), **as directed**, of unit width at hydraulic gradient of 1.0 and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.
 - b. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.
4. Ring Fabric Drainage Panels: Drainage-core panel for field application of geotextile filter fabric.
 - a. Drainage Core: 3-dimensional, HDPE rings in grid pattern, approximately 1 inch (25 mm) thick.
 - 1) Minimum In-Plane Flow Rate: 40 gpm/ft. (500 L/min. per m) of unit width at hydraulic gradient of 1.0 and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.
5. Fabric-Covered Insulated Drainage Panels: Extruded PS board insulation complying with ASTM C 578; fabricated with shiplap **OR** tongue-and-groove, **as directed**, edges and with one side having grooved drainage channels; unfaced **OR** ; faced with geotextile filter fabric, **as directed**.
 - a. Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) minimum density and 25-psig (172-kPa) minimum compressive strength.
 - b. Type VI, 1.8-lb/cu. ft. (29-kg/cu. m) minimum density and 40-psig (276-kPa) minimum compressive strength.
 - c. Minimum In-Plane Flow Rate: 9 gpm/ft. (112 L/min. per m) of unit width when tested according to ASTM D 4716.



- d. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.
6. Noncovered Insulated Drainage Panels: Extruded PS board insulation complying with ASTM C 578; fabricated with rabbeted edges and with one side having ribbed drainage channels.
 - a. Type VI, 1.8-lb/cu. ft. (29-kg/cu. m) minimum density and 40-psig (276-kPa) minimum compressive strength.
 - b. Type VII, 2.2-lb/cu. ft. (35-kg/cu. m) minimum density and 60-psig (414-kPa) minimum compressive strength.
 - c. Minimum In-Plane Flow Rate: 9 gpm/ft. (112 L/min. per m) of unit width when tested according to ASTM D 4716.
7. Expanded PS Insulated Drainage Panels: PS bead board insulation; panels are 4 inches (102 mm) thick by 48 inches (1220 mm) wide and faced with geotextile filter fabric.
 - a. Density: 2 lb/cu. ft. (32 kg/cu. m).
 - b. Compressive Strength: 800 lbf/sq. ft. (38 kPa).
 - c. Minimum In-Plane Flow Rate: 3 gpm/ft. (37 L/min. per m) of unit width when tested according to ASTM D 4716.
 - d. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.

D. Soil Materials

1. Soil materials are specified in Division 31 Section "Earth Moving".

E. Waterproofing Felts

1. Material: Comply with ASTM D 226, Type I, asphalt **OR** ASTM D 227, coal-tar, **as directed**, -saturated organic felt.

F. Geotextile Filter Fabrics

1. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4480 to 13 440 L/min. per sq. m) when tested according to ASTM D 4491.
 - a. Structure Type: Nonwoven, needle-punched continuous filament.
 - 1) Survivability: AASHTO **M 288 Class 2**.
 - 2) Style(s): Flat **OR** sock, **as directed**.

1.3 EXECUTION

A. Earthwork

1. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Foundation Drainage Installation

1. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches (150 mm) deep and 12 inches (300 mm) wide.
2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
4. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
5. Install drainage piping as indicated in Article 1.3 "Piping Installation" for foundation subdrainage.
6. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
7. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.



8. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
9. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed**, over top of drainage course, overlapping edges at least 4 inches (100 mm).
10. Install drainage panels on foundation walls as follows:
 - a. Coordinate placement with other drainage materials.
 - b. Lay perforated drainage pipe at base of footing. Install as indicated in Article 1.3 "Piping Installation."
 - c. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.
 - d. Attach panels to wall beginning at subdrainage pipe. Place and secure molded-sheet drainage panels, with geotextile facing away from wall.
11. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

C. Underslab Drainage Installation

1. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches (150 mm) between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
4. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
5. Install drainage piping as indicated in Part 1.3 "Piping Installation" Article for underslab subdrainage.
6. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
7. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.
8. Install horizontal drainage panels as follows:
 - a. Coordinate placement with other drainage materials.
 - b. Lay perforated drainage pipe at inside edge of footings.
 - c. Place drainage panel over drainage pipe with core side up. Peel back fabric and wrap fabric around pipe. Locate top of core at bottom elevation of floor slab.
 - d. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.

D. Retaining-Wall Drainage Installation

1. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
2. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches (100 mm).
3. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
4. Install drainage piping as indicated in Article 1.3 "Piping Installation" for retaining-wall subdrainage.
5. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
6. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.
7. Place drainage course in layers not exceeding 3 inches (75 mm) in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.
8. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed**, over top of drainage course, overlapping edges at least 4 inches (100 mm).
9. Install drainage panels on walls as follows:



- a. Coordinate placement with other drainage materials.
 - b. Lay perforated drainage pipe at base of footing as described elsewhere in this Specification. Do not install aggregate.
 - c. If weep holes are used instead of drainage pipe, cut 1/2-inch- (13-mm-) diameter holes on core side at weep-hole locations. Do not cut fabric.
 - d. Mark horizontal chalk line on wall at a point 6 inches (150 mm) less than panel width above footing bottom. Before marking wall, subtract footing width.
 - e. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.
 - f. Attach panel to wall at horizontal mark and at beginning of wall corner. Place core side of panel against wall. Use concrete nails with washers through product. Place nails from 2 to 6 inches (50 to 150 mm) below top of panel, approximately 48 inches (1200 mm) apart. Construction adhesives, metal stick pins, or double-sided tape may be used instead of nails. Do not penetrate waterproofing. Before using adhesives, discuss with waterproofing manufacturer.
 - g. If another panel is required on same row, cut away 4 inches (100 mm) of installed panel core and wrap fabric over new panel.
 - h. If additional rows of panel are required, overlap lower panel with 4 inches (100 mm) of fabric.
 - i. Cut panel as necessary to keep top 12 inches (300 mm) below finish grade.
 - j. For inside corners, bend panel. For outside corners, cut core to provide 3 inches (75 mm) for overlap.
10. Fill to Grade: Place satisfactory soil fill material over compacted drainage course . Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.

E. Landscaping Drainage Installation

1. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
4. Install drainage conduits as indicated in Article 1.3 "Piping Installation" for landscaping subdrainage with horizontal distance of at least 6 inches (150 mm) between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with adhesive or tape.
5. Add drainage course to top of drainage conduits.
6. After satisfactory testing, cover drainage conduit to within 12 inches (300 mm) of finish grade.
7. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
8. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed**, over top of drainage course, overlapping edges at least 4 inches (100 mm).
9. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.

F. Piping Installation

1. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
 - a. Foundation Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
 - b. Underslab Subdrainage: Install piping level.
 - c. Plaza Deck Subdrainage: Install piping level.



- d. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
 - e. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
 - f. Lay perforated pipe with perforations down.
 - g. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
2. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
 3. Install thermoplastic piping according to ASTM D 2321.
- G. Pipe Joint Construction
1. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.
 2. Join perforated PVC sewer pipe and fittings according to ASTM D 3212 with loose bell-and-spigot, push-on joints.
 3. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.
- 1.4 Backwater Valve Installation
1. Comply with requirements for backwater valves specified in Division 2 Section "Storm Drainage."
 2. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.
 3. Install horizontal backwater valves in piping in manholes or pits where indicated.
- B. Cleanout Installation
1. Comply with requirements for cleanouts specified in Division 2 Section "Storm Drainage."
 2. Cleanouts for Foundation, Retaining-Wall, and Landscaping Subdrainage:
 - a. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
 - b. In vehicular-traffic areas, use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches (450 by 450 by 300 mm) in depth. Set top of cleanout flush with grade. Cast-iron pipe may also be used for cleanouts in nonvehicular-traffic areas.
 - c. In nonvehicular-traffic areas, use NPS 4 (DN 100) cast-iron **OR** PVC, **as directed**, pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 12 by 12 by 4 inches (300 by 300 by 100 mm) in depth. Set top of cleanout plug 1 inch (25 mm) above grade.
 3. Cleanouts for Underslab Subdrainage:
 - a. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
 - b. Use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.
- C. Connections
1. Comply with requirements for piping specified in Division 2 Section "Storm Drainage." Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.



3. Where required, connect low elevations of foundation **OR** Underslab, **as directed**, subdrainage to stormwater sump pumps.

D. Identification

1. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Division 31 Section "Earth Moving".
 - a. Install PE warning tape or detectable warning tape over ferrous piping.
 - b. Install detectable warning tape over nonferrous piping and over edges of underground structures.

E. Field Quality Control

1. Tests and Inspections:
 - a. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
 - b. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.
2. Drain piping will be considered defective if it does not pass tests and inspections.
3. Prepare test and inspection reports.

F. Cleaning

1. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 33 14 13 23d



Task	Specification	Specification Description
33 14 13 23	01 22 16 00	No Specification Required
33 14 13 23	22 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 23	21 05 19 00	Water Distribution
33 14 13 23	23 11 23 00a	Monitoring Wells
33 14 13 23	22 11 23 23	Water Supply Wells
33 14 13 23	22 05 76 00	Sanitary Sewerage
33 14 13 23	33 42 11 00	Storm Drainage
33 14 13 36	22 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 36	22 11 23 23	Water Supply Wells
33 14 13 36	33 14 13 23b	Hydronic Distribution
33 14 13 36	23 05 29 00	Steam Distribution
33 14 13 39	22 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 39	21 05 19 00	Water Distribution
33 14 13 43	22 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 43	21 05 19 00	Water Distribution
33 14 13 43	22 11 23 23	Water Supply Wells
33 14 13 43	22 05 76 00	Sanitary Sewerage
33 14 13 43	33 14 13 23b	Hydronic Distribution
33 14 13 43	23 05 29 00	Steam Distribution
33 14 13 53	01 22 16 00	No Specification Required
33 14 13 53	07 63 00 00	Common Work Results for Fire Suppression
33 14 13 53	07 63 00 00a	Common Work Results for Plumbing
33 14 13 53	07 63 00 00b	Common Work Results for HVAC
33 14 13 53	22 11 16 00	Domestic Water Piping
33 14 13 53	22 11 16 00a	Sanitary Waste And Vent Piping
33 14 13 53	22 11 16 00b	Storm Drainage Piping
33 14 13 53	22 11 16 00c	Hydronic Piping
33 14 13 53	22 11 16 00d	Steam And Condensate Piping
33 14 13 53	22 11 16 00e	Refrigerant Piping
33 14 13 53	22 11 16 00f	General-Service Compressed-Air Piping
33 14 15 23	01 22 16 00	No Specification Required
33 14 15 23	22 05 23 00	Piped Utilities Basic Materials And Methods
33 14 15 23	21 05 19 00	Water Distribution
33 14 19 00	01 22 16 00	No Specification Required
33 14 19 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 14 19 00	21 05 19 00	Water Distribution
33 19 11 00	01 22 16 00	No Specification Required
33 19 11 00	21 05 19 00	Water Distribution
33 19 11 00	21 05 19 00a	Meters and Gages for Plumbing Piping
33 19 11 00	21 05 19 00b	Meters and Gages for HVAC Piping
33 31 11 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 31 11 00	33 14 13 23	Sand Drains
33 31 11 00	21 05 19 00	Water Distribution
33 31 11 00	23 11 23 00a	Monitoring Wells
33 31 11 00	22 11 23 23	Water Supply Wells
33 31 11 00	22 05 76 00	Sanitary Sewerage
33 31 11 00	33 14 13 23a	Septic Tank Systems
33 31 11 00	33 14 13 23b	Hydronic Distribution
33 31 11 00	33 14 13 23d	Subdrainage
33 31 11 00	33 42 11 00	Storm Drainage
33 32 16 00	01 22 16 00	No Specification Required
33 32 16 00	22 13 29 13b	Sewage Pumps
33 34 13 13	33 14 13 23a	Septic Tank Systems
33 34 13 23	33 14 13 23a	Septic Tank Systems
33 34 13 33	33 14 13 23a	Septic Tank Systems



33 34 51 00	33 14 13 23a	Septic Tank Systems
33 34 53 13	33 14 13 23a	Septic Tank Systems
33 34 56 00	33 14 13 23a	Septic Tank Systems
33 41 16 00	01 22 16 00	No Specification Required
33 41 16 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 41 16 00	22 05 76 00	Sanitary Sewerage
33 41 16 00	33 14 13 23a	Septic Tank Systems
33 41 16 00	33 14 13 23d	Subdrainage
33 41 16 00	33 42 11 00	Storm Drainage
33 41 16 00	22 11 16 00b	Storm Drainage Piping
33 41 19 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 41 19 00	33 14 13 23d	Subdrainage



SECTION 33 42 11 00 - STORM DRAINAGE

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for storm drainage. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
 - a. Pipe and fittings.
 - b. Nonpressure transition couplings.
 - c. Pressure pipe couplings.
 - d. Expansion joints and deflection fittings.
 - e. Backwater valves.
 - f. Cleanouts.
 - g. Drains.
 - h. Encasement for piping.
 - i. Manholes.
 - j. Channel drainage systems.
 - k. Catch basins.
 - l. Stormwater inlets.
 - m. Stormwater detention structures.
 - n. Pipe outlets.
 - o. Dry wells.
 - p. Stormwater disposal systems.

C. Definitions

1. FRP: Fiberglass-reinforced plastic.

D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings:
 - a. Manholes: Include plans, elevations, sections, details, frames, and covers.
 - b. Catch basins, stormwater inlets, and dry wells. Include plans, elevations, sections, details, frames, covers, and grates.
 - c. Stormwater Detention Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.
3. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
4. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.
5. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.
6. Field quality-control reports.

E. Delivery, Storage, And Handling

1. Do not store plastic manholes, pipe, and fittings in direct sunlight.
2. Protect pipe, pipe fittings, and seals from dirt and damage.
3. Handle manholes according to manufacturer's written rigging instructions.



4. Handle catch basins and stormwater inlets according to manufacturer's written rigging instructions.

F. Project Conditions

1. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - a. Notify the Owner no fewer than two days in advance of proposed interruption of service.
 - b. Do not proceed with interruption of service without the Owner written permission.

1.2 PRODUCTS

A. Hub-And-Spigot, Cast-Iron Soil Pipe And Fittings

1. Pipe and Fittings: ASTM A 74, Service class **OR** Extra-Heavy class, **as directed**.
2. Gaskets: ASTM C 564, rubber.
3. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

B. Hubless Cast-Iron Soil Pipe And Fittings

1. Pipe and Fittings: ASTM A 888 or CISPI 301.
2. CISPI-Trademarked, Shielded Couplings:
 - a. Description: ASTM C 1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
3. Heavy-Duty, Shielded Couplings:
 - a. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
4. Cast-Iron, Shielded Couplings:
 - a. Description: ASTM C 1277 and ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Ductile-Iron, Culvert Pipe And Fittings

1. Pipe: ASTM A 716, for push-on joints.
2. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
3. Compact Fittings: AWWA C153, for push-on joints.
4. Gaskets: AWWA C111, rubber.

D. Ductile-Iron, Pressure Pipe And Fittings

1. Push-on-Joint Piping:
 - a. Pipe: AWWA C151, for push-on joints.
 - b. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
 - c. Compact Fittings: AWWA C153, for push-on joints.
 - d. Gaskets: AWWA C111, rubber, of shape matching pipe and fittings.
2. Mechanical-Joint Piping:
 - a. Pipe: AWWA C151, with bolt holes in bell.
 - b. Standard Fittings: AWWA C110, ductile or gray iron, with bolt holes in bell.
 - c. Compact Fittings: AWWA C153, with bolt holes in bells.
 - d. Glands: Cast or ductile iron, with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
 - e. Gaskets: AWWA C111, rubber, of shape matching pipe, fittings, and glands.

E. Steel Pipe And Fittings



1. Corrugated-Steel Pipe and Fittings: ASTM A 760/A 760M, Type I with fittings of similar form and construction as pipe.
 - a. Special-Joint Bands: Corrugated steel with O-ring seals.
 - b. Standard-Joint Bands: Corrugated steel.
 - c. Coating: Aluminum **OR** Zinc, **as directed**.

- F. Aluminum Pipe And Fittings
 1. Corrugated Aluminum Pipe and Fittings: ASTM B 745/B 745M, Type I with fittings of similar form and construction as pipe.
 - a. Special-Joint Bands: Corrugated steel with O-ring seals.
 - b. Standard-Joint Bands: Corrugated steel.

- G. ABS Pipe And Fittings
 1. ABS Sewer Pipe and Fittings: ASTM D 2751, with bell-and-spigot ends for gasketed joints.
 - a. NPS 3 to NPS 6 (DN 80 to DN 150): SDR 35.
 - b. NPS 8 to NPS 12 (DN 200 to DN 300): SDR 42.
 2. Gaskets: ASTM F 477, elastomeric seals.

- H. PE Pipe And Fittings
 1. Corrugated PE Drainage Pipe and Fittings NPS 3 to NPS 10 (DN 80 to DN 250): AASHTO M 252M, Type S, with smooth waterway for coupling joints.
 - a. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
 - b. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.
 2. Corrugated PE Pipe and Fittings NPS 12 to NPS 60 (DN 300 to DN 1500): AASHTO M 294M, Type S, with smooth waterway for coupling joints.
 - a. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
 - b. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

- I. PVC Pipe And Fittings
 1. PVC Cellular-Core Piping:
 - a. PVC Cellular-Core Pipe and Fittings: ASTM F 891, Sewer and Drain Series, PS 50 minimum stiffness, PVC cellular-core pipe with plain ends for solvent-cemented joints.
 - b. Fittings: ASTM D 3034, SDR 35, PVC socket-type fittings.
 2. PVC Corrugated Sewer Piping:
 - a. Pipe: ASTM F 949, PVC, corrugated pipe with bell-and-spigot ends for gasketed joints.
 - b. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
 - c. Gaskets: ASTM F 477, elastomeric seals.
 3. PVC Profile Sewer Piping:
 - a. Pipe: ASTM F 794, PVC profile, gravity sewer pipe with bell-and-spigot ends for gasketed joints.
 - b. Fittings: ASTM D 3034, PVC with bell ends.
 - c. Gaskets: ASTM F 477, elastomeric seals.
 4. PVC Type PSM Sewer Piping:
 - a. Pipe: ASTM D 3034, SDR 35, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
 - b. Fittings: ASTM D 3034, PVC with bell ends.
 - c. Gaskets: ASTM F 477, elastomeric seals.
 5. PVC Gravity Sewer Piping:
 - a. Pipe and Fittings: ASTM F 679, T-1 **OR** T-2, **as directed**, wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.
 6. PVC Pressure Piping:
 - a. Pipe: AWWA C900, Class 100 **OR** Class 150 **OR** Class 200, **as directed**, PVC pipe with bell-and-spigot ends for gasketed joints.



- b. Fittings: AWWA C900, Class 100 **OR** Class 150 **OR** Class 200, **as directed**, PVC pipe with bell ends
 - c. Gaskets: ASTM F 477, elastomeric seals.
7. PVC Water-Service Piping:
- a. Pipe: ASTM D 1785, Schedule 40 **OR** Schedule 80, **as directed**, PVC, with plain ends for solvent-cemented joints.
 - b. Fittings: ASTM D 2466, Schedule 40 **OR** ASTM D 2467, Schedule 80, **as directed**, PVC, socket type.
- J. Fiberglass Pipe And Fittings
1. Fiberglass Sewer Pipe: ASTM D 3262, RTRP for gasketed joints fabricated with Type 2, polyester **OR** Type 4, epoxy, **as directed**, resin.
 - a. Liner: Reinforced thermoset **OR** Nonreinforced thermoset **OR** Thermoplastic **OR** No liner, **as directed**.
 - b. Grade: Reinforced, surface layer matching pipe resin **OR** Nonreinforced, surface layer matching pipe resin **OR** No surface layer, **as directed**.
 - c. Stiffness: 9 psig (62 kPa) **OR** 18 psig (124 kPa) **OR** 36 psig (248 kPa) **OR** 72 psig (496 kPa), **as directed**.
 2. Fiberglass Nonpressure Fittings: ASTM D 3840, RTRF for gasketed joints.
 - a. Laminating Resin: Type 1, polyester **OR** Type 2, epoxy, **as directed**, resin.
 - b. Reinforcement: Grade with finish compatible with resin.
 3. Gaskets: ASTM F 477, elastomeric seals.
- K. Concrete Pipe And Fittings
1. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 (ASTM C 14M), Class 1 **OR** Class 2 **OR** Class 3, **as directed**, with bell-and-spigot **OR** tongue-and-groove, **as directed** ends and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets **OR** sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant, **as directed**.
 2. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M).
 - a. Bell-and-spigot **OR** Tongue-and-groove, **as directed**, ends and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets **OR** sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant, **as directed**.
 - b. Class I, Wall A **OR** Wall B, **as directed**.
 - c. Class II, Wall A **OR** Wall B **OR** Wall C, **as directed**.
 - d. Class III, Wall A **OR** Wall B **OR** Wall C, **as directed**.
 - e. Class IV, Wall A **OR** Wall B **OR** Wall C, **as directed**.
 - f. Class V, Wall B **OR** Wall C, **as directed**.
- L. Nonpressure Transition Couplings
1. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
 2. Sleeve Materials:
 - a. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
 - b. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - c. For Fiberglass Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - d. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - e. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
 3. Unshielded, Flexible Couplings:
 - a. Description: Elastomeric sleeve, with stainless-steel shear ring, **as directed**, and corrosion-resistant-metal tension band and tightening mechanism on each end.
 4. Shielded, Flexible Couplings:



- a. Description: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
5. Ring-Type, Flexible Couplings:
 - a. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.
- M. Pressure Pipe Couplings
 1. Description: AWWA C219, tubular-sleeve coupling, with center sleeve, gaskets, end rings, and bolt fasteners.
 2. Metal, bolted, sleeve-type, reducing or transition coupling, for joining underground pressure piping. Include 150-psig (1035-kPa) **OR** 200-psig (1380-kPa), **as directed**, minimum pressure rating and ends sized to fit adjoining pipes.
 3. Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
 4. Gasket Material: Natural or synthetic rubber.
 5. Metal Component Finish: Corrosion-resistant coating or material.
- N. Expansion Joints And Deflection Fittings
 1. Ductile-Iron Flexible Expansion Joints:
 - a. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig (1725-kPa) minimum working pressure and for offset and expansion indicated.
 2. Ductile-Iron Expansion Joints:
 - a. Description: Three-piece assembly of telescoping sleeve with gaskets and restrained-type, ductile-iron or steel with protective coating, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Include rating for 250-psig (1725-kPa) minimum working pressure and for expansion indicated.
 3. Ductile-Iron Deflection Fittings:
 - a. Description: Compound-coupling fitting, with ball joint, flexing section, gaskets, and restrained-joint ends, complying with AWWA C110 or AWWA C153. Include rating for 250-psig (1725-kPa) minimum working pressure and for up to 15 degrees of deflection.
- O. Backwater Valves
 1. Cast-Iron Backwater Valves:
 - a. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
 - b. Horizontal type; with swing check valve and hub-and-spigot ends.
 - c. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
 - d. Terminal type; with bronze seat, swing check valve, and hub inlet.
 2. Plastic Backwater Valves:
 - a. Description: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.
- P. Cleanouts
 1. Cast-Iron Cleanouts:
 - a. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
 - b. Top-Loading Classification(s): Light Duty **OR** Medium Duty **OR** Heavy Duty **OR** Extra-Heavy Duty, **as directed**.
 - c. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.
 2. Plastic Cleanouts:



- a. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

Q. Drains

1. Cast-Iron Area Drains:

- a. Description: ASME A112.6.3 gray-iron round body with anchor flange and round secured **OR** non-secured, **as directed**, grate. Include bottom outlet with inside calk or spigot connection, of sizes indicated.
- b. Top-Loading Classification(s): Medium Duty **OR** Heavy Duty, **as directed**.

2. Cast-Iron Trench Drains:

- a. Description: ASME A112.6.3, 6-inch- (150-mm-) wide top surface, rectangular body with anchor flange or other anchoring device, and rectangular secured **OR** non-secured, **as directed**, grate. Include units of total length indicated and quantity of bottom outlets with inside calk or spigot connections, of sizes indicated.
- b. Top-Loading Classification(s): Medium Duty **OR** Heavy Duty **OR** Extra-Heavy Duty **OR** Medium and Heavy Duty **OR** Medium and Extra-Heavy Duty **OR** Heavy and Extra-Heavy Duty **OR** Medium, Heavy, and Extra-Heavy Duty, **as directed**.

3. Steel Trench Drains:

- a. Description: Factory fabricated from ASTM A 242/A 242M, welded steel plate, to form rectangular body with uniform bottom downward slope of 2 percent toward outlet, anchor flange, and grate. Include units of total length indicated, bottom outlet of size indicated, outlet strainer, acid-resistant enamel coating on inside and outside surfaces, and grate with openings of total free area at least two times cross-sectional area of outlet.
- b. Plate Thicknesses: 1/8 inch (3.2 mm) **OR** 1/4 inch (6.4 mm), **as directed**.
- c. Overall Widths: 7-1/2 inches (190 mm) **OR** 12-1/3 inches (313 mm), **as directed**.
 - 1) Grate Openings: 1/4 inch (6.4 mm) circular **OR** 3/8 inch (9.5 mm) circular **OR** 3/8-by-3-inch (9.5-by-76-mm) slots, **as directed**.

R. Encasement For Piping

1. Standard: ASTM A 674 or AWWA C105.
2. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) **OR** high-density, cross-laminated polyethylene film of 0.004-inch (0.10-mm), **as directed**, minimum thickness.
3. Form: Sheet **OR** Tube, **as directed**.
4. Color: Black **OR** Natural, **as directed**.

S. Manholes

1. Standard Precast Concrete Manholes:

- a. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
- b. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
- c. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
- d. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
- e. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
- f. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
- g. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
- h. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
- i. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing



- rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
- j. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
- OR**
- Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.
2. Designed Precast Concrete Manholes:
- a. Description: ASTM C 913; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for sealant joints.
- b. Ballast: Increase thickness of one or more precast concrete sections or add concrete to manhole as required to prevent flotation.
- c. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
- d. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
- e. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
- f. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
- OR**
- Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope.
3. Fiberglass Manholes:
- a. Description: ASTM D 3753.
- b. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
- c. Ballast: Increase thickness of concrete base as required to prevent flotation.
- d. Base Section: Concrete, 6-inch (150-mm) minimum thickness.
- e. Resilient Pipe Connectors (if required): ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
- f. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
- g. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
- OR**
- Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.
4. Manhole Frames and Covers:



- a. Description: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (102-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
- b. Material: ASTM A 536, Grade 60-40-18 ductile **OR** ASTM A 48/A 48M, Class 35 gray, **as directed**, iron unless otherwise indicated.

T. Concrete

1. General: Cast-in-place concrete according to ACI 318, ACI 350/350R (ACI 350M/350RM), and the following:
 - a. Cement: ASTM C 150, Type II.
 - b. Fine Aggregate: ASTM C 33, sand.
 - c. Coarse Aggregate: ASTM C 33, crushed gravel.
 - d. Water: Potable.
2. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.
 - a. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
 - b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.
3. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
 - a. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
 - 1) Invert Slope: **1 OR 2, as directed**, percent through manhole.
 - b. Benches: Concrete, sloped to drain into channel.
 - 1) Slope: **4 OR 8, as directed**, percent.
4. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.
 - a. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
 - b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

U. Polymer-Concrete, Channel Drainage Systems

1. General Requirements for Polymer-Concrete, Channel Drainage Systems: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include quantity of units required to form total lengths indicated.
2. Sloped-Invert, Polymer-Concrete Systems:
 - a. Channel Sections:
 - 1) Interlocking-joint, precast, modular units with end caps.
 - 2) 4-inch (102-mm) inside width and deep, rounded bottom, with built-in invert slope of 0.6 percent and with outlets in quantities, sizes, and locations indicated.
 - 3) Extension sections necessary for required depth.
 - 4) Frame: Include gray-iron or steel frame for grate.
 - b. Grates:
 - 1) Manufacturer's designation "Heavy **OR** "Medium, **as directed**, Duty," with slots or perforations that fit recesses in channels.
 - 2) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
 - c. Covers: Solid gray iron if indicated.
 - d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
3. Narrow-Width, Level-Invert, Polymer-Concrete Systems:
 - a. Channel Sections:
 - 1) Interlocking-joint, precast, modular units with end caps.



- 2) 5-inch (127-mm) inside width and 9-3/4-inch- (248-mm-) deep, rounded bottom, with level invert and with NPS 4 (DN 100) outlets in quantities, sizes, and locations indicated.
 - b. Grates:
 - 1) Slots or perforations that fit recesses in channels.
 - 2) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
 - c. Covers: Solid gray iron if indicated.
 - d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
 4. Wide-Width, Level-Invert, Polymer-Concrete Systems:
 - a. Channel Sections:
 - 1) Interlocking-joint, precast, modular units with end caps.
 - 2) 8-inch (203-mm) inside width and 13-3/4-inch- (350-mm-) deep, rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.
 - b. Grates:
 - 1) Slots or other openings that fit recesses in channels.
 - 2) Material: Fiberglass **OR** Gray iron, **as directed**.
 - c. Covers: Solid gray iron if indicated.
 - d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
 5. Drainage Specialties: Precast, polymer-concrete units.
 - a. Large Catch Basins:
 - 1) 24-by-12-inch (610-by-305-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
 - 2) Gray-iron slotted grate.
 - 3) Frame: Include gray-iron or steel frame for grate.
 - b. Small Catch Basins:
 - 1) 19- to 24-inch by approximately 6-inch (483- to 610-mm by approximately 150-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
 - 2) Gray-iron slotted grate.
 - 3) Frame: Include gray-iron or steel frame for grate.
 - c. Oil Interceptors:
 - 1) Polymer-concrete body with interior baffle and four steel support channels and two 1/4-inch- (6.4-mm-) thick, steel-plate covers.
 - 2) Steel-plate covers.
 - 3) Capacity: 140 gal. (530 L) **OR** 200 gal. (757 L) **OR** 260 gal. (984 L), **as directed**.
 - 4) Inlet and Outlet: NPS 4 (DN 100) **OR** NPS 6 (DN 150), **as directed**.
 - d. Sediment Interceptors:
 - 1) 27-inch- (686-mm-) square, polymer-concrete body, with outlets in quantities and sizes indicated.
 - 2) 24-inch- (610-mm-) square, gray-iron frame and slotted grate.
 6. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
 7. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

V. Plastic, Channel Drainage Systems

1. General Requirements for Plastic, Channel Drainage Systems:
 - a. Modular system of plastic channel sections, grates, and appurtenances.
 - b. Designed so grates fit into frames without rocking or rattling.
 - c. Number of units required to form total lengths indicated.
2. Fiberglass Systems:
 - a. Channel Sections:
 - 1) Interlocking-joint, fiberglass modular units, with built-in invert slope of approximately 1 percent and with end caps.
 - 2) Rounded or inclined inside bottom surface, with outlets in quantities, sizes, and locations indicated.



- 3) Width: 6 inches (150 mm) **OR** 6 or 8 inches (150 or 203 mm) **OR** 8 inches (203 mm), **as directed**.
 - b. Factory- or field-attached frames that fit channel sections and grates.
 - 1) Material: Galvanized steel **OR** Stainless steel **OR** Manufacturer's standard metal, **as directed**.
 - c. Grates with slots or perforations that fit frames.
 - 1) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
 - d. Covers: Solid gray iron if indicated.
 - e. Drainage Specialties:
 - 1) Large Catch Basins: 24-inch- (610-mm-) square plastic body, with outlets in quantities and sizes indicated. Include gray-iron frame and slotted grate.
 - 2) Small Catch Basins: 12-by-24-inch (305-by-610-mm) plastic body, with outlets in quantities and sizes indicated. Include gray-iron frame and slotted grate.
3. PE Systems:
- a. Channel Sections: Interlocking-joint, PE modular units, 4 inches (102 mm) wide, with end caps. Include rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.
 - b. Grates: PE, ladder shaped; with stainless-steel screws.
 - c. Color: Gray unless otherwise indicated.
 - d. Drainage Specialties: Include the following PE components:
 - 1) Drains: 4-inch- (102-mm-) diameter, round, slotted top; with NPS 4 (DN 100) bottom outlet.
OR
Drains: 8-inch- (203-mm-) diameter, round, slotted top; with NPS 6 (DN 150) bottom outlet.
OR
Drains: 4-inch- (102-mm-) square, slotted top; with NPS 3 (DN 80) bottom outlet.
OR
Drains: 8-inch- (203-mm-) square, slotted top; with NPS 6 (DN 150) bottom outlet.
OR
Catch Basins: 12-inch- (305-mm-) square plastic body, with outlets in quantities and sizes indicated. Include PE slotted grate 11-3/4 inches (298 mm) square by 1-1/8 inches (28.6 mm) thick.
 4. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
 5. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

W. Catch Basins

1. Standard Precast Concrete Catch Basins:
 - a. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
 - b. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
 - c. Riser Sections: 4-inch (102-mm) minimum thickness, 48-inch (1200-mm) diameter, and lengths to provide depth indicated.
 - d. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 - e. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
 - f. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
OR
Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.



- g. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches (1500 mm).
 - h. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.
 - 2. Designed Precast Concrete Catch Basins: ASTM C 913, precast, reinforced concrete; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for joint sealants.
 - a. Joint Sealants: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
 - b. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.

OR

Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.
 - c. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches (1500 mm).
 - d. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.
 - 3. Frames and Grates (for rectangular structures): ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include flat grate with small square or short-slotted drainage openings.
 - a. Size: 24 by 24 inches (610 by 610 mm) minimum unless otherwise indicated.
 - b. Grate Free Area: Approximately 50 percent unless otherwise indicated.
 - 4. Frames and Grates (for round, manhole-type structures): ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter flat grate with small square or short-slotted drainage openings.
 - a. Grate Free Area: Approximately 50 percent unless otherwise indicated.
- X. Stormwater Inlets
- 1. Curb Inlets: Made with vertical curb opening, of materials and dimensions according to utility standards.
 - 2. Gutter Inlets: Made with horizontal gutter opening, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.
 - 3. Combination Inlets: Made with vertical curb and horizontal gutter openings, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.
 - 4. Frames and Grates: Heavy duty, according to utility standards.
- Y. Stormwater Detention Structures
- 1. Cast-in-Place Concrete, Stormwater Detention Structures: Constructed of reinforced-concrete bottom, walls, and top; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated.
 - a. Ballast: Increase thickness of concrete as required to prevent flotation.
 - b. Grade Rings (if required): Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 229-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and cover.



- c. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of structure to finished grade is less than 60 inches (1500 mm).
2. Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, ductile-iron castings designed for heavy-duty service. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

Z. Pipe Outlets

1. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.
2. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."
 - a. Average Size: NSSGA No. R-3, screen opening 2 inches (51 mm).
 - b. Average Size: NSSGA No. R-4, screen opening 3 inches (76 mm).
 - c. Average Size: NSSGA No. R-5, screen opening 5 inches (127 mm).
3. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.
4. Energy Dissipaters: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, 3-ton (2721-kg) average weight armor stone, unless otherwise indicated.

AA. Dry Wells

1. Description: ASTM C 913, precast, reinforced, perforated concrete rings. Include the following:
 - a. Floor: Cast-in-place concrete.
 - b. Cover: Liff-off-type concrete cover with cast-in lift rings.
 - c. Wall Thickness: 4 inches (102 mm) minimum with 1-inch (25-mm) diameter or 1-by-3-inch- (25-by-76-mm-) maximum slotted perforations arranged in rows parallel to axis of ring.
 - 1) Total Free Area of Perforations: Approximately 15 percent of ring interior surface.
 - 2) Ring Construction: Designed to be self-aligning.
 - d. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.

OR

Description: Manufactured PE side panels and top cover that assemble into 50-gal. (190-L) storage capacity units.

- a. Side Panels: With knockout ports for piping and seepage holes.
- b. Top Cover: With knockout port for drain.
- c. Filter Fabric: As recommended by unit manufacturer.
- d. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.

OR

Description: Constructed-in-place aggregate type. Include the following:

- a. Lining: Clay or concrete bricks.

OR

Lining: Concrete blocks or precast concrete rings with notches or weep holes.
- b. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.
- c. Cover: Precast, reinforced-concrete slab, designed for structural loading according to ASTM C 890 and made according to ASTM C 913. Include slab dimensions that will extend 12 inches (300 mm) minimum beyond edge of excavation, with bituminous coating over entire surface. Cast cover with opening for manhole in center.
- d. Manhole: 24-inch- (610-mm-) diameter, reinforced-concrete access lid with steel lift rings. Include bituminous coating over entire surface.



BB. Stormwater Disposal Systems

1. Chamber Systems:

- a. Storage and Leaching Chambers: Molded PE with perforated sides and open bottom. Include number of chambers, distribution piping, end plates, and other standard components as required for system total capacity.
- b. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.
- c. Filter Mat: Geotextile woven or spun filter fabric, in one or more layers, for minimum total unit weight of 4 oz./sq. yd. (135 g/sq. m).

OR

Pipe Systems: Perforated manifold, header, and lateral piping complying with AASHTO M 252M for NPS 10 (DN 250) and smaller, AASHTO M 294M for NPS 12 to NPS 60 (DN 300 to DN 1500). Include proprietary fittings, couplings, seals, and filter fabric.

1.3 EXECUTION

1.4 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Piping Installation

1. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
2. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
4. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
5. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
6. Install gravity-flow, nonpressure drainage piping according to the following:
 - a. Install piping pitched down in direction of flow.
 - b. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
 - c. Install piping with 36-inch (915-mm) **OR** 48-inch (1220-mm) **OR** 60-inch (1520-mm) **OR** 72-inch (1830-mm), **as directed**, minimum cover.
 - d. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 - e. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 - f. Install ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
 - g. Install corrugated steel piping according to ASTM A 798/A 798M.
 - h. Install corrugated aluminum piping according to ASTM B 788/B 788M.
 - i. Install ABS sewer piping according to ASTM D 2321 and ASTM F 1668.
 - j. Install PE corrugated sewer piping according to ASTM D 2321.
 - k. Install PVC cellular-core piping according to ASTM D 2321 and ASTM F 1668.
 - l. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
 - m. Install PVC profile gravity sewer piping according to ASTM D 2321 and ASTM F 1668.



- n. Install PVC water-service piping according to ASTM D 2321 and ASTM F 1668.
 - o. Install fiberglass sewer piping according to ASTM D 3839 and ASTM F 1668.
 - p. Install nonreinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
 - q. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
7. Install force-main pressure piping according to the following:
- a. Install piping with restrained joints at tee fittings and at horizontal and vertical changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
 - b. Install piping with 36-inch (915-mm) **OR** 48-inch (1220-mm) **OR** 60-inch (1520-mm) **OR** 72-inch (1830-mm), **as directed**, minimum cover.
 - c. Install **ductile**-iron pressure piping according to AWWA C600 or AWWA M41.
 - d. Install ductile-iron special fittings according to AWWA C600.
 - e. Install PVC pressure piping according to AWWA M23, or ASTM D 2774 and ASTM F 1668.
 - f. Install PVC water-service piping according to ASTM D 2774 and ASTM F 1668.
8. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:
- a. Hub-and-spigot, cast-iron soil pipe and fittings.
 - b. Hubless cast-iron soil pipe and fittings.
 - c. Ductile-iron pipe and fittings.
 - d. Expansion joints and deflection fittings.

C. Pipe Joint Construction

1. Join gravity-flow, nonpressure drainage piping according to the following:
- a. Join hub-and-spigot, cast-iron soil piping with gasketed joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
 - b. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
 - c. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
 - d. Join ductile-iron culvert piping according to AWWA C600 for push-on joints.
 - e. Join ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
 - f. Join corrugated steel sewer piping according to ASTM A 798/A 798M.
 - g. Join corrugated aluminum sewer piping according to ASTM B 788/B 788M.
 - h. Join ABS sewer piping according to ASTM D 2321 and ASTM D 2751 for elastomeric-seal joints.
 - i. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
 - j. Join PVC cellular-core piping according to ASTM D 2321 and ASTM F 891 for solvent-cemented joints.
 - k. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
 - l. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasketed joints.
 - m. Join PVC profile gravity sewer piping according to ASTM D 2321 for elastomeric-seal joints or ASTM F 794 for gasketed joints.
 - n. Join fiberglass sewer piping according to ASTM D 3839 for elastomeric-seal joints.
 - o. Join nonreinforced-concrete sewer piping according to ASTM C 14 (ASTM C 14M) and ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
 - p. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
 - q. Join dissimilar pipe materials with nonpressure-type flexible couplings.
2. Join force-main pressure piping according to the following:
- a. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.



- b. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
 - c. Join PVC pressure piping according to AWWA M23 for gasketed joints.
 - d. Join PVC water-service piping according to ASTM D 2855 for solvent-cemented joints.
 - e. Join dissimilar pipe materials with pressure-type couplings.
- D. Backwater Valve Installation
1. Install horizontal-type backwater valves in piping where indicated.
 2. Install combination horizontal and manual gate-valve type in piping and in manholes where indicated.
 3. Install terminal-type backwater valves on end of piping and in manholes where indicated.
- E. Cleanout Installation
1. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
 - a. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
 - b. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
 - c. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
 - d. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.
 - e. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding earth grade.
 - f. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.
- F. Drain Installation
1. Install type of drains in locations indicated.
 - a. Use Light-Duty, top-loading classification drains in earth or unpaved foot-traffic areas.
 - b. Use Medium-Duty, top-loading classification drains in paved foot-traffic areas.
 - c. Use Heavy-Duty, top-loading classification drains in vehicle-traffic service areas.
 - d. Use Extra-Heavy-Duty, top-loading classification drains in roads.
 2. Embed drains in 4-inch (102-mm) minimum concrete around bottom and sides.
 3. Fasten grates to drains if indicated.
 4. Set drain frames and covers with tops flush with pavement surface.
 5. Assemble trench sections with flanged joints.
 6. Embed trench sections in 4-inch (102-mm) minimum concrete around bottom and sides.
- G. Manhole Installation
1. General: Install manholes, complete with appurtenances and accessories indicated.
 2. Install precast concrete manhole sections with sealants according to ASTM C 891.
 3. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.
 4. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.
- H. Catch Basin Installation
1. Construct catch basins to sizes and shapes indicated.
 2. Set frames and grates to elevations indicated.
- I. Stormwater Inlet And Outlet Installation
1. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
 2. Construct riprap of broken stone, as indicated.
 3. Install outlets that spill onto grade, anchored with concrete, where indicated.
 4. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
 5. Construct energy dissipaters at outlets, as indicated.

**J. Dry Well Installation**

1. Excavate hole to diameter of at least 6 inches (150 mm) greater than outside of dry well. Do not extend excavation into ground-water table.
2. Install precast, concrete-ring dry wells according to the following:
 - a. Assemble rings to depth indicated.
 - b. Extend rings to height where top of cover will be approximately 8 inches (203 mm) below finished grade.
 - c. Backfill bottom of inside of rings with filtering material to level at least 12 inches (300 mm) above bottom.
 - d. Extend effluent inlet pipe 12 inches (300 mm) into rings and terminate into side of tee fitting.
 - e. Backfill around outside of rings with filtering material to top level of rings.
 - f. Install cover over top of rings.
3. Install manufactured, PE dry wells according to manufacturer's written instructions and the following:
 - a. Assemble and install panels and cover.
 - b. Backfill bottom of inside of unit with filtering material to level at least 12 inches (300 mm) above bottom.
 - c. Extend effluent inlet pipe 12 inches (300 mm) into unit and terminate into side of tee fitting.
 - d. Install filter fabric around outside of unit.
 - e. Install filtering material around outside of unit.
4. Install constructed-in-place dry wells according to the following:
 - a. Install brick lining material dry and laid flat, with staggered joints for seepage. Build to diameter and depth indicated.
 - b. Install block lining material dry, with staggered joints and 20 percent minimum of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage. Build to diameter and depth indicated.
 - c. Extend lining material to height where top of manhole will be approximately 8 inches (203 mm) below finished grade.
 - d. Backfill bottom of inside of lining with filtering material to level at least 12 inches (300 mm) above bottom.
 - e. Extend effluent inlet pipe 12 inches (300 mm) into lining and terminate into side of tee fitting.
 - f. Backfill around outside of lining with filtering material to top level of lining.
 - g. Install manhole over top of dry well. Support cover on undisturbed soil. Do not support cover on lining.

K. Concrete Placement

1. Place cast-in-place concrete according to ACI 318.

L. Channel Drainage System Installation

1. Install with top surfaces of components, except piping, flush with finished surface.
2. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.
3. Embed channel sections and drainage specialties in 4-inch (102-mm) minimum concrete around bottom and sides.
4. Fasten grates to channel sections if indicated.
5. Assemble channel sections with flanged or interlocking joints.
6. Embed channel sections in 4-inch (102-mm) minimum concrete around bottom and sides.

M. Stormwater Disposal System Installation

1. Chamber Systems: Excavate trenches of width and depth, and install system and backfill according to chamber manufacturer's written instructions. Include storage and leaching chambers, filtering material, and filter mat.

OR



Piping Systems: Excavate trenches of width and depth, and install piping system, filter fabric, and backfill, according to piping manufacturer's written instructions.

N. Connections

1. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping".
2. Connect force-main piping to building's storm drainage force mains specified in Division 22 Section "Facility Storm Drainage Piping". Terminate piping where indicated.
3. Make connections to existing piping and underground manholes.
 - a. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
 - b. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
 - c. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.
 - 1) Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
 - 2) Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
 - d. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.
4. Connect to sediment interceptors specified in Division 22 Section "Sanitary Waste Interceptors".
5. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
 - a. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
 - 1) Unshielded **OR** Shielded, **as directed**, flexible couplings for same or minor difference OD pipes.
 - 2) Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
 - 3) Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
 - b. Use pressure-type pipe couplings for force-main joints.

O. Closing Abandoned Storm Drainage Systems

1. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
 - a. Close open ends of piping with at least 8-inch- (203-mm-) thick, brick masonry bulkheads.
 - b. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
2. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
 - a. Remove manhole or structure and close open ends of remaining piping.



- b. Remove top of manhole or structure down to at least 36 inches (915 mm) below final grade. Fill to within 12 inches (300 mm) of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.
3. Backfill to grade according to Division 31 Section "Earth Moving".

P. Identification

1. Materials and their installation are specified in Division 31 Section "Earth Moving". Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
 - a. Use warning tape **OR** detectable warning tape, **as directed**, over ferrous piping.
 - b. Use detectable warning tape over nonferrous piping and over edges of underground structures.

Q. Field Quality Control

1. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.
 - a. Submit separate reports for each system inspection.
 - b. Defects requiring correction include the following:
 - 1) Alignment: Less than full diameter of inside of pipe is visible between structures.
 - 2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - 3) Damage: Crushed, broken, cracked, or otherwise damaged piping.
 - 4) Infiltration: Water leakage into piping.
 - 5) Exfiltration: Water leakage from or around piping.
 - c. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 - d. Reinspect and repeat procedure until results are satisfactory.
2. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - a. Do not enclose, cover, or put into service before inspection and approval.
 - b. Test completed piping systems according to requirements of authorities having jurisdiction.
 - c. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 - d. Submit separate report for each test.
 - e. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - 1) Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
 - 2) Option: Test plastic piping according to ASTM F 1417.
 - 3) Option: Test concrete piping according to ASTM C 924 (ASTM C 924M).
 - f. Force-Main Storm Drainage Piping: Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 150 psig (1035 kPa).
 - 1) Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
 - 2) PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.
3. Leaks and loss in test pressure constitute defects that must be repaired.
4. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

R. Cleaning

1. Clean interior of piping of dirt and superfluous materials. Flush with potable water **OR** Flush with water, **as directed**.



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Task	Specification	Specification Description
33 42 11 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 42 11 00	33 14 13 23	Sand Drains
33 42 11 00	21 05 19 00	Water Distribution
33 42 11 00	22 05 76 00	Sanitary Sewerage
33 42 11 00	33 14 13 23c	Ground-Loop Heat-Pump Piping
33 42 11 00	33 14 13 23d	Subdrainage
33 42 11 00	22 11 16 00b	Storm Drainage Piping
33 42 11 00	22 05 76 00a	Storm Drainage Piping Specialties



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SECTION 33 42 13 13 - CULVERTS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for culverts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

C. Delivery, Storage, And Handling

1. Delivery and Storage: Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the the Owner. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.
2. Handling: Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

1.2 PRODUCTS

A. Pipe For Culverts

1. Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.
2. Concrete Pipe
 - a. ASTM C76/ASTM C76M, Class I **OR II OR III OR IV OR V, as directed**, or ASTM C655 D-Load. Note: D-load is defined as the minimum required three-edge test load on a pipe to produce a 0.01 inch crack and/or ultimate failure in pounds per linear foot per foot (no metric definition) of inside diameter.
 - b. Reinforced Arch Culvert and Storm Drainpipe: ASTM C506/ASTM C506M, Class A-II **OR A-III OR A-IV, as directed**.
 - c. Reinforced Elliptical Culvert and Storm Drainpipe: ASTM C507/ASTM C507M. Horizontal elliptical pipe shall be Class HE-A **OR HE-I OR HE-II OR HE-III OR HE-IV, as directed**. Vertical elliptical pipe shall be Class VE-II **OR VE-III OR VE-IV OR VE-V OR VE-VI, as directed**.
 - d. Nonreinforced Pipe: ASTM C14/ASTM C14M, Class 1 **OR 2 OR 3, as directed**.
 - 1) Cast-In-Place Nonreinforced Conduit: ACI 346, except that testing shall be the responsibility of and at the expense of the Contractor. In the case of other conflicts between ACI 346 and project specifications, requirements of ACI 346 shall govern.
NOTE: This type conduit should not be used beneath structures, for drain crossings, adjacent to paved areas, or under high fills.
3. Clay Pipe: Standard or extra strength, as indicated, conforming to ASTM C700.
NOTE: "Bell-and-spigot piping only" in areas where corrosion problems may be anticipated with the stainless steel parts of the couplings used for plain-end piping.



4. Corrugated Steel Pipe
 - a. ASTM A760/A760M, zinc or aluminum (Type 2) coated pipe of either:
 - 1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
 - 2) Type IR **OR** IIR, **as directed**, pipe with helical 3/4 by 3/4 by 7-1/2 inch (19 by 19 by 190 mm) corrugations.
 - b. Fully Bituminous Coated
 - 1) AASHTO M190 Type A and ASTM A760/A 760M zinc or aluminum (Type 2) coated pipe of either:
 - a) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
 - b) Type IR **OR** IIR, **as directed**, pipe with helical 3/4 by 3/4 by 7-1/2 inch (19 by 19 by 190 mm) corrugations.
 - c. Half Bituminous Coated, Part Paved: AASHTO M190 Type B and ASTM A760/A 760M zinc or aluminum (Type 2) coated Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
 - d. Fully Bituminous Coated, Part Paved: AASHTO M190 Type C and ASTM A760/A 760M zinc or aluminum (Type 2) coated Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
 - e. Fully Bituminous Coated, Fully Paved: AASHTO M190 Type D and ASTM A760/A 760M zinc or aluminum (Type 2) coated Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
 - f. Concrete-Lined: ASTM A760/A760M zinc coated Type I corrugated steel pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations and a concrete lining in accordance with ASTM A849.
 - g. Polymer Precoated: ASTM A 762/A 762M corrugated steel pipe fabricated from ASTM A742/A742M Grade 250/250 10/10 polymer precoated sheet of either:
 - 1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
 - 2) Type IR **OR** IIR, **as directed**, pipe with helical 3/4 by 3/4 by 7-1/2 inch (19 by 19 by 190 mm) corrugations.
 - h. Polymer Precoated, Part Paved: ASTM A762/A762M Type I **OR** II, **as directed**, corrugated steel pipe and AASHTO M190 Type B (modified) paved invert only, fabricated from ASTM A742/A742M Grade 250/250 10/10 polymer precoated sheet with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
 - i. Polymer Precoated, Fully Paved: ASTM A762/A762M Type I **OR** II, **as directed**, corrugated steel pipe and AASHTO M190 Type D (modified), fully paved only, fabricated from ASTM A 742/A 742M Grade 250/250 10/10 polymer precoated sheet with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
 5. Corrugated Aluminum Alloy Pipe: ASTM B745/B745M corrugated aluminum alloy pipe of either:
 - 1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, corrugations.
 - 2) Type IA **OR** IR **OR** IIA **OR** IIR, **as directed**, pipe with helical corrugations.
 - b. Aluminum Fully Bituminous Coated: Bituminous coating shall conform to ASTM A849. Piping shall conform to AASHTO M190 Type A and ASTM B745/B745M corrugated aluminum alloy pipe of either:
 - 1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, corrugations.
 - 2) Type IA **OR** IR **OR** IIA **OR** IIR, **as directed**, pipe with helical corrugations.
 - c. Aluminum Fully Bituminous Coated, Part Paved: Bituminous coating shall conform to ASTM A849. Piping shall conform to AASHTO M190 Type C and ASTM B 745/B 745M corrugated aluminum alloy pipe of either:
 - 1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, corrugations.
 - 2) Type IR **OR** IIR, **as directed**, pipe with helical corrugations.
 6. Structural Plate, Steel Pipe, Pipe Arches and Arches



- a. Assembled with galvanized steel nuts and bolts, from galvanized corrugated steel plates conforming to AASHTO M167. Pipe coating, when required, shall conform to the requirements of AASHTO M190 Type A **OR** AASHTO M243, **as directed**.
- b. Thickness of plates shall be as indicated.
- 7. Structural Plate, Aluminum Pipe, Pipe Arches and Arches
 - a. Assembled with either aluminum alloy, aluminum coated steel, stainless steel or zinc coated steel nuts and bolts. Nuts and bolts, and aluminum alloy plates shall conform to AASHTO M219. Pipe coating, when required, shall conform to the requirements of AASHTO M190, Type A **OR** AASHTO M 243, **as directed**.
 - b. Thickness of plates shall be as indicated.
- 8. Ductile Iron Culvert Pipe: ASTM A716.
- 9. Cast-Iron Soil Piping: Cast-Iron Soil Pipe shall conform to ASTM A74, service-weight; gaskets shall be compression-type rubber conforming to ASTM C564.
- 10. PVC Pipe
 - a. The pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, shall be submitted prior to installation of the pipe.
 - b. Type PSM PVC Pipe: ASTM D3034, Type PSM, maximum SDR 35, produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454-B.
 - c. Profile PVC Pipe: ASTM F794, Series 46, produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454-B.
 - d. Smooth Wall PVC Pipe: ASTM F679 produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454-B.
 - e. Corrugated PVC Pipe: ASTM F949 produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454-B.
- 11. PE Pipe
 - a. The pipe manufacturer's resin certification indicating the cell classification of PE used to manufacture the pipe shall be submitted prior to installation of the pipe. The minimum cell classification for polyethylene plastic shall apply to each of the seven primary properties of the cell classification limits in accordance with ASTM D3350.
 - b. Smooth Wall PE Pipe: ASTM F714, maximum DR of 21 for pipes 3 to 24 inches (80 to 600 mm) in diameter and maximum DR of 26 for pipes 26 to 48 inches (650 to 1200 mm) in diameter. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.
 - c. Corrugated PE Pipe: AASHTO M294, Type S or D, for pipes 12 to 48 inches (300 to 1200 mm) and AASHTO MP 7, Type S or D, for pipes 54 to 60 inches (1350 to 1500 mm) produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class in accordance with AASHTO M294. Pipe walls shall have the following properties:
 NOTE: Corrugated PE pipe culverts and storm drains shall not be installed beneath airfield pavements, Class A, B, or C roads, or road pavements with a design index of 6 or greater. Type S pipe has a full circular cross-section, with an outer corrugated pipe wall and a smooth inner liner. Type C pipe has a full circular cross-section, with a corrugated surface both inside and outside. Corrugations may be either annular or helical.

Nominal Size (in.)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in to the 4th/in)
12	1.50	0.024
15	1.91	0.053
18	2.34	0.062
24	3.14	0.116
30	3.92	0.163
36	4.50	0.222
42	4.69	0.543



48	5.15	0.543
54	5.67	0.800
60	6.45	0.800
Nominal Size (mm)	Minimum Wall Area (square mm/m)	Minimum Moment of Inertia of Wall Section (mm to the 4th/mm)
300	3200	390
375	4000	870
450	4900	1020
600	6600	1900
750	8300	2670
900	9500	3640
1050	9900	8900
1200	10900	8900
1350	12000	13110
1500	13650	13110

- d. Profile Wall PE Pipe: ASTM F894, RSC 160, produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 334433C. Pipe walls shall have the following properties:

Nominal Size (in.)	Minimum Wall Area (square in/ft)	Minimum Moment Of Inertia of Wall Section (in to the 4th/in)	
		Cell Class 334433C	Cell Class 335434C
18	2.96	0.052	0.038
21	4.15	0.070	0.051
24	4.66	0.081	0.059
27	5.91	0.125	0.091
30	5.91	0.125	0.091
33	6.99	0.161	0.132
36	8.08	0.202	0.165
42	7.81	0.277	0.227
48	8.82	0.338	0.277
Nominal Size (mm)	Minimum Wall Area (square mm/m)	Minimum Moment Of Inertia of Wall Section (mm to the 4th/mm)	
		Cell Class 334433C	Cell Class 335434C
450	6300	850	620
525	8800	1150	840
600	9900	1330	970
675	12500	2050	1490
750	12500	2050	1490



825	14800	2640	2160
900	17100	3310	2700
1050	16500	4540	3720
1200	18700	5540	4540

B. Drainage Structures

1. Flared End Sections: Sections shall be of a standard design fabricated from zinc coated steel sheets meeting requirements of ASTM A929/A929M.
2. Precast Reinforced Concrete Box: Four-sided box section with open ends to be monolithically cast of reinforced concrete, smooth inside surfaces. Each box section shall be manufactured with chamfered inside corners. Design and manufacture shall conform to ASTM C890.
 - a. Design References: ACI 318.
 - 1) Boxes subjected to highway loadings shall conform to requirements of AASHTO M259 or M273, as applicable, and ASTM C789, C850, C1433, and PS62.
 - 2) Boxes subjected to aircraft loadings shall conform to requirements of FAA specifications.
 - 3) Boxes subjected to railway loadings shall conform to requirements of AREMA specifications.
 - b. Concrete: 5,000 psi @ 30 days, unless otherwise directed.
 - c. Entrained Air: 5 to 9 percent.
 - d. Steel Reinforcing: ASTM A185, A615, A616, Grade 60, 60 ksi.
 - e. Design Loading: AASHTO HS-20-44 or HS-25-44 with 30 percent impact and equivalent soil pressure of 130 psf. Floatation forces not accounted for.
 - f. Joints: Each section shall have a male and female end with no less than 1-1/2-inch of concrete overlap and shall include a 1-inch square neoprene gasket, cemented to male surface of section during manufacture.
 - g. End Sections: As required for the individual installation, provide:
 - 1) Doweled end for 1-inch diameter x 12-inch deep steel dowels, keyway slot.
 - 2) Keyway slot, a shear connection between the precast and field cast sections.
 - 3) Plain end, for use where wing and end walls act independently of precast box.
 - h. Lifting Pins: Each section shall be equipped with 4 OSHA approved lifting pins.
 - i. For multi-cell installations, fill 1-inch spacing between cells with granular material to assume proper load distribution.
3. Three-Sided Structures for Culverts or Short Span Bridge System
 - a. Structures shall conform to requirements of ASTM C1504 and ACI 318. For structures subjected to roadway loadings, conform to requirements of AASHTO specifications.

C. Miscellaneous Materials

1. Concrete
 - a. Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements concrete under Division 03 Section "Cast-in-place Concrete". The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches (37.5 mm).
 - b. Air content shall be determined in accordance with ASTM C231. The concrete covering over steel reinforcing shall not be less than 1 inch (25 mm) thick for covers and not less than 1-1/2 inches (40 mm) thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 3 inches (75 mm) between steel and ground.
 - c. Expansion-joint filler material shall conform to ASTM D1751, or ASTM D1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.
2. Mortar: Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar. Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of



- the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.
3. Precast Concrete Segmental Blocks: Precast concrete segmental block shall conform to ASTM C139, not more than 8 inches (200 mm) thick, not less than 8 inches (200 mm) long, and of such shape that joints can be sealed effectively and bonded with cement mortar.
 4. Brick
 - a. Brick shall conform to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement.
 - b. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 1/2 inch (10 mm) of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.
 5. Precast Reinforced Concrete Manholes
 - a. Precast reinforced concrete manholes shall conform to ASTM C478/ASTM C478M.
 - b. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure **OR** made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS, **as directed**.
 6. Prefabricated Corrugated Metal Manholes
 - a. Manholes shall be of the type and design recommended by the manufacturer.
 - b. Manholes shall be complete with frames and cover, or frames and gratings.
 7. Frame and Cover for Gratings
 - a. Frame and cover for gratings shall be cast gray iron, ASTM A48/A48M,
 - b. Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26M/B26, Alloy 356.OT6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans.
 8. Joints
 - a. Flexible Watertight Joints
 - 1) Materials: Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for plastic gaskets shall conform to AASHTO M198, and rubber-type gaskets shall conform to ASTM C443/ASTM C443M. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 54 inches (1.35 m).
 - 2) Test Requirements: Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443/ASTM C443M. Certified copies of test results shall be delivered to the the Owner before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.
 - b. External Sealing Bands: Requirements for external sealing bands shall conform to ASTM C877/ASTM C877M.
 - c. Flexible Watertight, Gasketed Joints
 - 1) Gaskets: When infiltration or exfiltration is a concern for pipe lines, the couplings may be required to have gaskets. The closed-cell expanded rubber gaskets shall be a continuous band approximately 7 inches (178 mm) wide and approximately 3/8 inch (10 mm) thick, meeting the requirements of ASTM D1056, Type 2 A1 **OR** B3, **as directed**, and shall have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D1171. Rubber O-ring gaskets shall be 13/16 inch (21 mm) in diameter for pipe



diameters of 36 inches (914 mm) or smaller and 7/8 inch (22 mm) in diameter for larger pipe having 1/2 inch (13 mm) deep end corrugation. Rubber O-ring gaskets shall be 1-3/8 inches (35 mm) in diameter for pipe having 1 inch (25 mm) deep end corrugations. O-rings shall meet the requirements of AASHTO M198 or ASTM C443/ASTM C443M. Flexible plastic gaskets shall conform to requirements of AASHTO M198, Type B.

2) Connecting Bands: Connecting bands shall be of the type, size and sheet thickness of band, and the size of angles, bolts, rods and lugs as indicated or where not indicated as specified in the applicable standards or specifications for the pipe. Exterior rivet heads in the longitudinal seam under the connecting band shall be countersunk or the rivets shall be omitted and the seam welded. Watertight joints shall be tested and shall meet the test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.

- d. PVC Plastic Pipes: Joints shall be solvent cement or elastomeric gasket type in accordance with the specification for the pipe and as recommended by the pipe manufacturer.
- e. Smooth Wall PE Plastic Pipe: Pipe shall be joined using butt fusion method as recommended by the pipe manufacturer.
- f. Corrugated PE Plastic Pipe: Water tight joints shall be made using a PVC or PE coupling and rubber gaskets as recommended by the pipe manufacturer. Rubber gaskets shall conform to ASTM F477. Soil tight joints shall conform to the requirements in AASHTO HB-17, Division II, Section 26.4.2.4.(e) for soil tightness and shall be as recommended by the pipe manufacturer.
- g. Profile Wall PE Plastic Pipe: Joints shall be gasketed or thermal weld type with integral bell in accordance with ASTM F894.
- h. Ductile Iron Pipe: Couplings and fittings shall be as recommended by the pipe manufacturer.

D. Steel Ladder

- 1. Steel ladder shall be provided where the depth of the manhole exceeds 12 feet (3.66 m). These ladders shall be not less than 16 inches (406 mm) in width, with 3/4 inch (19 mm) diameter rungs spaced 12 inches (305 mm) apart. The two stringers shall be a minimum 3/8 inch (10 mm) thick and 2-1/2 inches (63 mm) wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123/A123M.

E. Resilient Connectors

- 1. Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923/ASTM C923M.

F. Hydrostatic Test On Watertight Joints

- 1. Concrete, Clay, PVC and PE Pipe: A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to AASHTO M198 or ASTM C443M ASTM C443. Test requirements for joints in clay pipe shall conform to ASTM C425. Test requirements for joints in PVC and PE plastic pipe shall conform to ASTM D3212.
- 2. Corrugated Steel and Aluminum Pipe: A hydrostatic test shall be made on the watertight joint system or coupling band type proposed. The moment strength required of the joint is expressed as 15 percent of the calculated moment capacity of the pipe on a transverse section remote from the joint by the AASHTO HB-17 (Division II, Section 26). The pipe shall be supported for the hydrostatic test with the joint located at the point which develops 15 percent of the moment capacity of the pipe based on the allowable span in meters feet for the pipe flowing full or 40,000 foot-pounds (54,233 Newton meters), whichever is less. Performance requirements shall be met



at an internal hydrostatic pressure of 10 psi (69 kPa) for a 10 minute period for both annular corrugated metal pipe and helical corrugated metal pipe with factory reformed ends.

- G. Erosion Control Riprap
 1. Provide nonerodible rock not exceeding 15 inches (375 mm) in its greatest dimension and choked with sufficient small rocks to provide a dense mass with a minimum thickness of 8 inches (200 mm) or as indicated.

1.3 EXECUTION

- A. Excavation for Pipe Culverts and Drainage Structures
 1. Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Division 31 Section "Earth Moving" and the requirements specified below.
 2. Trenching: The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 12-inches (300 mm) each side of pipe to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheet piling and bracing, where required, shall be placed within the trench width as specified. Contractor shall not overexcavate. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Owner.
 3. Removal of Rock: Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 8 inches (200 mm) or 1/2 inch (13 mm) for each meter foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Division 31 Section "Earth Moving".
 4. Removal of Unstable Material: Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the the Owner, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheet piling, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Owner.
- B. Bedding
 1. The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.
 2. Concrete Pipe Requirements: When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in a soil foundation accurately shaped and rounded to conform to the lowest one-fourth of the outside portion of circular pipe or to the lower curved portion of pipe arch for the entire length of the pipe or pipe arch. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall be not more than the length, depth, and width required for properly making the particular type of joint.
 3. Clay Pipe Requirements: Bedding for clay pipe shall be as specified by ASTM C12.
 4. Corrugated Metal Pipe: Bedding for corrugated metal pipe and pipe arch shall be in accordance with ASTM A798/A798M. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, the Contractor shall either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow v-shape. Bedding for corrugated structural plate pipe shall meet requirements of ASTM A807/A807M.
 5. Ductile Iron and Cast-Iron Pipe: Bedding for ductile iron and cast-iron pipe shall be as shown on the drawings.



- 6. Plastic Pipe: Bedding for PVC and PE pipe shall meet the requirements of ASTM D2321. Bedding, haunching, and initial backfill shall be either Class IB or II material.

C. Placing Pipe

- 1. Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (%)
Corrugated Steel and Aluminum Alloy	5
Concrete-Lined Corrugated Steel	3
Ductile Iron Culvert	3
Plastic	7.5

Not less than 30 days after the completion of backfilling, the Owner may perform a deflection test on the entire length of installed flexible pipe using a mandrel or other suitable device. Installed flexible pipe showing deflections greater than those indicated above shall be retested by a run from the opposite direction. If the retest also fails, the suspect pipe shall be replaced.

- 2. Concrete, Clay, PVC, Ribbed PVC, Ductile Iron and Cast-Iron Pipe: Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.
- 3. Elliptical and Elliptical Reinforced Concrete Pipe: The manufacturer's reference lines, designating the top of the pipe, shall be within 5 degrees of a vertical plane through the longitudinal axis of the pipe, during placement. Damage to or misalignment of the pipe shall be prevented in all backfilling operations.
- 4. Corrugated PE Pipe: Laying shall be with the separate sections joined firmly on a bed shaped to line and grade and shall follow manufacturer's recommendations.
- 5. Corrugated Metal Pipe and Pipe Arch: Laying shall be with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Part paved pipe shall be installed so that the centerline of bituminous pavement in the pipe, indicated by suitable markings on the top at each end of the pipe sections, coincides with the specified alignment of pipe. Fully paved steel pipe or pipe arch shall have a painted or otherwise applied label inside the pipe or pipe arch indicating sheet thickness of pipe or pipe arch. Any unprotected metal in the joints shall be coated with bituminous material as specified in AASHTO M190 or AASHTO M243. Interior coating shall be protected against damage from insertion or removal of struts or tie wires. Lifting lugs shall be used to facilitate moving pipe without damage to exterior or interior coatings. During transportation and installation, pipe or pipe arch and coupling bands shall be handled with care to preclude damage to the coating, paving or lining. Damaged coatings, pavings and linings shall be repaired in accordance with the manufacturer's recommendations prior to placing backfill. Pipe on which coating, paving or lining has been damaged to such an extent that satisfactory field repairs cannot be made shall be removed and replaced. Vertical elongation, where indicated, shall be accomplished by factory elongation. Suitable markings or properly placed lifting lugs shall be provided to ensure placement of factory elongated pipe in a vertical plane.
- 6. Structural-Plate Steel: Structural plate shall be installed in accordance with ASTM A807/A807M. Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to ensure that all bolts are tightened to meet the torque requirements of 200 foot-pounds (270 Newton meters) plus or minus 50 foot-pounds (68 Newton meters). Any power wrenches used shall be checked by the use of hand torque



wrenches or long-handled socket or structural wrenches for amount of torque produced. Power wrenches shall be checked and adjusted frequently as needed, according to type or condition, to ensure proper adjustment to supply the required torque.

7. **Structural-Plate Aluminum:** Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to ensure that all bolts are torqued to a minimum of 100 foot-pounds (136 Newton meters) on aluminum alloy bolts and a minimum of 150 foot-pounds (203 Newton meters) on galvanized steel bolts. Any power wrenches used shall be checked by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced. Power wrenches shall be checked and adjusted as frequently as needed, according to type or condition, to ensure that they are in proper adjustment to supply the required torque.
8. **Multiple Culverts:** Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 1 meter 3 feet apart, whichever is less.
9. **Jacking Pipe Through Fills:** Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Volume 1, Chapter 1, Part 4 of AREMA Manual.

D. Jointing

1. Concrete and Clay Pipe

- a. **Cement-Mortar Bell-and-Spigot Joint:** The first pipe shall be bedded to the established gradeline, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the lower portion of the bell filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.
- b. **Cement-Mortar Oakum Joint for Bell-and-Spigot Pipe:** A closely twisted gasket shall be made of jute or oakum of the diameter required to support the spigot end of the pipe at the proper grade and to make the joint concentric. Joint packing shall be in one piece of sufficient length to pass around the pipe and lap at top. This gasket shall be thoroughly saturated with neat cement grout. The bell of the pipe shall be thoroughly cleaned with a wet brush, and the gasket shall be laid in the bell for the lower third of the circumference and covered with mortar. The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted in the bell, and carefully driven home. A small amount of mortar shall be inserted in the annular space for the upper two-thirds of the circumference. The gasket shall be lapped at the top of the pipe and driven home in the annular space with a caulking tool. The remainder of the annular space shall be filled completely with mortar and beveled at an angle of approximately 45 degrees with the outside of the bell. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint thus made shall be wrapped with cheesecloth. Placing of this type of joint shall be kept at least five joints behind laying operations.
- c. **Cement-Mortar Diaper Joint for Bell-and-Spigot Pipe:** The pipe shall be centered so that the annular space is uniform. The annular space shall be caulked with jute or oakum. Before caulking, the inside of the bell and the outside of the spigot shall be cleaned.
 - 1) **Diaper Bands:** Diaper bands shall consist of heavy cloth fabric to hold grout in place at joints and shall be cut in lengths that extend one-eighth of the circumference of pipe above the spring line on one side of the pipe and up to the spring line on the other side of the pipe. Longitudinal edges of fabric bands shall be rolled and stitched around two pieces of wire. Width of fabric bands shall be such that after fabric has been securely stitched around both edges on wires, the wires will be uniformly spaced not less than 200 mm 8 inches apart. Wires shall be cut into



- lengths to pass around pipe with sufficient extra length for the ends to be twisted at top of pipe to hold the band securely in place; bands shall be accurately centered around lower portion of joint.
- 2) Grout: Grout shall be poured between band and pipe from the high side of band only, until grout rises to the top of band at the spring line of pipe, or as nearly so as possible, on the opposite side of pipe, to ensure a thorough sealing of joint around the portion of pipe covered by the band. Silt, slush, water, or polluted mortar grout forced up on the lower side shall be forced out by pouring, and removed.
 - 3) Remainder of Joint: The remaining unfilled upper portion of the joint shall be filled with mortar and a bead formed around the outside of this upper portion of the joint with a sufficient amount of additional mortar. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind actual laying of pipe. No backfilling around joints shall be done until joints have been fully inspected and approved.
- d. Cement-Mortar Tongue-and-Groove Joint: The first pipe shall be bedded carefully to the established gradeline with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be thoroughly cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.
 - e. Cement-Mortar Diaper Joint for Tongue-and-Groove Pipe: The joint shall be of the type described for cement-mortar tongue-and-groove joint in this paragraph, except that the shallow excavation directly beneath the joint shall not be filled with mortar until after a gauze or cheesecloth band dipped in cement mortar has been wrapped around the outside of the joint. The cement-mortar bead at the joint shall be at least 1/2 inch (15 mm), thick and the width of the diaper band shall be at least 8 inches (200 mm). The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind the actual laying of the pipe. Backfilling around the joints shall not be done until the joints have been fully inspected and approved.
 - f. Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe: Sealing compounds shall follow the recommendation of the particular manufacturer in regard to special installation requirements. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Sealing compounds shall be inspected before installation of the pipe, and any loose or improperly affixed sealing compound shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. If, while making the joint with mastic-type sealant, a slight protrusion of the material is not visible along the entire inner and outer circumference of the joint when the joint is pulled up, the pipe shall be removed and the joint remade. After the joint is made, all inner protrusions shall be cut off flush with the inner surface of the pipe. If nonmastic-type sealant material is used, the "Squeeze-Out" requirement above will be waived.
 - g. Flexible Watertight Joints: Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.



- h. External Sealing Band Joint for Noncircular Pipe: Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.
- 2. Corrugated Metal Pipe
 - a. Field Joints: Transverse field joints shall be designed so that the successive connection of pipe sections will form a continuous line free of appreciable irregularities in the flow line. In addition, the joints shall meet the general performance requirements described in ASTM A798/A798M. Suitable transverse field joints which satisfy the requirements for one or more of the joint performance categories can be obtained with the following types of connecting bands furnished with suitable band-end fastening devices: corrugated bands, bands with projections, flat bands, and bands of special design that engage factory reformed ends of corrugated pipe. The space between the pipe and connecting bands shall be kept free from dirt and grit so that corrugations fit snugly. The connecting band, while being tightened, shall be tapped with a soft-head mallet of wood, rubber or plastic, to take up slack and ensure a tight joint. The annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 30 inches (750 mm) or larger, shall be filled with a bituminous material after jointing. Field joints for each type of corrugated metal pipe shall maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations. The type, size, and sheet thickness of the band and the size of angles or lugs and bolts shall be as indicated or where not indicated, shall be as specified in the applicable standards or specifications for the pipe.
 - b. Flexible Watertight, Gasketed Joints: Installation shall be as recommended by the gasket manufacturer for use of lubricants and cements and other special installation requirements. The gasket shall be placed over one end of a section of pipe for half the width of the gasket. The other half shall be doubled over the end of the same pipe. When the adjoining section of pipe is in place, the doubled-over half of the gasket shall then be rolled over the adjoining section. Any unevenness in overlap shall be corrected so that the gasket covers the end of pipe sections equally. Connecting bands shall be centered over adjoining sections of pipe, and rods or bolts placed in position and nuts tightened. Band Tightening: The band shall be tightened evenly, even tension being kept on the rods or bolts, and the gasket; the gasket shall seat properly in the corrugations. Watertight joints shall remain uncovered for a period of time designated, and before being covered, tightness of the nuts shall be measured with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, the nut shall be retightened with a torque wrench and remain uncovered until a tight, permanent joint is assured.
- E. Concrete Placement
 - 1. Place cast-in-place concrete according to ACI 318/318R.
- F. Drainage Structures
 - 1. Manholes and Inlets: Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.
 - 2. Walls and Headwalls: Construction shall be as indicated.
- G. Steel Ladder Installation
 - 1. Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet (1.83 m) vertically, and shall be installed to provide at least 6 inches (152 mm) of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.



H. Backfilling

1. **Backfilling Pipe in Trenches:** After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches (150 mm) in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation of at least 12 inches (300 mm) above the top of the pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 8 inches (200 mm). Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the the Owner, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.
2. **Backfilling Pipe in Fill Sections:** For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 6 inches (150 mm) in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches (300 mm) above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet (4 m), whichever is less. After the backfill has reached at least 12 inches (300 mm) above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 8 inches (200 mm).
3. **Movement of Construction Machinery:** When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.
4. **Compaction**
 - a. **General Requirements:** Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.
 - b. **Minimum Density:** Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.
 - 1) Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.
 - 2) Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.
 - 3) Under nontraffic areas, density shall be not less than that of the surrounding material.
5. **Determination of Density:** Testing shall be the responsibility of the Contractor and performed at no additional cost to the Owner. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D2922. When ASTM D2922 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications.



ASTM D2922 results in a wet unit weight of soil and when using this method ASTM D3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D3017 or ASTM D2922. Test results shall be furnished to the Owner. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

I. Pipeline Testing

1. Leakage Tests: Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate. Low pressure air testing for vitrified clay pipes shall conform to ASTM C828. Low pressure air testing for concrete pipes shall conform to ASTM C924/ASTM C924M. Low pressure air testing for plastic pipe shall conform to ASTM F1417. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C828 or ASTM C924/ASTM C924M, after consultation with the pipe manufacturer. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C1103/ASTM C1103M. Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 600 mm 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Owner. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 2 feet (600 mm) is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 250 gallons per inch in diameter per mile (60 liters per mm in diameter per kilometer) of pipeline per day **OR** 0.2 gallons per inch in diameter per 100 feet (9 mL per mm in diameter per 100 meters), **as directed**, of pipeline per hour. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished.
2. Deflection Testing: Perform a deflection test on entire length of installed plastic pipeline on completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads shall not exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.
 - a. Pull-through device: This device shall be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Circular sections shall be so spaced on the shaft that distance from external faces of front and back sections will equal or exceed diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided that the device meets the applicable requirements specified in this paragraph, including those for diameter of the device. Ball, cylinder, or circular sections shall conform to the following:
 - 1) A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.
 - 2) A homogeneous material throughout, with a density greater than 1.0 as related to water at 39.2 degrees F (4 degrees C), and a surface Brinell hardness of not less than 150.
 - 3) Center bored and through bolted with a 1/4 inch (6 mm) minimum diameter steel shaft having a yield strength of not less than 70,000 psi (483 MPa), with eyes or loops at each end for attaching pulling cables.
 - 4) Each eye or loop shall be suitably backed with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.



- b. Deflection measuring device: Sensitive to 1.0 percent of the diameter of the pipe being tested and accurate to 1.0 percent of the indicated dimension. Deflection measuring device shall be approved by the the Owner prior to use.
- c. Pull-through device: Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions as specified.
- d. Deflection measuring device procedure: Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of 4.5 percent of average inside diameter of pipe, remove pipe which has excessive deflection, replace with new pipe, and completely retest in same manner and under same conditions.
- e. Warranty period test: Pipe found to have a deflection of greater than 5 percent of average inside diameter when deflection test is performed just prior to end of one-year warranty period shall be replaced with new pipe and tested as specified for leakage and deflection.

J. Field Painting

1. After installation, clean cast-iron frames, covers, gratings, and steps not buried in masonry or concrete to bare metal of mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint **OR** After installation, clean steel covers and steel or concrete frames not buried in masonry or concrete to bare metal of mortar, dirt, grease, and other deleterious materials. Apply a coat of primer and apply a top coat as specified in Division 09 Section "Exterior Painting", **as directed**. Do not paint surfaces subject to abrasion.

END OF SECTION 33 42 13 13



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Task	Specification	Specification Description
33 42 13 13	01 22 16 00	No Specification Required
33 42 13 13	22 05 23 00	Piped Utilities Basic Materials And Methods
33 42 13 13	22 05 76 00	Sanitary Sewerage
33 42 13 13	33 42 11 00	Storm Drainage
33 42 23 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 42 23 00	33 42 11 00	Storm Drainage
33 42 23 00	33 01 30 81a	Sewage Treatment Lagoons
33 42 26 16	22 05 23 00	Piped Utilities Basic Materials And Methods
33 42 26 16	33 14 13 23	Sand Drains
33 42 26 16	33 42 11 00	Storm Drainage
33 42 26 19	22 05 23 00	Piped Utilities Basic Materials And Methods
33 42 26 19	33 42 11 00	Storm Drainage
33 42 26 23	33 42 11 00	Storm Drainage
33 42 31 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 42 31 00	33 42 11 00	Storm Drainage
33 42 31 00	33 01 30 81a	Sewage Treatment Lagoons
33 42 33 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 42 33 00	33 42 11 00	Storm Drainage
33 42 33 00	33 01 30 81a	Sewage Treatment Lagoons
33 42 36 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 42 36 00	33 42 11 00	Storm Drainage
33 42 36 00	33 01 30 81a	Sewage Treatment Lagoons



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**SECTION 33 44 36 00 - OIL/WATER SEPARATOR**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for oil/water separator. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Scope

1. The separator shall be designed for gravity separation of sand, grit, settleable solids, or semisolids, and free oils (hydrocarbons and other petroleum products) from wastewater. Separator shall be installed belowground with top access at or above grade level. The source of the influent to the separator shall be gravity flow from storm water runoff, hydrocarbon spills, and/or cleaning/maintenance operations.

C. Performance

1. Influent Characteristics

- a. Provide separator designed for intermittent and variable flows of water, oil, or any combination of non-emulsified oil-water mixtures. Minimum separator retention time shall be 10 minutes. Operating temperatures of the influent oil in water mixture shall range from 40 degrees F. to 80 degrees F. The specific gravity of the oils at operating temperatures shall range from 0.71 to 0.92. The specific gravity of the fresh water at operating temperatures shall range from 1.00 to 1.03.

2. Effluent Characteristics

- a. The free oil and grease concentration in the effluent from the separator shall not exceed 10 mg/l (10 PPM) to satisfy requirements of the NPDES stormwater discharge permit. To achieve this goal, it will be necessary to remove all free oil droplets equal to and greater than 20 microns.

D. Design Criteria

1. The separator shall be listed to Underwriters' Laboratories UL-SU2215. Construction and performance of the oil/water separators shall be in accordance with UL-SU2215. Provide certification documentation detailing criteria under which the system was tested. UL-SU2215 label shall be prominently displayed on manway covers.
2. Separator shall be designed in accordance with Stokes Law and the American Petroleum Institute Publication 421, "Monographs on Refinery Environmental Control - Management of Water Discharges; Design and Operation of Oil/Water Separators." Effective surface area calculations, signed and stamped by a Registered Professional Engineer shall be submitted to document specified effluent quality based on complete removal of the specified oil globule at design flow. A separator with lower effective surface area than required is not permissible.
3. Separator capacities, dimensions, construction, and thickness shall be in strict accordance with Underwriters' Laboratories, Subject UL-58 Standard for Safety, Steel Underground Tanks for Flammable and Combustible Liquids, September 30, 1997, Double Wall construction with 360 degree Steel Secondary Containment. The inner steel tank shall be completely contained within the outer steel tank, enclosing 100% of the tank volume. The tank shall have a double steel shell with a space between the layers. The space between the inner and outer steel walls shall be monitored with an approved electronic leak detection device through a pipe that extends vertically to the top of the tank from a small sump at the bottom. Tank construction using thin walled primary tank with external fiberglass jacket shall not be permissible.
4. Separator Corrosion Control System shall be in strict accordance with Underwriters' Laboratories Inc. Subject UL-1746 Standard for External Corrosion Protection Systems for Steel Underground Storage Tanks and the HighGuard® External Corrosion Protection Specifications.



5. Oil/water separator shall comply with National Fire Protection Association NFPA 30 Flammable and Combustible Liquids Code, 2003 Edition.
6. Separator vessel volume shall allow for a hydraulic retention time of ten (10) minutes to ensure laminar flow conditions which result in hydraulic uniformity and high effluent quality. Volume reduction will adversely affect separator performance by increasing horizontal velocity and turbulence, therefore a separator of smaller volume is not permissible.
7. Separator shall be the standard patented product of a steel tank manufacturer regularly engaged in the production of such equipment. Manufacturer shall have at least 20 years experience in manufacturing similar units for identical applications. No subcontracting of tank fabrication shall be permitted.
8. Separator shall be fabricated, inspected, and tested for leakage before shipment from the factory by manufacturer as a completely assembled vessel ready for installation.
9. Separator shall be cylindrical, horizontal, atmospheric-type steel vessel intended for the separation and storage of flammable and combustible liquids. The separator shall have the structural strength to withstand static and dynamic hydraulic loading while empty and during operating conditions. The Oil/Water Separator's dimensions and thickness shall be in strict compliance with Roark's Formulas for Stress and Strain as presented in UL 58, September 30, 1997. Calculations, signed and stamped by a Registered Professional Engineer shall be submitted to document structural strength under specified overbearing or external pressure. A separator with a reduced shell thickness is not permissible.
10. Separator shall have an oil storage capacity equal to about 43% of the total vessel volume and an emergency oil spill capacity equal to 80% of the total vessel volume.
11. To prevent extensive shutdown and maintenance, the separator design must allow solids to fall unhindered by turbulence, and oil droplets to rise without risk of re-emulsifying due to collisions with interfering solids. The use of plastic perforated tubes, spherical balls, or irregular shaped media will increase the facility's maintenance costs and shall not be permitted.
12. Separator shall consist of inlet and outlet connections, integral sand interceptor compartment, non-clogging flow distributor and energy dissipater device, stationary under flow baffle, presettling chamber for solids, sludge baffle, oil coalescing chamber with removable parallel flat/corrugated plate coalescer, with removable plates, and sectionalized removable polypropylene impingement coalescers to optimize separation of free oil from water, effluent downcomer positioned to prevent discharge of free oil that has been separated from the water, access ways for coalescers and each chamber, fittings for vent, oil pump-out, sampling, gauging, leak detection, and lifting lugs.

E. Submittals:

1. Shop Drawings: shop drawings for oil water separators shall show principal dimensions and location of all fittings.
2. Instructions: provide three complete sets of installation, operation, and maintenance instructions with separator.
3. Quality Control: Quality control, inspection procedures, and reports shall be considered part of the submittal package.

F. Warranty

1. The manufacturer shall warrant its products to be free from defects in material and workmanship for a period of one year from the date of shipment. The warranty shall be limited to repair or replacement of the defective part(s).
2. The manufacturer's warranty shall be standard limited warranty in effect at time of purchase.

1.2 PRODUCTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Highland Tank, One Highland Road, Box 338, Stoystown, PA 15563, Phone 814-893-5701, FAX 893-6126, E-mail ows.info@highlandtank.com, Website <http://www.highlandtank.com>

**B. Product**

1. Provide and install Highland Tank Model HTC Series "G" UL-SU2215 approved Belowground Double Wall Parallel Flat/Corrugated Plate Gravity Displacement Oil/Water Separator with Integral Sand Interceptor Compartment. Separator shall be furnished with oil level alarm and leak detection systems. Oil/Water Separator shall be of capacity to comply with Spill Prevention Control and Countermeasures (SPCC) plan requirements at the facility. The sizing of this oil/water separator is consistent with industry protocols for complying with the minimum federal spill and discharge regulations therefore a separator of smaller volume is not permissible.
2. Separator shall be furnished with a Corella™ inclined parallel flat/corrugated plate coalescer to simultaneously separate free oil droplets and settleable or suspended solids particles from water without clogging of the coalescer.

C. Description

1. Separator shall be standard prefabricated inclined parallel flat/corrugated plate, gravity displacement type unit.
2. Separator shall be cylindrical with capacities, dimensions, construction, and thickness in strict accordance with Underwriters' Laboratories Subject 58, Double Wall construction using flat-flanged heads. Separator shall comply with National Fire Protection Association NFPA 30 Flammable and Combustible Liquids Code, 2003 Edition.
3. The separator shall be a pre-packaged, pre-engineered, ready to install unit consisting of:
 - a. An influent connection, flanged. An internal influent nozzle at the inlet end of the separator. Nozzle discharge to be located at the furthest diagonal point from the effluent discharge opening.
 - b. An integral sand interceptor compartment containing one (1) manhole, UL approved, complete with extension, cover, gasket, and bolts. A heavy-duty bulkhead shall retain sand, grit, settleable solids or semisolids and prevent them from entering the separation chamber. Bulkhead shall have a transfer pipe.
 - c. A velocity head diffusion baffle at the inlet to:
 - 1) reduce horizontal velocity and flow turbulence.
 - 2) distribute the flow equally over the separator's cross-sectional area.
 - 3) direct the flow in a serpentine path in order to enhance hydraulic characteristics and fully utilize all separator volume.
 - 4) completely isolate all inlet turbulence from the separation chamber.
 - d. A sediment chamber to disperse flow and collect oily solids and sediments.
 - e. A sludge baffle to retain settleable solids and sediment and prevent them from entering the separation chamber.
 - f. An Oil/Water Separation Chamber containing a removable Corella™ inclined parallel flat/corrugated plate coalescer. The coalescer shall have individual removable plates, sloped towards the sediment chamber. Each coalescing plate shall be flat on the top and corrugated on the bottom. The flat top plate shall resist clogging and clotting with solids. The corrugations of each of the plate bottoms shall be shaped and positioned to enhance collisions between the rising oil droplets and coalesce between them thereby improving separator efficiency. The coalescer shall:
 - 1) effect separation of oil and solids from all strata of the wastewater stream.
 - 2) shorten the vertical distance that an oil globule or solid particle has to rise or sink, respectively, for effective removal. Minimum plate gap to be 3/4".
 - 3) enhance coalescence and agglomeration by causing the smaller globules and particles (those possessing smaller rising/settling rates) to coalesce and collect on the plates thereby forming larger globules and particles that separate rapidly in water.
 - 4) direct the flow paths of the separated oil to the surface of the separator and separated solids to the bottom of the separator.
 - 5) allow solids to fall unhindered by turbulence, and oil droplets to rise without risk of re-emulsifying due to collisions with interfering solids.
 - g. The Oil/Water Separation Chamber shall also contain a sectionalized removable "Petro-Screen"™ polypropylene impingement coalescer designed to intercept oil globules of less



than 20 microns in diameter. Heavy, one-piece impingement coalescers are not permissible.

- h. An internal effluent downcomer at the outlet end of the separator, to allow for discharge from the bottom of the separation chamber only.
- i. An effluent connection, flanged.
- j. Fittings for vent, interface/level sensor, leak detection, waste oil pump-out, sampling, and gauge.
- k. Two (2) manholes, UL approved, complete with extension, cover, gasket, and bolts. One manway shall be placed between the inlet and the parallel flat/corrugated plate coalescer to facilitate access into sediment chamber for solids removal. One manway shall be placed between the parallel flat/corrugated plate coalescer and outlet to facilitate access into the oil water separation chamber for oil removal.
- l. Lifting lugs at balancing points for handling and installation.
- m. Identification plates: Plates shall be affixed in prominent location and be durable and legible throughout equipment life.
- n. HighGuard® Corrosion Protection System consisting of:
 - 1) Isolation Spool Pieces
 - 2) Dielectric Isolation Gaskets and Bushings
 - 3) External surfaces commercial grit blast, coated 75 mils DFT Self-Reinforcing Polyurethane.
- o. Internal surfaces commercial grit blast and coated with 10 mils DFT heavy duty Polyurethane.

D. Accessories

- 1. Separator shall be supplied with an audible and visual alarm system that indicates hi oil level (visual only) and hi hi oil level (audible and visual) of oil storage in the oil/water separator and an audible and visual leak detection alarm system that indicates hydrocarbon and/or water in the interstice. A silence control shall be provided for the audible alarms. Level sensor(s) shall be intrinsically safe. Level sensor floats shall be made of stainless steel. The control panel shall contain both level sensor and detection control. The control panel shall be NEMA 4. Power to the control panel shall be as directed by the Owner.
- 2. Separator shall be supplied with Polyester Hold-down straps.
- 3. Separator shall be supplied with prefabricated Concrete Deadman Anchors.
- 4. Separator shall be supplied with cylindrical and/or rectangular steel Grade Level Manways designed to AASHTO H20 requirements.

1.3 EXECUTION

A. Installation

- 1. Installation shall be in strict compliance with manufacturer's instructions and shall comply with all applicable local, state, and federal requirements.

END OF SECTION 33 44 36 00



Task	Specification	Specification Description
33 44 36 00	22 13 19 26	Interceptors
33 46 51 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 46 51 00	33 14 13 23	Sand Drains
33 46 51 00	23 11 23 00	Relief Wells
33 52 16 13	01 22 16 00	No Specification Required
33 52 16 13	22 05 23 00	Piped Utilities Basic Materials And Methods
33 52 16 13	07 63 00 00	Common Work Results for Fire Suppression
33 52 16 13	07 63 00 00a	Common Work Results for Plumbing
33 52 16 13	07 63 00 00b	Common Work Results for HVAC
33 52 16 13	23 11 23 00b	Facility Natural-Gas Piping
33 52 16 13	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
33 52 16 23	23 11 23 00b	Facility Natural-Gas Piping
33 52 16 23	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
33 53 16 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 59 11 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 59 16 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 61 13 00	22 05 23 00	Piped Utilities Basic Materials And Methods
33 61 13 00	33 14 13 23b	Hydronic Distribution



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Task	Specification	Specification Description
40 05 23 43	22 05 23 00	Piped Utilities Basic Materials And Methods
40 05 23 43	23 11 23 00	Relief Wells
40 05 23 43	23 11 23 00a	Monitoring Wells
40 05 23 43	22 11 23 23	Water Supply Wells
40 05 23 43	22 05 76 00	Sanitary Sewerage
40 05 23 43	07 63 00 00	Common Work Results for Fire Suppression
40 05 23 43	07 63 00 00a	Common Work Results for Plumbing
40 05 23 43	07 63 00 00b	Common Work Results for HVAC



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**SECTION 41 01 20 00 - MATERIAL HANDLING HOISTS****1.1 GENERAL****A. Description Of Work**

1. This specification covers the furnishing and installation of material handling hoists. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS**A. Electric Chain Hoists**

1. Hoist motors shall be H4 duty classification. Class F insulation shall be used in hoist motor for 30 minute operation. Load chain shall be grade 80 alloy, case hardened and zinc plated sized for the intended load. Hoists shall employ AC motor brakes employing single or multiple all-steel disks. Controls shall be hand-held, low voltage electrical, with emergency shut off and enclosed in NEMA 3R rated weatherproof enclosure. Hoist shall include fail safe limit switches in the hoist enclosure. Hoist shall meet requirements of ANSI B30.16 standard. Load hook shall be heavy-duty drop forged with safety latch. Hoist shall have swivel top and bottom hooks.

B. Manual Chain Hoists

1. Load capacity of hoist shall be as specified. Load chain shall be grade 80 alloy, case hardened and zinc plated sized for the intended load. Load hook shall be heavy-duty drop forged with safety latch. Hoist mechanism shall be double pawl ratchet system with Weston type brake using a non-asbestos friction disk. Hoist shall have swivel top and bottom hooks. Hoist shall require between 50 and 80 pounds effort to move load.

C. Electric Wire Rope Hoists

1. Hoist motors shall be H4 duty classification. Class F insulation shall be used in hoist motor for 30 minute operation. Lift range shall be between 20 and 150 feet. Lifting cable shall be pre-formed wire rope, of hoisting service construction, made of extra improved steel (XIP) with an independent wire rope center. Load hook shall be heavy-duty drop forged with safety latch. Hoist shall have swivel top and bottom hooks. Controls shall be hand held, low voltage electrical, with emergency shut off and enclosed in NEMA 3R rated weatherproof enclosure. Hoist shall include fail-safe limit switches in the hoist enclosure. Hoist shall meet requirements of ANSI B30.16 standard.

1.3 EXECUTION**A. Installation**

1. The Contractor shall complete the assembly of any equipment furnished partially assembled and place the items in position as directed. The hoists shall be assembled and securely bolted in position, hoisting chain or wire rope installed, and the hoist made ready for regular operation. The Contractor shall furnish all miscellaneous hardware items required to complete the installation of all equipment and components. Equipment shall be primed and finish painted with a suitable corrosion-resistant paint on all parts and components not made of corrosion-resistant materials or otherwise protected.



END OF SECTION 41 01 20 00

**SECTION 41 22 23 13 - MONORAILS WITH AIR MOTOR POWERED HOIST**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for monorails with air motor powered hoist. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Verification Of Dimensions

1. The Contractor shall be responsible for the coordination of his work with the work of all trades involved and as it relates to the building structure. The Contractor shall verify all building dimensions that relate to fabrication of the monorail system, and shall notify the the Owner of any discrepancy before order to the monorail manufacturer is finalized.

C. Submittals

1. Shop Drawings
2. Design Data
3. Test Reports
4. Certificates
5. Operation and Maintenance Data

D. Quality Assurance

1. Drawings: Submit drawings showing the general arrangement of the track beam system, including curves and switches, clearances, principal dimensions, details of structural connections, air system details, and all component details. Manufacturer's catalog data will suffice for items of standard manufacturer.
2. Certificates: Submit certification of minimum wire rope breaking strength for each hoist. Where applicable, submit factory certification of the load chain rated capacity.
3. Design Data: Submit design calculations verifying the size of structural members, structural supports (fittings, rods, brackets, and components), and lifting beams for the track beam system. The calculations shall include stress and loading diagrams. Submit calculations with monorail drawings.

- E. Maintenance: Submit data package for the entire monorail system.

1.2 PRODUCTS

A. Fabrication And Construction

1. The hoist and trolley shall conform to ANSI/ASME HST-5M or ANSI/ASME HST-6M, **2 OR 3 OR 5, as directed**, ton (2 **OR 3 OR 5, as directed**, metric ton), for general service **OR** protected indoor **OR** all weather outdoor, **as directed**, (0 degrees to 100 degrees F (-18 to 38 degrees C)) working conditions. 2 ton (2 metric ton) design criteria shall apply to hoists of 2 ton (2 metric ton), or less, rated lifting capacity. Hoists of 2, 3, or 5 ton (2, 3, or 5 metric ton) rated capacity, shall be equipped with an automatic mechanical load lowering brake.
2. Capacity: The hoist shall have a minimum rated capacity as required to meet project requirements. The monorail system shall have a minimum rated capacity as required to meet project requirements.
3. Hook Lift and Speed: Shall be the manufacturer's standard within the limits specified in ANSI/ASME HST-5M or ANSI/ASME HST-6M. The hook lift shall be at its highest point a minimum height as required to meet project requirements above the finished floor and at its lowest point a minimum as required to meet project requirements below the finished floor.



OR

B. Fabrication And Construction

1. The 1/4 **OR** 1/2 **OR** 1, **as directed**, ton (1/4 **OR** 1/2 **OR** 1, **as directed**, metric ton) hoist and trolley shall meet the design requirements specified in ANSI/ASME HST-5M or ANSI/ASME HST-6M for the 2 ton (2 metric ton) hoist trolley.
2. Capacity: The hoist shall have a minimum rated capacity as required to meet project requirements. The monorail system shall have a minimum rated capacity as required to meet project requirements.
3. Hook Lift and Speed: For 1/4 **OR** 1/2 **OR** 1, **as directed**, ton (1/4 **OR** 1/2 **OR** 1, **as directed**, metric ton) hoist(s), the hook lift shall be at its highest point a minimum height as required to meet project requirements above the finished floor and at its lowest point a maximum **OR** minimum, **as directed**, as required to meet project requirements above **OR** below, **as directed**, the finished floor. The hook lift and speed limits for 1/4 **OR** 1/2, **OR** 1 ton, **as directed**, (1/4 **OR** 1/2 **OR** 1, **as directed**, metric ton) rated capacity hoists shall be within the limits shown in the following table.

Standardized hoist lift ranges and rated lifting speed ranges for 1/4, 1/2, and 1 metric ton rated capacity

Rated load Capacity (metric tons)	Hoist lift range (meter)	Hoist lifting speed range (mm/s)	
		Low	High
1/4	3 to 15	120	350
1/2	3 to 12	80	250
1	3 to 10	40	225

Standardized hoist lift ranges and rated lifting speed ranges for 1/4-, 1/2-, and 1-ton rated capacity

Rated load capacity (tons)	Hoist lift range (feet)	Hoist lifting speed range (feet per minute)	
		Low	High
1/4	10 to 50	24	70
1/2	10 to 40	16	50
1	10 to 30	8	45

4. Hooks: Shall be of the safety type with hook nuts keyed to hook shanks by means of a setscrew installed in a plane parallel to the longitudinal axis of the hook shank, or by any other similar easily removable securing device. All hook components shall be magnetic-particle inspected over the entire area in accordance with ASTM A 275/A 275M. The acceptance standard shall be one of no defects. A defect is defined as a linear indication revealed by magnetic-particle inspection that is greater than 1/8 inch (3 mm) long whose length is equal to or is greater than three times its width.
5. Hoist Wire Rope: Rope lengths shall be sufficient to maintain a minimum of two full wraps of rope at the dead end(s) of the drum, with the block in its lowest indicated position.
6. Hoist Chain: Chain hoists of 10 foot (3 m) lift or more shall be equipped with a load chain bucket.
7. Hoist Limit Switch: Hoists shall be equipped with upper and lower hoist limit switches/devices.
8. Control Pendant: Shall extend as required to meet project requirements below the underside of the track beam.
9. Trolley: Shall have a manual **OR** geared manual **OR** air motor powered, **as directed**, drive and shall be designed to operate from track beam section. Where two or more hoists are located on the same monorail beam, the trolleys shall be equipped with rubber bumper devices designed to prevent contact of any part or parts of the hoists.



C. Monorail Track Beam System

1. Shall conform to MMA MH27.1, for powered hoists. The maximum allowable deflection shall not exceed 1/600 of the unsupported span, with the hoist(s) at rated load(s) and at any location(s). The track beam system shall have trolley stops at all open end locations. The stops shall be designed to retain the hoist on the track. Wheel stops shall interface with the trolley wheel treads on both sides of the track web simultaneously and shall not interface with the trolley wheel flanges. The air supply valve specified shall be of the quick shutoff type, readily accessible from the floor, and located within proximity to the monorail system.
2. Color of Finished Equipment: Shall be the manufacturer's standard brilliant yellow.
3. Identification Plates: The manufacturer shall furnish and install identification plates of noncorrosive metal. Information and data on the plates shall include, in clearly legible permanent lettering, the manufacturer's name, model number, capacity rating, and other essential information. In addition, the monorail track beam system shall be furnished with identification plates showing the capacity of the system, which shall be legible from the floor and from either side of the monorail track beam.

1.3 EXECUTION

A. Erection And Installation

1. The Contractor shall erect and install the hoist and monorail system in accordance with of MMA MH27.1. The monorail supplier shall provide supervisory erection services.

B. Field Inspection And Tests

1. Pre-Erection Inspection: Before erection, the Contractor and the manufacturer's representative shall jointly inspect the monorail and hoist systems and components at the job site to determine compliance with specifications and manufacturer's data and detail drawings as approved. The Contractor shall notify the the Owner 3 days before the inspection.
2. Load Tests: Upon completion, and before final acceptance, the hoist, trolley, and monorail shall be tested in operation as specified, carrying 125 percent of the rated capacity, and with the units spaced to obtain maximum possible loads in the monorail track beam systems. The air equipment will not necessarily operate at rated speed with a 125 percent overload. For hoists that incorporate mechanical load brakes, the mechanical load brake shall hold a static, as well as control a dynamic, 125 percent rated load. The systems shall be thoroughly tested in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. The Contractor shall furnish test loads, operating personnel, instruments, and other apparatus as necessary to conduct field tests on hoist and monorail. The test and final adjustments of the equipment shall be under the supervision of the the Owner. The Contractor shall rectify any deficiencies found and completely retest work affected by such deficiencies.

END OF SECTION 41 22 23 13



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**SECTION 41 22 23 13a - MONORAILS WITH MANUAL HOIST**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for monorails with manual hoist. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Verification Of Dimensions:

1. The Contractor shall verify all building dimensions that relate to fabrication of the monorail system, and shall notify the Owner of any discrepancy before the order to the monorail manufacturer is finalized.

C. Submittals

1. Shop Drawings: Submit drawings showing the general arrangement of the track beam system, including curves and switches, clearances, principal dimensions, details of structural connections, and all component details. Manufacturer's catalog data will suffice for items of standard manufacturer.
2. Design Data: Structural design calculations.
3. Test Reports
 - a. Hook and hook nut magnetic-particle tests.
 - b. Monorail system load tests
4. Certificates: Manual hoist load chain
5. Operation and Maintenance Data
 - a. Track beam system
 - b. Hoist and trolley

D. Quality Assurance

1. Certifications: Submit factory certification of load chain rated capacity.
2. Design Data: Submit design calculations verifying the size of structural members, structural support fittings, rods, brackets, components, and lifting beams for the track beam system. The calculations shall include stress and loading diagrams. Submit calculations with monorail drawings.

1.2 PRODUCTS

- A. Fabrication And Construction: Provide manual hoist and trolley, ANSI/ASME HST-2M, ANSI/ASME HST-3M, trolley suspension. Trolley and wheels shall be suitable for operation on the steel monorail track beam provided, and shall have not less than four wheels.

1. Capacity: The hoist shall have a minimum rated capacity as required to meet project requirements. The monorail system shall have a minimum rated capacity as required to meet project requirements.
2. Hook Lift: Shall be the manufacturer's standard. The hoist lift shall be at its highest point a minimum of 8 feet (2400 mm) above the finished floor and at its lowest point a minimum of 2 feet (600 mm) below the finished floor.
3. Hooks: Shall be of the safety type with hook nuts keyed to hook shanks by means of a setscrew installed in a plane parallel to the longitudinal axis of the hook shank, or by any other similar easily removable securing device. All hook components shall be magnetic-particle inspected over the entire area in accordance with ASTM A 275/A 275M. The acceptance standard shall be one of no defects. A defect is defined as a linear indication revealed by magnetic-particle



inspection that is greater than 1/8 inch (3 mm) long whose length is equal to or is greater than three times its width.

4. Trolley: Shall be designed to operate from track beam section. Where two or more hoists are located on the same monorail beam, the trolleys shall be equipped with rubber bumper devices designed to prevent contact of any part or parts of the hoists.
5. Load Chain: High strength steel links, flexible; minimum safety factor of 5 to 1 based on ratio of minimum chain breaking load to the calculated load on the chain when the hoist is assumed loaded to rated capacity. Certification from hoist manufacturer of provided chain's breaking strength shall be submitted to the Owner and approved prior to final acceptance of hoist. Do not paint or coat the load chain.
6. Load Hooks and Load Hook Components
 - a. Hook: Forged steel; complete with spring-loaded steel throat opening safety device. The hook shall be carried on suitably sealed or shielded anti-friction thrust bearings and shall swivel freely through 360 degrees rotation with full load without twisting chain.
 - 1) Disassembly. Hook and hook nut shall be capable of complete disassembly that enables access to all surfaces of the hook, including shank and hook nut for inspection purposes. Provision shall be made for the hook nut, or other hook-to-block fastener, to be keyed to hook shank by means of a set screw or similar, easily removable, securing device.
 - 2) Hook Non-Destructive Test. Each hook, including shank and hook nut, shall be inspected over the entire surface areas by magnetic particle inspection. If hook nut is not used, any device that functions the same as the hook nut shall be inspected by magnetic particle inspection.
 - a) Procedure: Magnetic particle inspection shall be conducted in accordance with ASTM A 275/A 275M. This inspection shall be conducted at the factory of the hook manufacturer or hoist manufacturer. Alternately, a recognized independent testing lab may conduct the inspections if equipped and competent to perform such a service, and if approved by the the Owner.
 - b) Acceptance Criteria: Defects found on the hook or hook nut shall result in rejection of defective items for use on furnished hoist. For this inspection, a defect is defined as a linear or non-linear indication for which the largest dimension is greater than 1/8 inch (3 mm). Weld repairs for defects on hook or hook nut will not be permitted.
 - c) Test Report: A test report of the magnetic particle inspection of each hook and hook nut provided shall be submitted to and approved by the the Owner prior to final acceptance of hoist installation. Test reports shall be certified by the testing organization.

B. Monorail Track Beam System: Comply with MMA MH27.1 except as modified and supplemented herein.

1. Patented Track: Provide specially designed trackage, e.g., patented track beam, curves, and switches constructed from welded steel components. The lower flange of the track section shall have flat wheel treads; minimum lower flange width of 3.25 inches (80 mm); chemical composition of 0.45 to 0.60 percent carbon content, 0.60 to 1.1 percent manganese content; and wheel treads shall be hardened to a minimum Brinell Hardness Number of 225. Upper flange and web of the track section shall be steel, continuously welded together or provided as one monolithic piece.
2. Track Suspension: Provide means of suspending the monorail track system, including curves and switches from the structural supports. The suspension system shall be the sole responsibility of the track supplier; however, design shall be subject to the requirements specified herein.
 - a. Cataloged Products: If possible, provide track manufacturer's standard cataloged devices for connection of the track to the indicated supporting structures. If track manufacturer's cataloged devices are not provided for this suspension system, complete shop drawings and calculations for the custom suspension device shall be submitted for review and approval by the the Owner. Track suspension devices which are not the track



- manufacturer's cataloged products shall meet the additional requirements specified in Division 05 Section "Metal Fabrications".
- b. Design: The suspension system shall be designed and constructed to ensure no impairment of the strength of track or the structural support. A hanger or suspension shall be located at each rack splice joint. Provide bracing to hold track sections in rigid alignment at all joints.
 - c. Suspension of Curves and Switches: Provide steel framing (structural supports), in addition to that indicated, as required by monorail curve and switch manufacturer to support curves and switches. The additional steel framing shall be the sole responsibility of the monorail supplier. Submit shop drawings and framing design calculations to the the Owner for approval.
 - d. Sway Bracing: Where the track is suspended from hanger rods, track shall be braced laterally and longitudinally to prevent sway.
 - e. Lock Nuts: Where the track is suspended from hanger rods, lock nuts or other means shall be provided to prevent the nuts from backing off the rods.
 - f. Multiple Suspension Devices: Where more than one suspension device attached to the track at a single point, the suspension devices shall be provided so that the loads shall be induced in each in proportion to the device's size.
3. Identification Plates: Provide identification plates of noncorrosive metal. Information and data on the plates shall include, in clearly legible permanent lettering, the manufacturer's name, model number, capacity rating, and other essential information. In addition, the monorail track beam system shall be furnished with identification plates showing the capacity of the system, which shall be legible from the floor and from either side of the monorail track beam.
- C. Painting Of System: Provide manufacturer's standard painting or shop painting of components specified in this section; comply with the requirements specified in Division 07. Do not paint, coat, or galvanize load chain, load, hook nut, or load chain sheave.

1.3 EXECUTION

- A. Erection And Installation: The Contractor shall erect and install the hoist trolley and monorail system in accordance with manufacturers written instructions, MMA MH27.1, and the contract drawings. The monorail supplier shall provide supervisory erection services. Welding new sections of monorail track to existing shall conform to AWS D1.1.
- B. Field Inspection And Tests
1. Pre-Erection Inspection: Before erection, the Contractor and the manufacturer's representative shall jointly inspect the monorail and hoist systems and components at the job site to determine compliance with specifications and manufacturer's data and shop drawings as approved. The Contractor shall notify the the Owner 3 days before the inspection.
 2. Operational Inspection and Load Tests: Upon completion, and before final acceptance, the hoist, trolley, and monorail shall be given the rated load test specified in ASME/ANSI B30.11, carrying 125 percent (plus 5 percent, minus 0 percent) of the rated capacity, and with the units spaced to obtain maximum possible loads in the monorail track beam systems. Hoists shall hold a static, as well as control a dynamic, 125 percent rated load. The systems shall be thoroughly tested in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. The Contractor shall furnish test loads, operating personnel, instruments, and all other necessary apparatus at no additional cost to the Owner. The test and final adjustments of the equipment will be under the supervision of the Owner. The Contractor shall rectify any deficiencies found and completely retest work affected by such deficiencies.

END OF SECTION 41 22 23 13a



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Task	Specification	Specification Description
41 22 23 13	41 01 20 00	Material Handling Hoists
41 22 23 13	26 05 19 23	Monorails With Electric Powered Hoists



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43 - Process Gas and Liquid Handling, Purification, and Storage
Equipment

Task	Specification	Specification Description
43 23 78 31	22 05 23 00	Piped Utilities Basic Materials And Methods
43 24 41 23	22 05 23 00	Piped Utilities Basic Materials And Methods
43 41 31 00	01 22 16 00	No Specification Required



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Task	Specification(s)
01 22 16 00	01 22 16 00
01 22 20 00	01 22 16 00
01 22 23 00	01 22 16 00
01 32 33 00	01 32 33 00, 01 32 33 00a, 01 32 33 00b, 01 32 33 00c, 01 32 33 00d
01 51 13 00	01 51 13 00
01 52 13 00	01 52 13 00, 01 22 16 00
01 52 19 00	01 22 16 00, 01 52 13 00
01 54 23 00	01 22 16 00
01 54 26 00	01 22 16 00
01 54 29 00	01 22 16 00
01 55 23 00	01 22 16 00
01 55 26 00	01 22 16 00
01 56 16 00	01 22 16 00
01 56 26 00	01 56 26 00, 01 56 26 00a, 01 22 16 00
01 56 29 00	01 22 16 00
01 56 33 00	01 22 16 00
01 56 39 00	01 22 16 00
01 58 13 00	01 22 16 00
01 66 19 00	01 22 16 00
01 71 13 00	01 22 16 00
01 71 23 16	01 71 23 16
01 74 16 00	01 22 16 00
01 74 19 00	01 74 19 00
02 41 19 13	02 41 19 13, 02 41 19 13a, 02 41 19 13b, 01 71 23 16
02 41 19 16	02 41 19 13, 02 41 19 13a, 02 41 19 13b
02 81 00 00	02 81 00 00, 02 81 00 00a
02 82 16 00	02 82 16 00
02 82 33 00	02 82 33 00, 02 82 33 00a, 01 22 16 00, 02 81 00 00a, 02 82 16 00
02 83 19 13	02 83 19 13, 02 83 19 13a, 02 83 19 13b, 02 83 19 13c, 02 82 33 00, 02 82 33 00a
02 83 33 13	02 83 19 13, 02 83 19 13a, 02 83 19 13b, 02 83 19 13c
02 84 16 00	02 84 16 00, 02 84 16 00a, 02 84 16 00b
02 84 33 00	02 84 33 00
02 87 13 33	02 87 13 33
02 87 16 13	02 87 16 13
02 89 00 00	01 22 16 00, 02 83 19 13, 02 83 19 13a, 02 83 19 13b, 02 83 19 13c
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05 13 00 00	05 50 00 00
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05 36 00 00	05 31 00 00
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05 42 33 00	05 12 23 00
05 43 00 00	01 22 16 00, 05 12 23 00, 05 50 00 00
05 50 00 00	05 50 00 00
05 51 13 00	05 51 13 00, 05 51 13 00a, 05 50 00 00
05 51 19 00	05 50 00 00, 05 51 13 00, 05 51 13 00a
05 51 33 13	05 50 00 00, 05 52 13 00
05 51 33 16	05 50 00 00
05 51 33 23	05 50 00 00, 05 52 13 00
05 52 13 00	05 52 13 00, 05 50 00 00

Task	Specification(s)
05 53 13 00	05 53 13 00, 01 22 16 00, 05 50 00 00
05 54 00 00	05 50 00 00
05 55 13 00	05 50 00 00, 05 51 13 00, 05 51 13 00a
05 55 16 00	05 50 00 00, 05 51 13 00, 05 51 13 00a
05 56 00 00	05 50 00 00
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05 59 65 00	01 22 16 00, 05 58 16 00
05 73 00 00	05 73 00 00, 05 73 00 00a, 05 58 16 00
05 75 00 00	05 58 16 00, 05 73 00 00, 05 58 16 00a
07 05 13 00	07 05 13 00, 07 05 13 00a, 07 05 13 00b, 07 05 13 00c, 07 05 13 00d, 07 51 13 00, 07 53 16 00
07 11 13 00	07 11 13 00, 07 14 16 00
07 13 13 00	07 13 13 00, 07 11 13 00
07 13 53 00	07 13 53 00, 07 13 53 00a
07 14 13 00	07 14 13 00
07 14 16 00	07 14 16 00
07 16 13 00	07 16 13 00
07 16 16 00	07 16 16 00
07 16 19 00	07 16 19 00
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41 22 23 13	41 22 23 13, 41 22 23 13a, 41 01 20 00, 26 05 19 23
43 23 78 31	22 05 23 00
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